Mixing With The Mountains

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Socio-Cultural Viability with Respect to Compounding Natural Hazards: A case study of Alpine Ski Areas

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Today there is interest in building resilient communities. Identifying and managing the risks of natural hazards with communities who face compounding hazards is challenging. Alpine ski areas provide a unique context to study this challenging and complex process. The traditional approach taken to manage natural hazards is discipline-centric and focuses on common (e.g. high probability low consequence) natural hazards such as avalanches. While this thesis acknowledges that the common approach is rational, it argues that we can extend our communities of practice to include rare (e.g. low probability / high consequence) natural hazards such as earthquakes. The dynamically complex nature of these 'rare' hazards limits our understanding about them, but by seeking and using the lived experiences of people in mountain communities some knowledge can be gained to help improve our understanding of how to adapt. This study focuses on such an approach in the context of alpine ski areas prone to earthquakes as a first step toward identifying key policy opportunities for hazard mitigation in general.

The contributions can be broken down into methodological, contextual, and theoretical pursuits, as well as opportunities for improving future research. A development mixed method triangulated approach was justified because the research problem (i.e. earthquakes in ski areas) has had little consideration. The context provided the opportunity to test the integration of methods while dealing with the challenges of research in a novel context. Advancement to fuzzy cognitive mapping was achieved through the use of unsupervised neural networks (Self-organizing Maps or Kohonen Maps). The framework applied in the multi-site case study required a synthesis of current approaches, advances to methods and a functional use of cultural theory. Different approaches to participatory policy development were reviewed to develop a research protocol that was accessible.

Cultural theory was selected as a foundation for the thesis because of its' preference for plural rationalities from five ways of organizing. Moreover, the study undertook a shift away from the dichotomy of 'methodological individualism' and 'methodological collectivism' and instead chose the dividual (i.e. social solidarities that consist of culural biases, behavioral strategies and social relations) as a consistent unit of analysis despite three different methodologies including: field studies, qualitative interviews, and fuzzy cognitive maps. In this sense, the thesis sought to move away from 'elegant solutions' from singular solidarities or methods toward a research philosophy that sustains requisite variety and clumsy solutions. Overall the approach was a trandisciplinary framework that is a step toward sustainable hazards mitigation.

The results indicate that the selections of risks and adaptation strategies associated with the in-situ hazards are driven by roles that managers, workers, and riders play in the context. Additionally, fuzzy cognitive maps were used as an extension of qualitative interviews and demonstrated the potential for power struggles that may arise between participant groups when considering strategies for preparation, response and recovery. Moreover, the results stress that prolonged engagement with stakeholders is necessary to improve the policy development process. Some comments are made on the compatibility condition of congruence between cultural biases, behavioural strategies, and social relations. As well, inclusion of the hermit/autonomous solidarities is stressed as a necessary component of future applications of cultural theory. The transdisciplinary mixed-method framework is an approach that can be transferred to many other vital areas of research where integration is desirable.

Keywords: Mixed Methodology, Transdisciplinary, Triangulation, Geomorphic Assessments, Qualitative Interviews, Fuzzy Cognitive Maps, Natural Hazards, Cultural Theory, Requisite Variety.

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Chapter 1: **Introduction**

The world we live in presents us with many challenging problems, some characterised by complexity, uncertainty, unknowns, or worse still, unknown unknowns. How can we begin to comprehend things that are unknown, uncertain, or not easily understood? Some issues have been described as not just queer, but queerer than we can imagine them to be (Haldane, 1927). Yet somehow, the things that we as individuals, hierarchies, or as a collective once believed to be strange or perhaps even beyond comprehension have now come to be not only understood, but even perhaps taken for granted.

Consider, for example, earthquakes. Thousands of years ago, our understanding of earthquakes was far different from today. Though none of his written work survives, Thales of Miletos (c. 625 – c.545 B.C.E.) "laid very early foundations for seismology as not by appealing to the gods, but by suggesting the occurrence of tremors in the water upon which the earth rests" (King, 2004, p.14). Thanks to the development of continental drift theory , which is correctly attributed to Ortelius in 1596 (Romm, 1994), it has been possible to gain a better understanding of earthquakes. Later, Wenger in 1912 put forward a more developed theory with fossil and paleo-topological and climatological evidence. Still, continental drift was rejected until Carey (1958) put forward a theory of plate tectonics, which included a convective mechanism driving plate movement. Seismological evidence from Oliver (1968) advanced the understanding leading to the New Global Tectonics which provided scientific evidence and a convective mechanism (i.e. seafloor spreading) for earth movement. More recently, the New Global Tectonics has been abandoned in favour of simply plate tectonics, which has benefited from advances in technology, methods, and the integrated coordination of understanding (i.e. remote sensing satellites that are calibrated with ground measurements stations) (Keary *et al.,* 2009). Most scientists agree that we now understand earthquakes as a part of the naturally occurring larger process of organising and disorganising continents (Zhao *et al.,* 2002, 2004). Some, however, still refute the strong evidence of gradual plate movement in favour of catastrophic plate movement (Baumgardner, 2002) or uniform landscapes (Oard, 2002). And yet, understanding what to do about the consequences of earthquakes, or other rare (i.e. low probability and frequency) compounding natural hazards, is an even greater challenge.

That we are here, and that we are continually evolving an understanding of how to adapt to these challenges (such as how to mitigate the consequences of earthquakes) contests the very principle of 'un-understandable' things. Human curiosity, a natural desire to "figure things out", is what has brought researchers to this point. In fact, if humans had not had the curiosity towards understanding cause and effect, we might not have survived the myriad of natural hazards and disasters that affected our ancestors, forming our present world. We often disagree about how to mitigate hazards, whether through resistance, acceptance, rejection, adaptation or resilience. Moreover, our approaches to understanding the variety of strategies also generate disputes.

Some believe that certain forms of understanding are more valid than others. For instance, the scientific method is offered as "superior" to traditional knowledge and belief systems of other forms. Each approach to understanding advocates distinct social constructions of human nature and physical nature that can be in opposition to other approaches, stemming from equally distinct points of view. And yet, sometimes contradictory certainties can converge to generate better understandings despite polarizing social solidarities. Quite often, a synthesis of two, or better still, three, seemingly opposing points of view provides a degree of insight from which all concerned can equally benefit.

Our shifting understanding of natural hazards is an example of how different approaches can converge toward an integrated knowledge system. After reviewing decades of research regarding natural hazards and disasters, Mileti (1999) highlights an alternative way to view, study and manage those hazards, which he named *sustainable hazard mitigation*. The approach differs from a traditional planning model; that is, studying the problem, implementing a technical solution, and moving on to the next problem, which all cast "hazards as static and mitigation as an upward, positive, linear trend" (Mileti and Peek-Gottschlich, 2001, p.61). The traditional approach to hazards is based on short-sighted development patterns, cultural premises, attitudes toward nature, and science and technology that often resulted in an inability to reduce losses associated with hazard events and natural disasters (Ibid, 2001). The shift to sustainable hazard mitigation focuses on viewing natural hazards and disasters in a more holistic manner, emphasising long-term sustainability and community-based adaptation for disaster resilience, which is a significant shift in perspective.

1.1 Shifting Perspectives of Natural Hazards

Following the works of White (1936, 1945), natural hazards are seen not just as physical phenomena separated from society, but "are linked to countless individual decisions to settle and develop hazard prone land" (Smith, 2004, p.4; Cohen, 2006). White (1936,

1945) influenced other pioneers of social sciences, who for the first time introduced a social (human ecology) perspective.

> Whilst earth scientists – geologists, meteorologists, hydrologists and civil engineers – worked to predict extreme natural events and construct defensive control works, geographers and others explored a wider program of loss mitigation through human adjustments, such as disaster aid and better planning (Smith, 2004, p.4).

These changes propelled two shifts in hazard management: movement to the dominant (behavioural), and then the radical (structuralist) paradigms. The behavioural paradigm approaches mitigation through environmental engineering, and field monitoring of geophysical processes, coupled with an emphasis on military-style organization of disaster plans and emergency responses. The structuralist paradigm states that, "disasters are caused by human exploitation…and disaster mitigation depends on a fundamental change involving a re-distribution of wealth and power" (Hoffman and Oliver-Smith, 2002, in Smith, 2004, p.6, sic).

In order to successfully mitigate natural disasters, the structuralist paradigm posits that "strategies are believed to originate in community-based adaptation, assimilated into local activities" rather than only using investment in the form of "externally inspired engineering works aimed at 'designing-out' hazards from the environment", which is the approach of the behaviourist paradigm (Smith, 2004, p.6). At the end of the twentieth century, a more holistic approach has emerged that is grounded in sustainable development.

> Called Sustainable Hazard Mitigation by Mileti and Myers (1997), [the holistic paradigm] looks beyond local, short-term loss reduction and seeks to mesh disaster reduction strategies into an ongoing development agenda for a changing world (p.7, *sic*)

Though Sustainable Hazard Mitigation (SHM) has been termed a "new paradigm" (Pine, 2008) its pioneers had actually laid its philosophical foundations much earlier;

> Hazards and disasters involve much more than what goes on in a community in the immediate prelude and aftermath of one unique disaster event. It is, among other things, very much the effect of long-term community processes such as land use management, building codes, and community preparedness for warning. Factors such as these exist prior to any disaster event and to a significant extent determine the population-at-risk, the susceptibility of structures, and the efficacy of warnings in future events (Mileti *et al.,*1975, p. 78).

One of the essential components of such an approach is to work towards practical strategies (e.g., policies and guidelines) through stakeholder participation (Mileti, 1999).

Despite the shift in understanding, natural disasters have continued to impact communities, countries, and global regions (White *et al.,* 2001; ISDR, 2010). This may be due to a lack of implementation of the SHM, or that the SHM is yet to be applied in a meaningful way. Nevertheless, it seems that SHM has strengthened our ability to employ holistic approaches in hazard research; for example, the United Nations International Strategy for Disaster Reduction report stressed the need for SHM.

> Disaster reduction must be delivered to people in ways that are financially, environmentally, and culturally sensitive; mitigation methods must be developed through public consultation that are flexible to meet future and present needs; ... communities must be trained to take more direct responsibility in disaster reduction; and, there must be resistance to powers demanding an unsustainable return to previous normal conditions after disasters occur (UN/ISDR, 2004).

This is a breakthrough for integrating the needs of local communities into the mitigation of disasters. The UN member countries are expected to advance their delivery of natural disaster relief and community-renewal methods (UN/ISDR, 2004) to move toward SHM.

Sustainable hazard mitigation requires that "public participation is integrated into disaster management planning and community planning" (Pearce, 2002, p.215). Yet, Pearce (2002) highlights how the plethora of multi-stakeholder policy development processes that proliferated in the 1990s were criticized as being "too costly, slow, overemphasizing public interests, and usurping the role of elected officials" (p.218). Dorcey and McDaniels (1999) also argue that consensus-based approaches may be desirable, but they can heighten expectations of empowerment for actual decisions when their stakeholders actual role is advisory; a situation that can easily lead to disappointment (Pearce, 2002).

Many theoretical approaches have been developed that attempt to optimize stakeholder involvement to improve policy development. For example, consider participatory disaster risk assessment (PDRA) which attempts to engage stakeholders in the assessment of hazards, vulnerability, coping capacity and risk, though there is no single definition (Pelling, 2007). The lack of definitions can reflect the diversity of interests from agencies who are interested in PDRA. Yet, according to Pelling (2007) "a lack of common understanding also opens this field of work to misplaced or exaggerated claims of participation, inclusiveness or, perhaps most difficult of all, empowerment" (p.375). Scrutiny of the diverse approaches that claim participatory status must consider procedural, methodological, and ideological characters of any assessment tools (Pelling, 2007). Relevant to this thesis are the risk management approach, the empowerment approach, and the resilience approach.

1.2 Participatory Approaches to Policy Research:

The following section highlights three examples of participatory approaches to policy development research, pointing out their strengths and weaknesses regarding their procedural, methodological, and ideological characters while highlighting exemplars.

1.2.1 The Risk Management Approach

> One of the prime aims of the communicator is to provide information to an audience in a manner in which they will attach meaning similar to that of the communicator. To assist in this, the communication must successfully move the audience from passive reception of the message to active processing of the information (Gibson, 2007).

The risk management approach is the predominant approach for engaging experts and lay experts to reduce "the possibility of something happening that impacts on your objectives" (AS/NZS 4360:2004). The distinction between the modern approach and more traditional expert centred risk management is the inclusion of multi-way risk communication between experts and lay experts (Boholm, 2008).

Risk communication was initially "to teach the public about real risk so that they can act 'rationally' and make informed choices about what risks to take or not to take" (Leiss, 1996). This technocratic "real risk" approach has mostly been abandoned in favour of the incorporation of public values and preferences to enable better risk management (Renn, 1998). Instead of experts informing the public (lay-experts) about how they should view risks, consensus building and conflict resolution are viewed as more favourable and are critical to the ideology of the risk management approach.

A systematic analysis of challenges in the related field of risk management is offered by Klinke and Renn (2002) who outline a new approach to risk evaluation and management that compares risk-based, precaution-based, and discourse-based strategies. In their framework they highlight the controversial issues in risk management and develop a risk classification scheme with six different classes of risk. They use a decision tree for evaluating and classifying risks. Critical to my study is their implications for analysis and deliberation in managing complexity, uncertainty, and ambiguity. They argue that problems of uncertainty require managers to rely on *resilience* as the guiding principle for action (WBGU, 2000 in Klinke and Renn, 2002):

> Decisions based on uncertainty management require…more than input from risk specialists. They need to include stakeholder concerns…, and social evaluations (Kelinke and Renn, 2002, p. 1086).

Klinke and Renn (2002) also provide a brief review of different forms of deliberation including: epistemological discourse, reflective discourse, and *participatory discourse*; the last is the most relevant to this thesis.

> Participatory discourses are mainly appropriate as a means to search for solutions that are compatible with the interests and values of the people affected and to resolve conflicts among them. This discourse involved subjective weightings of the criteria and interpretations of the results (Klinke and Renn, 2002, p.1090).

Overall, one of the strengths of the risk management process is that it has become more standardized (e.g. AS/NZ 4360, ISO 31000) and simpler to follow (see Gibson 2007). In addition to standardization and simplicity, it has a myriad of possible instruments, tools, and frameworks to improve participatory policy development.

One exemplary framework of the risk management approach that highlights participatory policy development is provided by Carey etal. (2006), who developed an inclusive and transparent protocol for stakeholder involvement in the identification of valued attributes and associated risk to ecological systems. Their procedure involved a three-tired assessment of ecological values with 15 stakeholder workshops. The workshops helped to identify threats not previously considered by the management agency. Among the weaknesses of using workshops were that they limited opportunities for people to participate at specific dates and times, and that nearly half of the participants were agency staff. Nevertheless, a separate study outlined how participants were pleased to have been involved, and they anticipated ongoing interactions with the management agency (Treffney, 2006; Carey, *et al.,* 2009). This point highlights their approach as an emancipatory approach, that is, "long-term and iterative or continuous, and as a mechanism for participants' self-reflection and consciencisation" (Freire, 1981 in Pelling, 2007). Hence, it appears that the workshops empowered some stakeholders toward prolonged participation with the management agency.

1.2.2 The Empowerment Approach

> Empowerment embodies an interaction between individuals and environments that is culturally and contextually defined. As a result, interdisciplinary approaches, paradigm shifts, and creative research strategies may be required to fully understand the construct. (Zimmerman, 1990, p.170)

Empowerment research has two main perspectives. The first is the social-structural (or contextual) and focuses on empowering structures, policies and practices. The second perspective draws from the psychological experience of empowerment in the workplace and focuses on the perceptions of empowerment (Spreitzer, 2007). The roots of the social-structural perspective are in theories of social exchange and social power. Though the term empowerment had emerged in organizational research in the mid-1980s, it was Conger and Kanungo (1988) who provided an analytical treatment of the empowerment construct. They did so by reviewing management literature which viewed the construct as relational, and the psychology literature where the construct was motivational (Conger and Kanungo 1988).

This research proved seminal for three reasons. First, it provided a useful framework for researchers; second, they called for validation and testing of their model (i.e., five stages of empowerment) and other specific elements or links to empowerment such as good leadership; and third, their split of the empowerment construct led to years of research in distinct 'silos' that likely strengthened the overall understanding and applicability of empowerment. Conger and Kanungo (1988) also criticized the social-structural perspective for its failure to consider that management could not empower if employees lacked self-efficacy. Answering Conger and Kanungo's (1988) calls for further research, Thomas and Velthouse (1990) laid strong foundations for the psychological perspective, by building on the earlier model and providing a more complex cognitive model. The extended model articulated intrinsic task motivation manifest in cognitions including: meaning competence, self-determination, and impact (Spreitzer, 2007).

Drawing from the interdisciplinary literature on cognition, Spreitzer, (1995, 1996) concluded that the cognitions reflect an active rather than passive orientation hence, if one dimension is missing, the empowerment is limited (Spreitzer, 2007). The social-structural perspective is limited because it is organizationally centric, costly to implement, and pays little attention to effects on individual employees. Yet, this perspective has provided positive outcomes for organizations in terms of firm, unit, and team performance. The psychological perspective toward empowerment is also limited because it is individually centric (Spreitzer, 2007). Still, the psychological perspective can be validated against various statistical measurement tools, is continuous rather than dichotomous, and has been used cross-culturally and cross-contextually (Spreitzer, 1995).

The overall strengths of the empowerment approach include the comprehensiveness over earlier theories due to the alignment of the two perspectives. Validation of individual empowerment is possible using the myriad of tools and techniques from psychological measurement. Finally, it has been proposed that empowerment can be integrated with other areas of research such as health, leadership and resilience (Spreitzer, 2007), though there is still a call for longitudinal research on this approach (Conger and Kanungo, 1988).

Empowerment is not without criticism though. The measurement of empowerment relies mainly on questionnaires for data collection, which limits our understanding of the construct (Zimmerman, 1990). A psychological construct such as empowerment can also be investigated through more qualitative means (Zimmerman, 1990; Keifer, 1984; Levine, 1980). Similar to many desirable constructs (e.g. sustainability, resilience, adaptive capacity), empowerment is easier "to define in its absence – alienation, powerlessness, helplessness" (Zimmerman, 1990); however, defining the positive elements of empowerment is difficult because it "takes on a different form in different people and contexts" (Rappaport, 1984). Zimmerman (1990) stresses that we should,

> shift our attention away from debates between the merits of research at one level of analysis versus another to building bridges between levels of analysis. We must integrate theories and methods from other disciplines and develop research strategies that incorporate qualitative procedures and the voice of research participants (p.176).

Thus, similarly to the risk management approach, the empowerment approach has evolved to a point where it seeks participation from diverse stakeholders, across disciplines, while utilizing both quantitative and qualitative methods to improve our understanding and application of the empowerment construct. This new understanding is, in essence, satisfying *requisite variety* for meaningful engagement. A different approach that has integrated *requisite variety* for some time is the resilience (adaptive management) approach.

1.2.3 The Resilience Approach

> Defining the problem at the start involves identifying the critical, necessary stakeholders. Without their participation, achieving a collectively and socially desirable outcome is not possible, because key information resides in the knowledge and mental models of stakeholders, and because, without the inclusion that comes from participatory approaches, any proposed solution would face a legitimacy problem (Walker *et al.,* 2002, p. 5).

Adaptive management includes an iterative decision-making process which provides necessary feedback between monitoring and decisions (e.g., learning), as well as characterizing the system's uncertainty through multi-model inferencing (Holling, 1978). Research on resilience seeks to understand the "magnitude of disturbance" that a socio-ecological /environmental system can tolerate before it changes to an undesirable state (Carpenter *et al.,* 2001). To this end, adaptive management has become a leading scientific approach for improving resilience in complex and uncertain environments (Berkes *et al.,* 2003).

Walker *et al.,* (2002) outline a working hypothesis for a participatory approach for resilience analysis and management that integrates ideas from several social scientists. The hypothesis stresses the following key points: working with stakeholders (Solcum *et al.,* 1995), conceptualizing complex situations (Senge, 1990), policy exercises (Toth, 1998), participatory integrated assessment (van de Kerhof, 2001), companionable modelling and role games (Boursquet *et al.,* 2002) and participatory geographic information systems (Craig *et al.,* 2002). Further, Walker *et al.* (2002) explain that the goal of resilience management is to prevent a system from moving into 'undesirable configurations'. To be considered resilient, the system needs to be able to cope with external shocks in the face of irreducible uncertainty. Thus, Walker *et al.* (2002) stress that resilience analysis needs to stimulate creative thinking about the future while enabling stakeholders, and researchers "to compare maps of various pathways to the future" (p.5).

Identifying and improving resilience can be achieved by using a four-step process (Walker *et al.,* 2002). The first step is to involve representative stakeholder groups for establishing the important attributes of the study system. The second step is for the stakeholders to identify the range of possible trajectories that the system might follow. This information is used in step three for quantitative analyses of where resilience may reside. Finally, step four is an integrated evaluation of management and policy implications using input from both scientists and stakeholders.

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

Walker *et al.* (2004) also outline four critical aspects of resilience: latitude, resistance, precariousness, and panarchy.

> 1) Latitude refers to the maximum amount a system can be changed before losing its ability to recover (before crossing a threshold which, if breached, makes recovery difficult or impossible).
>
> 2) Resistance: the ease or difficulty of changing the system; how resistant it is to being changed.
>
> 3) Precariousness: how close the current state of the system is to a limit or "threshold".
>
> 4) Panarchy: because of cross-scale interactions, the resilience of a system at a particular focal scale will depend on the influences from states and dynamics at scales above and below.

Despite the traction that the resilience approach has received in recent years, it may be difficult for many organizations to shift from risk management ideologies to adaptive management and/or resilience ideologies. The ideologies within adaptive/resilience thinking often do not provide easy paths toward future policies. However, being comfortable with uncertainty and complexity is also a strength of the approach which favours adaptive capacity (i.e. the ability to change directives or courses of action with new information). The resilience approach also actively seeks 'outliers' rather than common problems (Walker *et al.,* 2002). Resilience studies often seek to model non-linear dynamics within social ecological systems which is well suited to the policy arena. However, this can be a strength as well as a weakness as the tools available for non-linear modelling are unfamiliar to policy makers. Overall, the resilience approach focuses on social ecological systems which behave as *complex adaptive systems* (Anderise *et al.,* 2006; Walker *et al.,* 2002).

Complex adaptive systems as outlined by Holland (1992, 2008) have the following characteristics: 1) there is no universal competitor or global optimum; 2) there is great diversity with many niches occupied by different kinds of agents; 3) innovation is a regular feature – equilibrium is rare and temporary; 4) anticipations change the course of the system. Investigating complex adaptive systems means placing emphasis on the leverage points of the system. Thus, a major question that arises is what are the building blocks for resilience to perturbations of a given system? If the problem has not been investigated, then the solution requires identification of building blocks and pursuing innovation. Innovation is a matter of recombining building blocks that have been well known, but recombining them for some new purpose. Recombination creates new rules which can make new hypotheses (Holland, 2008).

1.2.4 Summary of the three approaches

The frameworks presented above are only a select few of the participatory policy development tools. A common message among the three approaches is the advancements that are achieved through debate and eventual collaboration from different perspectives. The recombination of ideas seems to be critical to provide a mechanism for stakeholder involvement in the policy development process. Still, one of the great challenges of taking a holistic/system approach to study policy development for mitigating risks and natural hazards is developing flexible and integrated methods.

The first two approaches, the risk management approach and the empowerment approach, both lack a social and relational framework and depend on the individual being the unit of analysis. The problem with this is that people do markedly different things in exactly the same situation yet all being perfectly rational, given their convictions as to how the world and people are (Thompson, 2011 pers comm.). Framings that assume a uni-rationality (e.g. neoclassical economics, behavioural economics, decision theory, and individual psychology) contributors to the risk management and empowerment approaches in methodology simply cannot get to grips with socially generated plurality. Other framings (e.g. Postmodernist and critical framings) having no hypotheses about viable and unviable ways of organising/relating, have to insist that there are no limits to the proliferation of plurality, resulting in an unbounded reality and infinite number of ways of organizing – lacking explanatory power (Thompson, 2011 pers comm.).

Bearing this challenge in mind, I am proposing a triangulated development mixed-method approach for initiating policy development with mountainous recreational communities exposed to hazards. A brief introduction to the framework is now presented.

As a starting point, geomorphic assessments (i.e. field assessments) of mountain recreational areas gauge the possible physical consequences of natural hazards. Then the results of these geomorphic assessments aid in the development of questions to pose to people in mountain communities regarding their experiences with, and perceptions of mountain hazards. Experiences are collected with semi-structured qualitative interviews, capturing accounts of direct experiences with mountain hazards over a diverse sample of stakeholders. The accounts of experience enable the development of 'horizons' for natural disasters with respect to different perspectives among social groups. The interviews can activate memories through eliciting narratives of actual experiences with small- to medium-scale events (severe weather and avalanches) while focusing on applied preparation, response, and recovery. Subsequently, participants guide the drawing of a fuzzy cognitive map (FCM) (Ozesmi, 1999, 2004) considering earthquakes of high intensity. Although the maps are a static glimpse of participants' mental models, they afford the opportunity to simulate simple scenarios of targeted policy considerations based on participants' FCMs, and recombined Social Group Fuzzy Cognitive Maps (SGFCM) (Axelrod, 1976; Kosko, 1992; Carley and Palmquist, 1992; Dickerson and Kozko, 1994; Palmquist *et al.,* 1997, and Ozesmi, 1999, Ozesmi and Ozesmi, 2004). As this proposed methodology indicates, assailing what to do about natural hazards necessitates crossing disciplinary "fault-lines".

1.3 Crossing Disciplinary "Fault-Lines"

Intertwining hard sciences, such as geology, with soft social/human sciences, such as history and sociology, commonly still presents great difficulties.

> Researchers representing the hard and soft sciences do not use the same investigative techniques, approaches and vocabularies, nor attend the same conferences and meetings. However, it is crucial that scientists from both areas work together as the field of environmental catastrophe research allies both the physical and social arenas. (Leroy, 2006, p.2)

Natural hazard and disaster researchers have stressed the need for an integration of methods, philosophical approaches, and disciplines as an attempt to improve our understanding and ability to mitigate adverse consequences of natural hazard events (Mileti *et al.,*1975; Mileti, 1999; Slaymaker, 1999; Hoffman and Oliver-Smith, 2002; Tierney, 2007; Pine, 2009). Despite the challenges of integrating philosophies and methodologies, many researchers believe that multidisciplinary, or as stressed herein, transdisciplinary research is essential for improving understanding.

Garcia-Acosta (2002) stressed that multidisciplinary disaster research is crucial for understanding the interrelationship between vulnerable context and hazard while focusing on mutual relationship between the natural and social worlds. (Modern practitioners in natural hazard research are collaborating more effectively across disciplines and have focused more on areas of research with common goals. For example, Tierney (2007) outlines how productive interchanges should occur between people studying risk, organization research on accidents and disasters, and environmental sociology. It is essential that humans realize many of the problems (e.g. risks, natural hazards, and disasters) that we create are the result of human and nature interactions, which are by-and-large products of worldviews that separates humans from nature.

> Disasters can be traced either directly or indirectly to the manner in which societies organize their interactions with nature, and the more these linkages become evident through research on disasters and the environment, the less justification there is for these two specialty areas to remain distinct (Tierney, 2007, p.520).

Disasters are not only caused by how humans interact with nature, but also by how we interact with one another in the social arena.

The incorporation of stakeholder values in planning and design of communities is but one characteristic of the movement toward developing sustainable communities. Sustainable communities are a solution to help reduce community losses from natural hazards (Beatley, 1995). Yet developing sustainable communities requires the integration of risk perceptions into the rational dimension of the decision making process, where divergent values and beliefs are compared, evaluated, assessed and synchronized to improve multi-way risk communication (Gheorghe and Mock, 1999). Developing such communities necessitates integration of “the physical processes of natural hazards, with the human-use system, and moral beliefs about how we should live on earth” (Gregg and Houghton, 2006 in Paton and Johnston, 2006, p.20). Achievement of such ideals is perplexing and Paton (2006) captures the challenge quite precisely:

> In increasingly pluralistic societies, people and groups differ with regard to their needs, perceptions, goals and expectations. In this context, the sustained availability of a collective capacity will require an ability to resolve conflicts and reconcile needs, costs and benefits in ways that are fair and just (Paton, 2006, p. 310).

Community-based adaptation is becoming a common practice for mitigating natural hazards (Schneider, 2006). The main reasons for this are that it is cost effective, and has proven to reduce the adverse impacts of natural hazards (Paton, 2006). This means that there is a critical need to improve processes of deliberation to enhance participation of stakeholders. Furthermore, communities should strive to include participants from diverse world-views to enable *requisite variety*.

> A particular future challenge in the area of deliberative processes will be the integration of expert and (in many cases very culturally diverse) community perspectives on an issue. New approaches to risk communication, such as using mental models (Morgan *et al.,* 2002) and risk rankings (Florig *et al.,* 2000) have begun to explore this issue (Pidgeon and Gregory, 2004, p.618).

Therefore, one of the challenges is to create a deliberative process that is transparent, inclusive, and adaptive enough to enable the exchange of diverse perspectives to support a productive recombination of ideas. Furthermore, from the very start of the deliberation process until the policy implementation and review process, stakeholder values must be made explicit.

At this point in the thesis, the human dimension of hazards is cast as a problem challenged by complexity and uncertainty. The shifting perspectives were emphasised to highlight confidence in community-based hazard mitigation. Three brief reviews of participatory approaches to policy research were reviewed in order to stress the need for integration and collaboration between and within disciplines. This crossing of disciplinary fault lines, which has been stressed for some time, is re-emphasised with a call for moving beyond multi-disciplinary and interdisciplinary investigations toward transdisciplinary understanding, while acknowledging the advancement gained from discipline-centred investigations. Now, cultural theory is presented as an ideal conceptual framework to begin participatory policy development for the mitigation of compounding natural hazards.

1.4 From Plural Rationality to Socio-cultural Viability

> We postulate that these four ways of life are at issue in every conceivable domain of social life. Most such domains (say the way in which a school operates, or the way in which an international regime functions) will consist of some mixture of these pure forms. As many social domains can be distinguished within and between societies (and as many societies can be distinguished around the world), the theory allows one to perceive a wide and ever-changing cultural and social variety – while still enabling one to formulate general propositions about social and political life (Douglas *et al.,* 2003).

Cultural theory[1] originates in the work of Durkheim (1897) who argued that one could classify social organization based on just two dimensions. The first, "social integration – the degree to which social life is bounded and bonded within accountabilities of individuals and to some group or other" (6 and Mars, 2008). The second, "social regulation – the degree to which social life is structured by accountability of both individuals and groups by rule, role and given fact" (*ibid*, 2008). The theory evolved when Douglas (1970) cross-tabulated the two dimensions and considered what types of social organization occurred at the intersections (*ibid,* 2008). The four basic forms that result from the cross-tabulation are often described as 'ways of life' (Douglas, 1982b, 1992, 1996, 1999, Mars 1982, and Thompson *et al.,* 1990). The 'ways of life' include the following: Hierarchy – characterized by strong regulation, strong integration[2]; Individualism – characterized by weak regulation and weak integration[3], Enclave – characterised by weak regulation and strong integration[4], Isolate – characterized by strong regulation and weak integration: power is experience [5]

[1] Cultural Theory has sailed under a number of different names including: Grid-group analysis (Douglas, 1986), the Theory of Plural Rationality, Socio-cultural viability (Thompson et al, 1990, Thompson, 2008), the institutional theory of culture (6 and Mars, 2008).

[2] Hierarchy - status and power vary independently; thought style emphasizes order and authorization; adjustments are made to accommodate anomalies; behaviour is rule-bound; leadership is bureaucratic or hierarchical; sacrifice is expected but in different ways from members with different status boundaries are defended; rituals are like processions

[3] Individualism - status varies with power as does control over resources; thought style emphasizes liberty; anomalies are for exploitation behaviour is strategic leadership is that of the merchant adventurer boundaries are treated as opportunities and routinely spanned; rituals are like street fairs

[4] Enclave - power is collective but fragile; status is undifferentiated; thought style emphasizes internal equality; strong boundaries against outsiders and commitment to principle anomalies are threats and rejected leadership is charismatic sacrifice for the group is expected of members external boundaries are defended very fiercely; rituals are like revivalist meetings

[5] Isolate - as arbitrary; status is fixed; thought style is eclectic; anomalies are tolerated as inevitable; behaviour is coping and opportunistic; leadership is either despotic or absent; boundaries are treated as inconveniences or as irrelevant but not as moral claims or as opportunities; rituals are like carnivals.

Cultural theory is thus a pervasive and rather simple typology based on everyday life. Thompson *et al.* (1990) provide a review of sociocultural viability using the Grid-Group analytical scheme (Douglas and Wildavasky, 1982) as a point of departure. Thompson *et al.* (1990) support a detailed description of their theory as a cultural functional explanation outlining philosophical worldviews by comparing typologies of the five viable ways of life. This is done through a review of the "Masters of Sociology" including: Montesquieu, Comte, and Spencer; Durkheim, Marx, and Weber; Malinowski, Radcliffe-Brown and Parsons; and Merton, Stinchombe and Elster while outlining similarities and differences of earlier theories, all toward an end of demonstrating cultural theory's superiority (Thompson *et al.,* 1990). Cultural theory, as discussed in relation to environmental policy, was initially a four-fold typology. More recently, an additional type was included (the hermit/autonomous way of life) to make it a typology of five viable ways of life that serves as an analytical tool for examining people, culture, and politics (Thompson *et al.,* 1990). The theory designates ways of life as viable combinations of cultural biases (i.e., shared values and beliefs) and social relations (i.e., patterns in interpersonal relations); relations and biases are reciprocal, interacting, and mutually reinforcing in a *compatibility condition*. That is,

> A change in the way an individual perceives physical or human nature, for instance, changes the range of behaviour an individual can justify engaging in and hence the type of social relations an individual can justify living in. Shared values and beliefs are thus not free to come together any which way; they are always closely tied to the social relations they help legitimate (Thompson *et al.,* 1990, p.2).

Put another way, the *compatibility condition* means "ways of life must attach patterns of social relations with cultural biases" (p. 16). Thompson *et al.* (1990) stress, "that Five and only five ways of life –hierarchy, Egalitarianism, fatalism, individualism, and autonomy – meet these conditions of viability" (p.3). There being only five ways of life, it is characterised as the *impossibility theorem* which holds that there can be no fewer than five ways of organizing. Now a reference point clarifies the meaning of these ways of life.

In the development of socio-cultural viability, Thompson *et al*. (1990) used the Group/Grid 'analytical scheme' or 'heuristic device' (Douglas, 1970) as a point of departure. The analytical scheme holds that the variability of social involvement can be captured by two dimensions of sociality, namely *Group and Grid*.

The *Group* dimension refers to forms of organization lying on a continuum as either collectivized (i.e., high group) or individualized (i.e., low group). *Group* also depicts "the outside boundary that people have erected between themselves and the outside world"

(Douglas and Wildavasky, 1982, p.135). The *Group* dimension can also be explained as how, and to what extent, an individual is incorporated into units with defined boundaries (Thompson *et al.,* 1990).

The *Grid* dimension refers to social prescriptions along a continuum from prescribed inequality (high grid) to prescribed equality (low grid). Hence, *Grid* can be interpreted as the combination of social distinctions and delegations of authority that it uses to influence how people behave toward one another; put another way, "the degree to which an individual's life is circumscribed by externally imposed prescriptions" (Thompson *et al.,* 1990, p.5). Douglas (1986) uses the *Gird/Group* typology to introduce the four viable ways of life incorporated within cultural theory. The four viable ways of life are *Individualist; Egalitarian; Hierarchist;* and *the Fatalist* (Figure 1.2).

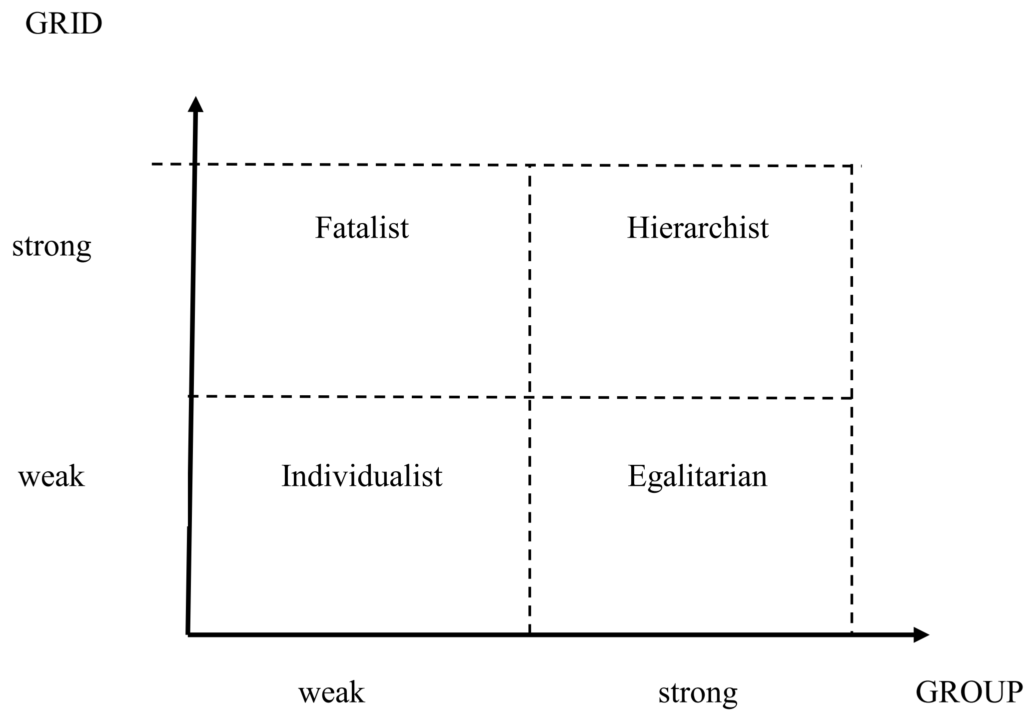

Figure 1.1 The four ways of life from cultural theory mapped onto the GRID/ GROUP analytical scheme. After Thompson *et al.* (1990).

Each way of life depends respectively on a social construction of nature with four primary myths. The four ways of life are based on the respective myths: Nature Benign (Individualist), Nature Ephemeral (Egalitarian), Nature Perverse/Tolerant (Hierarchist), and Nature Capricious (Fatalist) (Thompson *et al.,* 1990, Shwartz and Thompson, 1990; Thompson, 2008) (Figure 1.2).

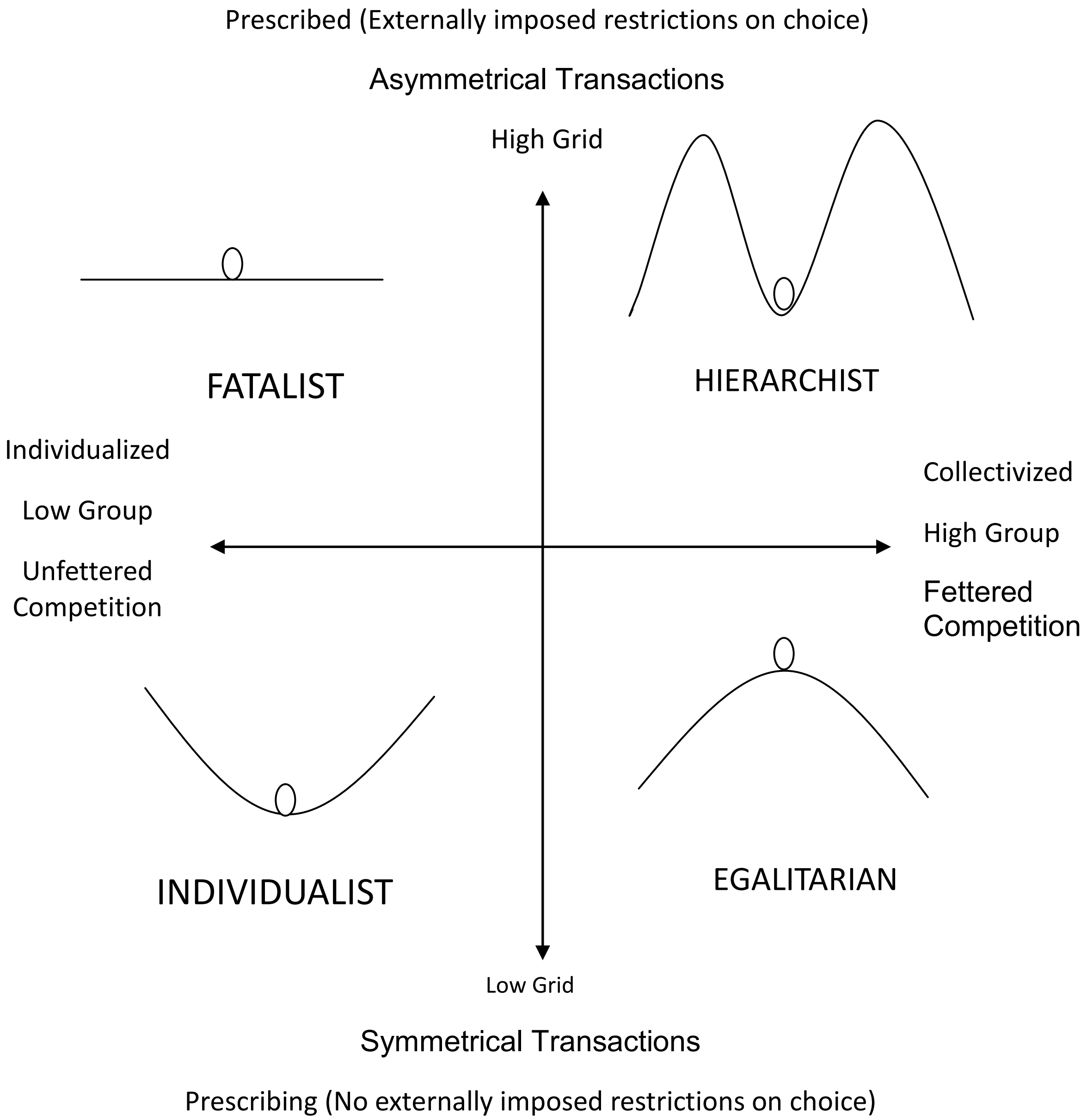

Figure 1.2 The four social solidarities and their respective myths of nature mapped onto the Cultural Theory typology. After: Holling, 1978; 1986; Timmerman, 1986; Thompson *et al.,* 1990; Thompson, 2008).

The myths of nature are not to be understood as falsehoods. Each myth captures some essence of experience and wisdom, and there is ample scientific evidence for the world (in space and time) being each of these five ways (Holling, 1986; Gunderson *et al.,* 2002; Holling, 2004; Walker *et al.,* 2004). Perhaps a short story will help the reader better understand the five and only five ways of life.

1.4.1 The Five Ways of Life: A short fictitious story of four different people depending on each other for viability

Indy is a staunch *Individualist*. From his perspective, as an owner-operator of a private commercial ski area, nature is nothing if not robust. At least, according to Indy, she used to be. His wife and children, on the other hand, would probably label him a *Hierarchist* at home, where he ran a tight ship from the top down. This was likely a direct result of his years in the military as a captain of a helicopter crew and later search and rescue.

He was the first to allow the counter-culture of snowboarding on their slopes in the early nineties. Most clubs lauded the new fad, but Indy saw the opportunity and capitalized on the fastest growth in the history of the ski industry. He was also the first to convert his small club ski area to commercial status. Today he might risk his life's work; however, this risk will pay dividends, as he plans to sell the resort to his nemesis Harry (his estranged eldest son), and then retire to run a B&B in Kaikoura for 'Surfies' and 'Backpackers'. Indy will do this because he is getting on in years, and wants to retire to a warmer business climate where he can run things the way he wants, take the risks he wants, and continue to do things his own way. He has, however, reservations of forming an alliance with Harry for three reasons. First, it was Indy's heroic spirit that lead to the road being cut into the mountains, and the building of lifts and structures to make a playground for people to enjoy. Second, Harry, who was lucky enough to be educated (on Indy's dime) and climb the hierarchy in the commercial ski industry, could very well shut down the ski area to decrease competition with that darn conglomerate of defectors HigherArchs Inc. Lastly, he does not like the idea of giving up his power over the playground he created, especially to that little so-and-so Harry. He altered a landscape with mechanical force to make it safer from avalanches and severe weather, and built reservoirs for the best machine-made snow in the country. Yet, Indy knows that he and his ski area is struggling to compete; old lifts, silted up reservoirs, buildings that need upgrades again, as well as a clientele that is asking for more and more. Indy is well aware that the time to change is now, he is sick and tired of the routine, mundane, business of cutting corners to save money, leaving little time to actively seek new opportunities through taking risks. So, Indy swallows his pride and sells his ski area to Harry's conglomerate, HigherArchs Inc.

Harry, a *Hierarchist*[6], is enthusiastic about the purchase. After all, he has secured the last privately owned ski area in the region. One that he believes is his inheritance. Furthermore, Harry began his career at Mt. Sovereign, that is until Indy let those "Knuckle-Draggers" (a colloquial term for snowboarders) take over the hill. At the time snowboarding was introduced, Harry, then head of Ski Patrol, was dead set against the idea of allowing snowboarding on the hills because he believed that skiers and snowboarders would clash. Harry had no idea how large the snowboarding "fad" would become. He also laid the foundations to professionalize Mt Sovereign, designing a new lift, snowmaking reservoirs, active avalanche control, and state of the art buildings. When Indy gave the green light to snowboarding, they had a falling-out of biblical proportions. Harry quit, and moved on to another resort. They have not spoken since.

Harry was proud of his accomplishments in the ski industry. He acted as a *Hierarchist* in his operational capacity, but deep down, he was selfish. He knew his directors would likely reward his division of the company with pay-raises. Now that HigherArchs Inc. is the only commercial game in town, they can increase prices by a significant margin across all of their fields. This will enable them to increase their resources and satisfy more needs. Perhaps a few more lifts, or a gondola. Instead, Harry decides that with more revenue they can upgrade their snow-making at all their areas, because the warmer winters for several seasons have caused snow lines to rise to dangerous levels. With the revenue generated from more clients satisfied with better and more consistent snow conditions, they can finally upgrade their safety programme. After all, Harry started in ski patrol, and not for nothing was he called "Mr. Safety". When it comes to safety, he might even be a bit of an *Egalitarian*. He believes there have been too many accidents over the years that could have been prevented, especially with people accessing the back country from his ski fields. He is a self-proclaimed "expert" in risk assessment, and he knows that having people in the back country is too high a risk for HigherArch Inc. Why would they risk the lives of their patrollers, to say

[6] The world, in the hierarchical solidarity, is controllable. Nature is stable until pushed beyond discoverable limits (hence the two humps), and man is malleable: deeply flawed but redeemable by firm, long-lasting and trustworthy institutions (i.e. the way the methodological collectivist assumes man is, as in "Give me the boy and I will give you the man"). Fair distribution is by rank and station, or, in the modern context, by need (with the level of need being determined by expert and dispassionate authority). Environmental management requires certified experts (to determine the precise locations of nature's limits and statutory regulation (to ensure that all economic activity is then kept within those limits)" (Thompson, 2008, p.24)

nothing of incurring potential liability, to rescue victims of avalanches, severe weather, or injury? They pay peanuts for their one ride pass to the top. He could take the American approach and ban backcountry access from their fields. This would protect the business and their employees, and force the counter-culture hippies to stay at the club fields where they belong. He decides to phone his ex-wife Alita to brag about HigherArchs Inc's new acquisition.

Alita is a strong *Egalitarian*[7] actor within the ski industry who believes ski areas should tread lightly on the mountains. To her, Mother Nature affords them the privilege of skiing. Her Presidency of the Club Fields Association is a direct result of her ex-husband Harry's and his employer HigherArchs Inc's strategy of buying up privately owned clubs to strengthen their conglomerate. Their business model clearly enables them to jack up prices to expand their empire and buy out leases from club operated ski areas. Alita gathered Association members through lobbying, with what she admits was a bit of well-articulated fear-mongering. Her argument to other clubs was simple: "HigherArchs Inc. is a real estate company dependent on growth, and they plan to buy up all the ski areas in our region so they can increase prices and expand their empire. If we club field operators don't unite, we will be picked off one by one as our leases are bought out. Ultimately, all ski areas will be commercial for-profit enterprises with lifts, snowmaking, and extravagant on-mountain accommodation, all of which will put prices only within reach of the super-rich. We must protect skiing for all snow riders."

Alita also found some members in a group of disgruntled avalanche control employees who had been fired from HigherArchs Inc. They were fired last season when an inbound avalanche exceeded what they thought was possible and damaged a lift tower, knocking it out of alignment. Her ex-husband Harry fired the whole team for not exercising due diligence. After the Club Fields Association negotiated 100-year leases for their club ski areas, Alita hired the entire team and dispersed them to various fields. Alita knows that even a tiny avalanche bomb can cause huge avalanches. To her,

[7] "Nature, for those who bind themselves into the egalitarian solidarity, is almost the exact opposite [of Hierachist's view] (hence the ball on the upturned basin) – fragile, intricately interconnected and ephemeral – and individual is essentially caring and sharing (until corrupted by coercive and inegalitarian institutions: markets and hierarchies). We must all tread lightly on the Earth, and it is not enough that people start off equal; they must end up equal as well – equality of result. Trust and levelling go hand-in-hand, and institutions that distribute unequally are distrusted. Voluntary simplicity is the only solution to our environmental problems, with the "precautionary principle" being strictly enforced on those who are tempted not to share the simple life" (Thompson, 2008, p.24).

Mother Nature is ephemeral. Hence, the team is happy to be employed, with more job security, but controlling avalanches without an *Avalauncher*[8], *Gas-Ex*[9] *or Heli-bombing*[10] is proving difficult. One of her new employees, Fata, the leader of the team, resigned just yesterday after an in-bound avalanche killed a club member.

Fata, as a result of her two mishaps in as many seasons, has reverted back to being a *Fatalist*[11]*;* prior to these accidents she was an *Individualist*, willing to take risks to get the job done. She was once able to use one avalanche bomb to trigger all five major avalanche paths to slide at one of HigherArchs Inc's top ski areas. Unfortunately, the slides accumulated considerable mass and knocked one of the lifts out of alignment. She and her whole team was fired.

Now, as a result of a death on her watch at a small club ski field, she wrote the following letter of resignation (Figure 1.3),

July 25th, 2011

Dear Alita,

I regret to inform you of my resignation, effective immediately. Too many accidents, and now a death on my watch. Twelve years controlling avalanches, training teams, and learning every day, until yesterday my heuristics failed me. When the HigherArchs accident happened last year and we were all fired, I felt responsible. I ignored the possibility of a full depth slab avalanche because the bomb we used was so small. But this is different, exactly the opposite, a small avalanche knocking someone off balance and over a cliff. Had we bombed the area, it never would have happened. Isn't Mother Nature cruel? I don't want to partake in trying to "tame the white dragon" anymore. It's too much risk without any chance of gain. What's the point?

Sincerely,

Fata Lista

P.S. Get out while you still can….

[9] A Gas-Ex is a permanent fixture which uses compressed gas and blasts a strong downward force on a trigger point for an avalanche

[10] Heli-bombing is flying above an avalanche path and dropping bombs to explode releasing the avalanche.

[11] "Fatalist actors (or perhaps we should say non-actors, since their voice is seldom heard in policy debates; if it was they wouldn't be fatalistic!) find neither rhyme nor reason in nature, and know that [humans are] fickle and untrustworthy. Fairness, in consequence, is not to be found in this life, and there is no possibility of effecting change for the better. "Defect first: - the winning strategy in the one-off Prisoner's Dilemma – makes sense here, given the unreliability of communication and the permanent absence of prior acts of good faith. With no way of ever getting in sync with nature (push the ball this way or that and the feedback is everywhere the same), or of building trust with others, the fatalist's world (unlike those of the other three solidarities) is one in which learning is impossible. 'Why bother'?, therefore, is the rational management response" (Thompson, 2008, p. 24-25)

Figure 1.3 Letter of Resignation

As Alita is reading the letter, the telephone rings. It's Harry. Alita explains to Harry that as a result of the death yesterday, Fata quit her job. Harry replies, "It's probably for the best. It will protect the association, not to mention cover you. Plus, Fata was a risk taker. Sure, she knew a lot about avalanches, but mostly from making so many mistakes and getting spanked as a result". Alita responds, "For the first time in three years, I think you are right. Is that why you are calling"?

Harry's tone changed to that of cavalier hunter. "No, I just wanted to boast a bit. My Dad is going to sell us Mt. Sovereign." Alita's heart sank. She was working behind the scenes to have the clubs pool their money to buy it. Another call came in. "Sorry, Harry. I have another call coming in. Can you hold on?" she asked. In his usual patronising tone, he replied,, "Sure. Just don't hang up on me again!" Alita switched to the other call. It was Indy. "I'm sorry, love, but I've had to sell out. Would you like to come and run my B & B for me? It'll be yours anyway when I go. Better you and my grandkids than that little… Anyway, it comes with a far more handsome salary than that lefty operation you call a cooperative". Her response was even tempered. "I'll think about it," And dropping her tone, she said, "For now, I'm stuck with your son and his gloating on the other line." Indy replied, "Well, I'm really sorry, love. Perhaps someday you'll understand. In the meantime, knowing your love for the snow and for all the times your ingenuity saved us in the lean years, I've given you the first crack as operations manager for five years. It's in the sale agreement. Think of it as making an old man happy. At least this way I can imagine you and Harry together again. Not that I blame you much for splitting." Alita, her tone a cautious mix of neutrality and gratitude, replied, "Thanks, Indy. You are too kind".

Her subsequent return to Harry was met with equal disappointment by him. "Don't keep the new boss waiting all day; did I mention I've got a handsome offer for you?" said Harry. Alita snapped at him "You know what, Harry?" "If you're not careful you guys are going to get too big for your own egos! We warned you that if HigherArchs jacks up prices and/or even attempts to buy out our leases, you can forget coordinated emergency response from our fields. That means no personnel, no avalanche dogs, no years of collective experience! You and I both know you do not have the capability to respond to major emergencies without all of us!"

Harry responded in his customary patronizing tone, “Well darling, if we get too big, we may well find you getting too small to be of any use anymore. What can you possibly offer us?” “Mr. Safety my foot!” Alita spat furiously. “You are in this for yourself. You don’t care about anyone but yourself!” Harry continued to carry on until finally he said, “Well, I was going to offer you a job, but I can see now that’s not going to work. I should let you know we are experimenting with cloud-seeding so don’t be surprised if by the end of the season you have no snow!” Alita flatly replied “I’ll stick with LowerArchs thanks”, and then hung up the telephone.

It was too much for her, and to her surprise she began to smile, seeing the overwhelming ignorance for what it was. She knew why Indy did it; their offer was likely half of what HigherArchs could pay. She didn’t blame any of them for their ignorance or limited knowledge: Indy, for his being sufficient and timely; Harry, for being almost completely organized; Fata, whose knowledge was now irrelevant after being forced to the margins of organized patterns. Though she was indeed tired of all the ignorance, her new resolve of inner calm and peace through acceptance of *what is* meant that none of it was in vain. She thought of a retreat to the backcountry to be a hermit for the rest of her life. She is now *Autonomous*[12].

The ground then began to shake violently; it was an earthquake…..To be continued in Chapter 4.

1.4.2 Lessons from the Short Story

The purpose of the short story is to outline what cultural theory defines as three experienceable patterns of social relationships: “Ego-focused networks, egalitarian-bounded groups, and hierarchically nested groups” (Thompson, 2008). Each of these three patterns forms itself into a dynamic equilibrium by maximizing its constituents’

[12] “Since the avoidance of coercive social relationships is the first essential of the autonomous way of life, the hermit will have to disengage himself from all the time structures if he is to stabilise his life around the hinges he prefers. Small wonder then, that he opts for a rationality of immediacy....The essence of experience and wisdom that is captured by the hermit’s myth (and missed by the other four) is the *transformational* nature of the ball and landscape: the fact that the ball alters the landscape through which it moves....we can represent the hermit’s myth as subsuming the other four myths as “stills” in a never-ending cycle of change...”(Thompson, 2008, p. 37) “The hermit, for his part, has to avoid being taken over by any of these contradictory certitudes, and this de does by conceding that each is true up to a point. Since the hermit’s myth tells him that the ravening desires each of the other myths incites in its holders only serve to hasten its conquest by the next one in the cycle, his aim in life is to avoid finding himself caught up in this coercive merry-go-round. Desires, he concludes, are fuelled by ignorance and, since ignorance is something he wishes to rid himself of, he eliminates what he sees to be the false dualism inherent in all the other myths – the clear separation of ball and landscape – and thereby makes himself one with nature” (Thompson, 2008, p. 48).

transactions (Thompson *et al.,* 1990, p. 89). The short story also attempts to highlight the *Fatalist* viability whose lack of interaction is imposed upon by external prescriptions, and that of the *hermit* who decides not to interact, as they deliberately withdraw. Hence, the story is meant to suggest plausible transactions between characters operating from different social solidarities, as well as how plausible reactions to surprise ("the cumulative mismatches between expectations and result") [p.81] can cause a transformation from one solidarity to another. Excluded from the story above is the Hermit's myth, Nature Resilient.

> The hermit's strategy is one of withdrawal; yet coercive social involvement is what the other ways of life are about – each seeks to maximise the transactions through its favoured pattern of relationships, and thereby to minimize those through the other patterns of relationships. The hermit's strategy of minimizing his transactions is viable, therefore, only if everyone else is maximizing theirs. (Thompson *et al.,* 1990, p. 29).

The myth of Nature Resilient "in transcending the duality of the ball in the landscape, captures the transformational properties of the world that are ignored by the other four myths" (Thompson *et al.,* 1990, p.31). Change is inevitable according to the hermit's myth, which views nature as resilient. Visualising this myth requires an understanding that the ball and landscape are mutually reinforcing. That is, Thompson *et al.,* (1990) asks us to imagine what would happen to the ball and the landscape if the ball (e.g. imbued with anti-gravity) sucks up the landscape as it moves through it (Figure 1.4).

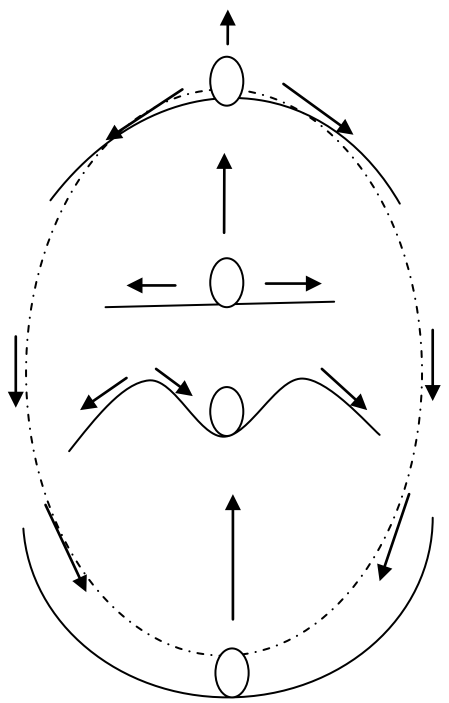

Figure 1.4 The landscape sucking ball (after Thompson, 2008; Thompson *et al.,* 1990)

> If we start off with a bowl-shaped landscape, we find that it changes first to a depression on a mesa, then to a flat surface, and then to an up-turned bowl. In the last situation, the ball will roll off, coming to rest only when it finds its way into another depression. (p.31)

A conceptual model from conservation ecology is helpful to describe how change is permanent. The adaptive cycle is a model of assumptions about ecosystem processes containing a flow through four potential events in any natural cycle (Holling, 1986 and Holling *et al.,* 1993). (Figure 1.5).

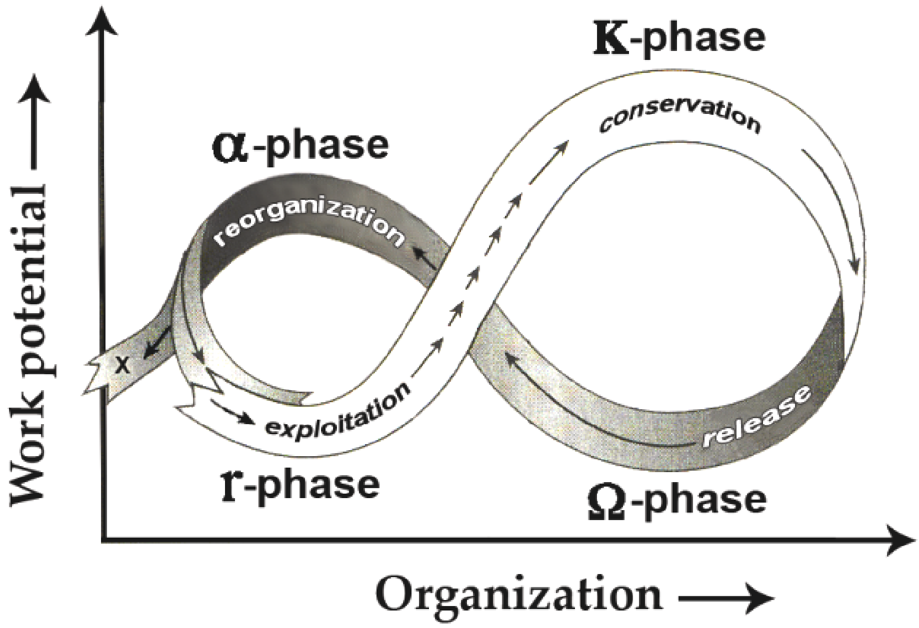

Figure 1.5: The adaptive cycle illustrating the four phases of ecosystem development. (Adapted from Holling & Gunderson, 2002).

The transition occurs in four phases; from the (r) or growth and exploitation phase (resources are readily available) to the (K) or conservation phase (things change slowly as they are locked up and a slow accumulation and storage of energy and materials is emphasized), and then to (Ω) or release phase (things change very rapidly; locked- up resources are suddenly released) and finally to (α) or reorganization phase (system boundaries are tenuous; and innovations are possible) (Resilence Alliance, 2011). Between the (r) and the (K) phases there is slow, cumulative forward loop of the system during which the system is reasonably predictable (Walker *et al.,* 2004). As the (K) phase continues and resources become locked up, the system loses flexibility and its ability to respond to external shocks. Inevitably, chaos, or collapse and release phase (Ω) occurs giving way to reorganization (α) which can be rapid or slow. During this time innovations and new opportunities are possible. Together, the (Ω) and (α) phases comprise an unpredictable backloop. The (α) leads into a subsequent (r) phase, which can resemble the previous (r) phase or be significantly different (Ibid, 2011).

Nature resilient contains both truth and wisdom as it captures the essential transformational properties in a sequence from Nature Benign, through Nature Perverse/Tolerant and then Nature Capricious, to Nature Ephemeral and back to Nature Benign to start the cycle again. This transformation may be described as the logical cycle (ecocycle) through the different phases; however, it is also possible for solidarities to transform in "surprising" ways. An illustrative version of the complex critique of the environmental assumptions is provided in Figure 1.6.

> An event is never surprising in itself; it is potentially surprising only in relation to a particular set of convictions about how the world is; it is actually surprising only if it is noticed by the holder of that particular set of convictions (Thompson and Tayler, 1986; Thompson *et al.,* 1990 in Thompson, 2008, p.101).

Some have highlighted that though the adaptive cycle is based on observed system changes, it does not necessarily follow fixed regular cycling (Walker *et al.,* 2004). The system can move back from (K) to (r) unlocking resources more gradually, or from (r) directly into (Ω) precipitating a chaotic release of unstructured resources, or back from (α) to (Ω) where during reorganization another release occurs brought on perhaps by another chaotic collapse (Ibid, 2004). Surprises, as Thompson (2008) outlines, can flow in a never-ending sequence from one phase to another. The various phases of the adaptive cycle may correlate to the myths of nature, cultural biases, behavioural strategies, and social relations that embody social solidarities.

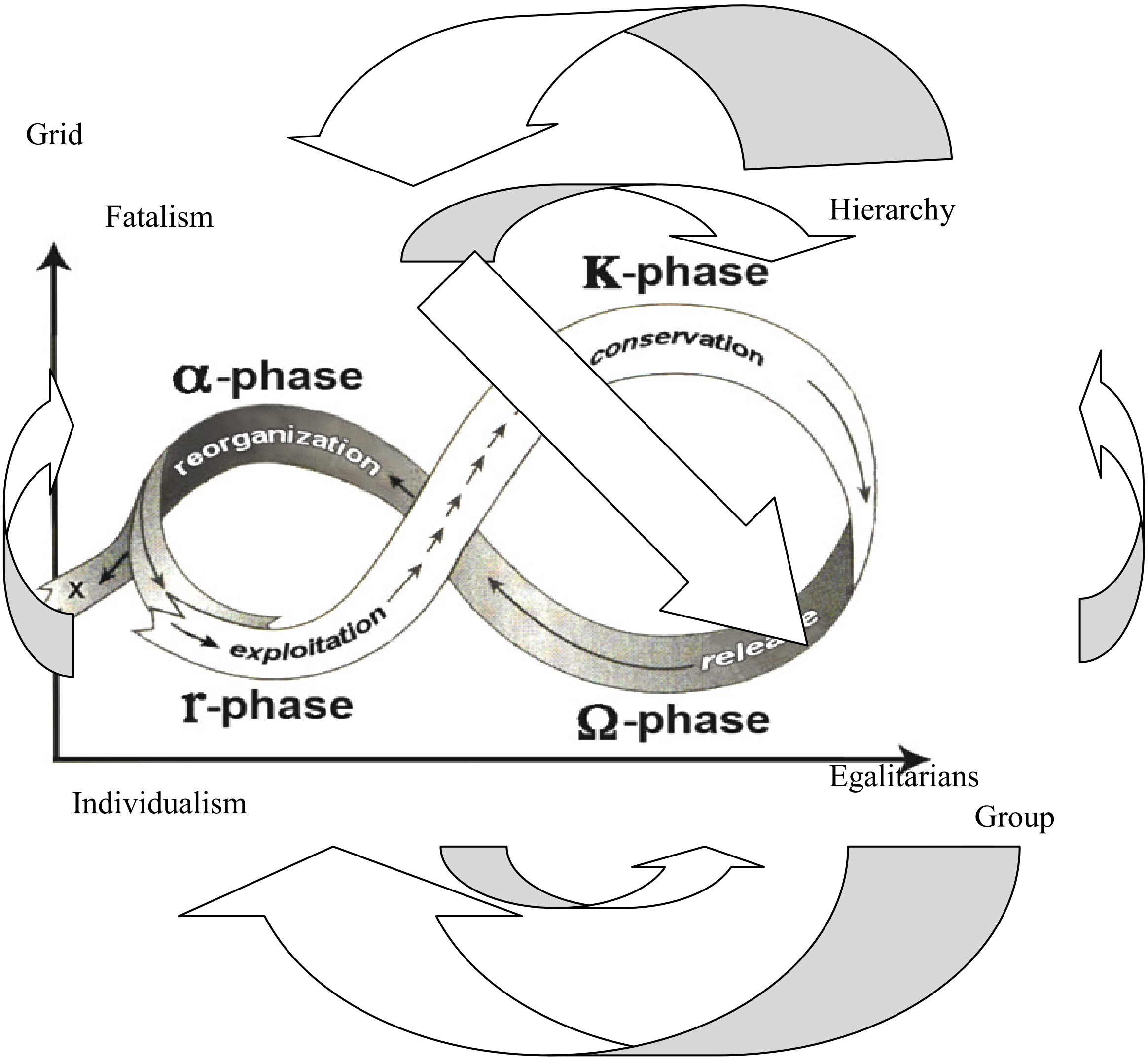

Figure 1.6 The complex critique of conventional assumptions about natural systems. (Adapted from Thompson 2008)

Though the hermit's construction of nature might lead us to conclude it contains all truth and wisdom, this is not so. The hermit is biased away from all four of the other myths of nature. "It is this – their autonomous cultural bias—that makes their way of life liveable, reproducible, and a part of the proper study of social science" (Thompson, 2008, p.32).

In summary, Cultural Theory says that there are more than markets and hierarchies (i.e., more than dualism) that are dominant in the majority of social sciences (Thompson, *et al.,* 1990; Shwartz and Thompson, 1990, Thompson, 2008).. Furthermore, it goes beyond the common dualism of social sciences of markets and hierarchies (i.e., Individualists and Hierarchists, respectively) by including three additional *solidarities*[i] of Egalitarian and Fatalist, and the Autonomous ways of life that are not countenanced in other theories. The strength of the theory, as Thompson (2008) explains, is its ability to make explicit the premises (i.e. the different social constructions of natural, physical and human systems) from which the five ways of life base their positions

Critically, cultural theory demonstrates several normative implications (Verweij *et al.,* 2006; Thompson, 2008). First, there is a recognition that people start from premises that are anchored in different forms of organising, which might suggest ‘they will never agree’. Second, policy analysis has taken an ‘argumentative turn’ this is unavoidable and actually beneficial: something to be harnessed through constructive communication.

> Each way of organising and perceiving: (1) distils certain elements of experience and wisdom that are missed by the others; (2) provides a clear expression of the way in which a significant portion of the populace feels we should live with one another and with nature; and (3) needs all the others in order to be sustainable. (Verweij, *et al.,* 2006, p.821)

Therefore, it is vitally important that they all be taken into account to some degree in the policy creation process (Thompson, 2007 p. 221). With respect to their sustainability, this is not in reference to environmental sustainability (though it could have some relevance), but instead,

> Each way of life undermines itself. Individualism would mean chaos without hierarchical authority to enforce contracts and repel enemies. To get work done and settle disputes the egalitarian order needs hierarchy, too. Hierarchies, in turn, would be stagnant without the creative energy of individualism, uncohesive without the binding force of equality, unstable without the passivity and acquiescence of fatalism. Dominat and subordinate ways of life thus exist in alliance yet this relationship is fragile, constantly shifting, constantly generating a societal environment conducive to change (Schwartz, 1991, p. 765).

The five viable ways of life provide a parsimonious description to describe social interaction that is derived from an explicit theory. Instead of the dualistic fallacies of either/or, (e.g., markets and hierarchies, black and white, right and wrong, et cetera), cultural theory recognizes that each way of life competes with and depends on the others for its viability. Put simply, “Each way of life needs each of its rivals, either to make up for its deficiencies, or to exploit, or define itself against” (Thompson *et al.,* 1990 p.4).

In addition, proponents of cultural theory hold that it can be applied virtually anywhere and can provide functional propositions such as the possible ways people perceive and structure their time (Douglas *et al.,* 2003). With respect to social constructions of time, each of the solidarities has distinct perceptions (Douglas *et al.,* 2003). The Individualist tends to see the long-term as a mere continuation of the short[13]. Hierarchical actors see both the short-term and the long-term, but do not see the latter as merely the continuation of the former[14]. For the Egalitarians, the short term is severely truncated-- it is wonderful if we do learn the errors of our inequitable ways, but the long-term is disastrous if we do not[15]. The Fatalistic actors see no point in doing anything about the long or short term, as there is no point in bothering with something you can do nothing about[16].

In addition to these social constructions of time, each solidarity has distinct styles of information rejection (Thompson and Wildavsky, 1986; Thompson, 2008). The Individualists' information rejection style is that of *individualized manipulative* utilizing his 'connections' to the 'old boys' network' to efficiently sift through information from the periphery of his network so as to center him/herself closer to the most important information, keeping the ball nestled comfortably in the cup.

The hierarchical actors information rejection is characterized as *collectivized manipulative*. Any information that threatens to change their hierarchical structure, change the resistance of the organism and thus transfer their power by questioning the unstated assumptions of the pyramid is diffused and depersonalized. When these types of information surface, though this is rare, they are conveyed in an aura of altruistic self-sacrifice. The sacrifices in turn, keep the ball balanced between the two humps maintained by a secure internal structure of authority.

The Egalitarian's information rejection is characterized as collectivized survival; they focus on defending the boundary, "protecting the soft and vulnerable 'us' from the nasty predatory 'them' by a total rejection of threatening information" (Thompson, 2008, p.65). Given that they do not negotiate or compromise, they only manipulate their own members, but it is not coercive as members willingly joined the

[13] "Myopically, they insist that doing well in the here-and-now is the best guarantee for doing well later on. 'Business as usual' is how complex systems-modellers characterise this individualistic line of action" (Douglas, et al., 2003,p.103)"

[14] "Development in the here and now, they reason, may not be sustainable a decade or two down the road. Their aim, therefore, is to provide a clear descriptions of long-term sustainability and then to intervene in the short term activities of the market actors to ensure that we all arrive safely at the desirable future: 'wise guidance', as modellers call it" (Ibid, p.103)

[15] "Egalitarian actors will tend to be as distrustful of hierarchies as they are of unfettered markets….Radical change now – not business-as-usual and not wise guidance – is what is needed if we are to have a future at all"(Ibid, p.103).

[16] "Those Fatalistic actors who find themselves marginal to all three active solidarities – individualistic ego-focused networks, bounded and hierarchically ranked organizations, and bounded but unranked groups – will see no point in sorting out long-terms and short-terms in this way or that. "If your number's on it," they assure one another, "that's it" " (Ibid, p. 103).

cause to stop 'them' before time runs out. Hence, only radical action in the short term can keep the ball from rolling down either side of the hill in the medium or long term. These four styles are also known as political cultures and are summarised in a table based on Schwarz and Thompson (1990) in Appendix 1.A.

The hermit's/autonomous style of information rejection sees each of the other four ways of life as erring on ignorance. The hermit therefore possesses an unwillingness to go along with any of these four styles. Instead, the hermit's style is that of the storyteller, telling the plural rationality story within a rationality of immediacy. For the hermit, the ball changes the landscape as it moves through it. In essence, the autonomous style sees all systems as connected complex adaptive systems; there are no climax communities but there is great diversity and innovations are a regular feature – equilibria are rare and short-lived, and anticipations change the course of the systems that make up the system(s). The whole is greater than the sum of the parts by virtue of the feed forwards and feedbacks between all elements of the system(s).

This is where cultural theory differs from transaction theory. Thompson (2008) argues that cultural theory is superior because transaction theory assumes humans move towards one global maximum "we start off all over the place and we all end up at the same place" (p. 21), instead of the five solidarities as mentioned above. Thompson borrows an idea from Thom (1972) that ads a dynamical flavour to cultural theory suggesting that the five viable ways of life are attractors in a morphogenic field (Figure 1.7).

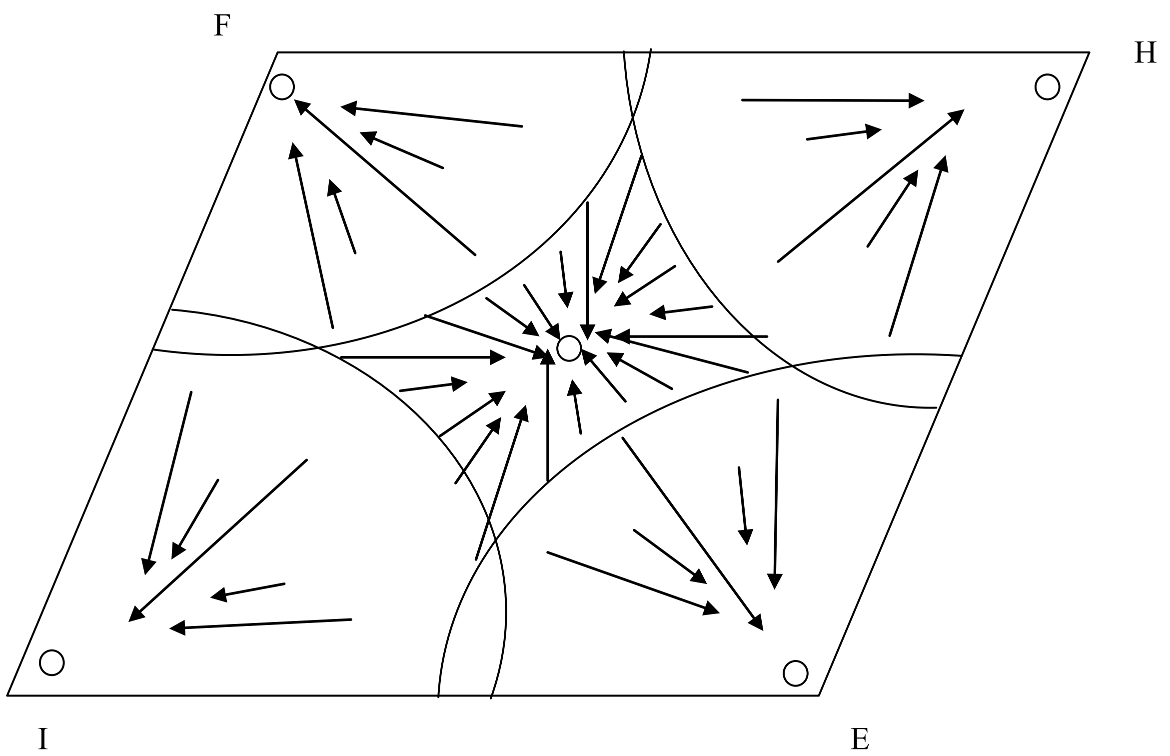

Figure 1.7 The morphogenic field and their separatices (the watersheds between attractors). (Adapted from Thompson 2008)

Each of the solidarities is an attractor attempting to control the others. The central attractor is the hermit/autonomous solidarity, which is equally biased against the other four. Thompson (2008) goes even further borrowing the idea from Nils Lind (See Thompson, 2008, p. 142) of a third dimension to the morphogenic field called Grip (Figure 1.8).

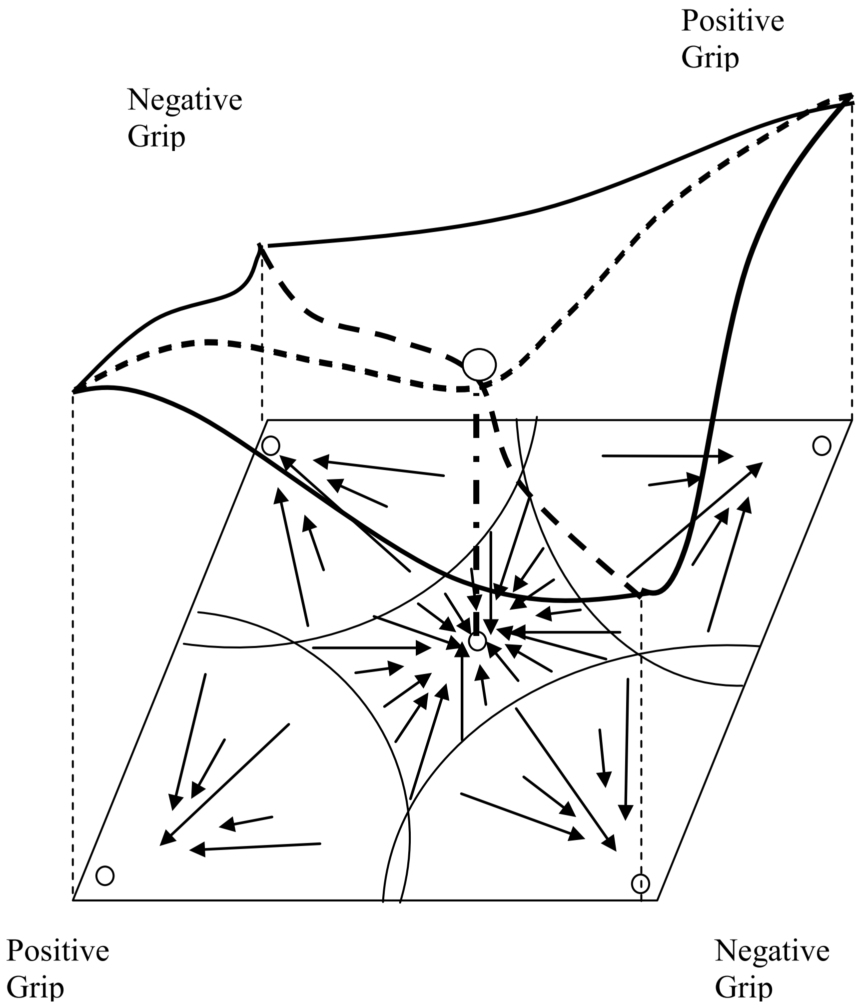

Figure 1.8 The third dimension of sociality Grip .Adapted from Thompson (2008) Note: the hermit zero grip point has also been described as insight by Adams (1995).

Grip is the behaviour space that results from the interactions between the five ways of organising. The Individualist and Hierarchist strategies result in positive grip whereas the Fatalists and the Egalitarians result in negative grip, and the hermit is at the central point *zero grip* (i.e. let the system be what it is; autonomous). Thus, Thompson's (2008) modern version of cultural theory is a dynamic, non-linear, and self-organising framework that has serious implications for emergence within institutions. Throughout the thesis, I will try to demonstrate some of these implications as they relate to the context of alpine ski areas and compounding natural hazards. It is noted at this point that cultural theory is not without criticisms.

1.4.3 Criticisms of Cultural Theory

Cultural theory has been subject to criticism for several reasons including: rigidity, linking risks to worldviews, its functionalist stance, circularity, and its insufficient determinism, and that the myths of physical and human nature may not be linked. First, it can be seen as too rigid and does not take into account how people constantly shift between the four worldviews (Lupton, 1999, Thompson, 2008). Second, risks are inexorably linked to world views and that the difference in world views is the source of differential response to risks, rather than the nature of the risk itself (Lupton, 1999). Third, cultural theory has also been criticised for its functionalist stance. Grimmen (1999) notes that cultural does not distinguish between intended and unintended consequences and that one must be able to distinguish between logical and causal connections. Boholm (1996) levelled criticisms of cultural theory suggesting: people may not be able to choose what they fear, it is circular because it explains ideas by reference to other ideas, and it is insufficiently deterministic in its mode of explanation (6 and Mars, 2008).

An empirical criticism of cultural theory is offered by Grendstad and Sell (2000), who argued that the myths of human nature and physical nature are logically independent of one another. Moreover, Grendstad and Selle (2000) also questioned the compatibility condition disconfirming that the myths appear irrational from the perspective of any of the other myths. Despite these criticisms, they do acknowledge that no other social or even political theory is as committed to integration of the political significance of physical nature, and therefore suggest continued application of cultural theory as a heuristic device.

Recent work on cultural theory has advanced toward a dynamical understanding of ways of life and, in particular, how they can be used (functionally) in developing clumsy solutions (Thompson, 2008). It should be noted that this notion of dynamics is what separates the two main versions of the theory. The first is the stability version attributed to Douglas (1982) that suggests that individuals use the same cultural bias in all areas of life and over time (Langford *et al.,* 2000) and is thus the older (though by no means outdated) grid/group analytical scheme. The second, mobility version attributed to (Thompson 1992; 1990), suggests that individuals select institutions with differing social arrangements in the different spheres of their lives (Langford *et al.,* 2000). Thus, adherence to a particular solidarity is context dependent.

Marris, Langford, and O'Riordan (1998) outlined how the ambiguity between the two versions of the theory has implications for developing a methodology to test the theory empirically (Langford *et al.,* 2000). The stability version suggests cultural biases could be measured in the individual. Dake (1991) devised such a questionnaire and maintained that it was capable of measuring the four cultures and how they related to differences in risk perception (Dake, 1991, 1992; Dake and Wildavsky, 1991). The mobility version, however, suggests the use of qualitative approaches because the cultural biases are context dependent (Gross & Rayner; 1985, Rayner 1985; Rayner & Cantor 1987). Both versions have been criticized for attempting to test a theory on an individual level while taking no account of the social relations, thus missing the grid group dimensions of cultural theory (Boholm, 1996; Douglas, 1986; Rayner, 1992 in Langford *et al.,* 2000). Boholm (2003) provided a critical view of cultural theory by questioning the simplistic idea "that risks are culturally defined and selected" (p.159). Instead, culture is approachable "from a perspective of cognitive theory, and is hence understood as shared schemata that define categories, relationships and contexts, making it possible to process meanings and order information" (Boholm, 2003, p. 159).

1.4.4 Summary of Cultural Theory

Despite criticisms, cultural theory has evolved to a point of effecting a transformation of social sciences where social sciences could be changed. Taking an intellectual risk that circumvents the disputes between methodological collectivism and methodological individualism, a dynamical version of cultural theory instead considers the *dividual*[17] as the unit of analysis, that is, each social solidarity and how it manifests itself in different contexts (Thompson, 2008). This means that the manifestation of each of the five solidarities in any given context provide insights as to how decisions based on *elegant solutions* from one solidarity emerge. Or, if there is sufficient variety from all five ways of life, as socio-cultural viability demands, *clumsy solutions* can be developed based on input from all five ways of life.

[17] "The unit of analysis is the form of the solidarity: the pattern of social relationships, together with the shared set of beliefs and values and the behavioural strategy that is rendered rational by those beliefs and values" (p. Thompson, 2008, p. 141).

As explained earlier, cultural theory, in relation to policy creation and institutions, maybe used as an analytical tool for examining people and culture, and for strategizing. The viabilities offer insight into the ways that people organize their worlds. Though there are many different ways of organising, cultural theory says that in a social organization (i.e., community) there can be no less than five varieties in order for a community to exist over a long term. The five ways of organising provide a framework that helps explain interactions and transactions based on worldviews supported by the myths of nature and corresponding constructions of time, selection of risks, subversive tactics, and critically, the rejection of information (Thompson, 2008).

Cultural theory argues that the purpose of participatory policy development is to achieve a high deliberative quality by incorporating high accessibility with high responsiveness (Figure 1.9)

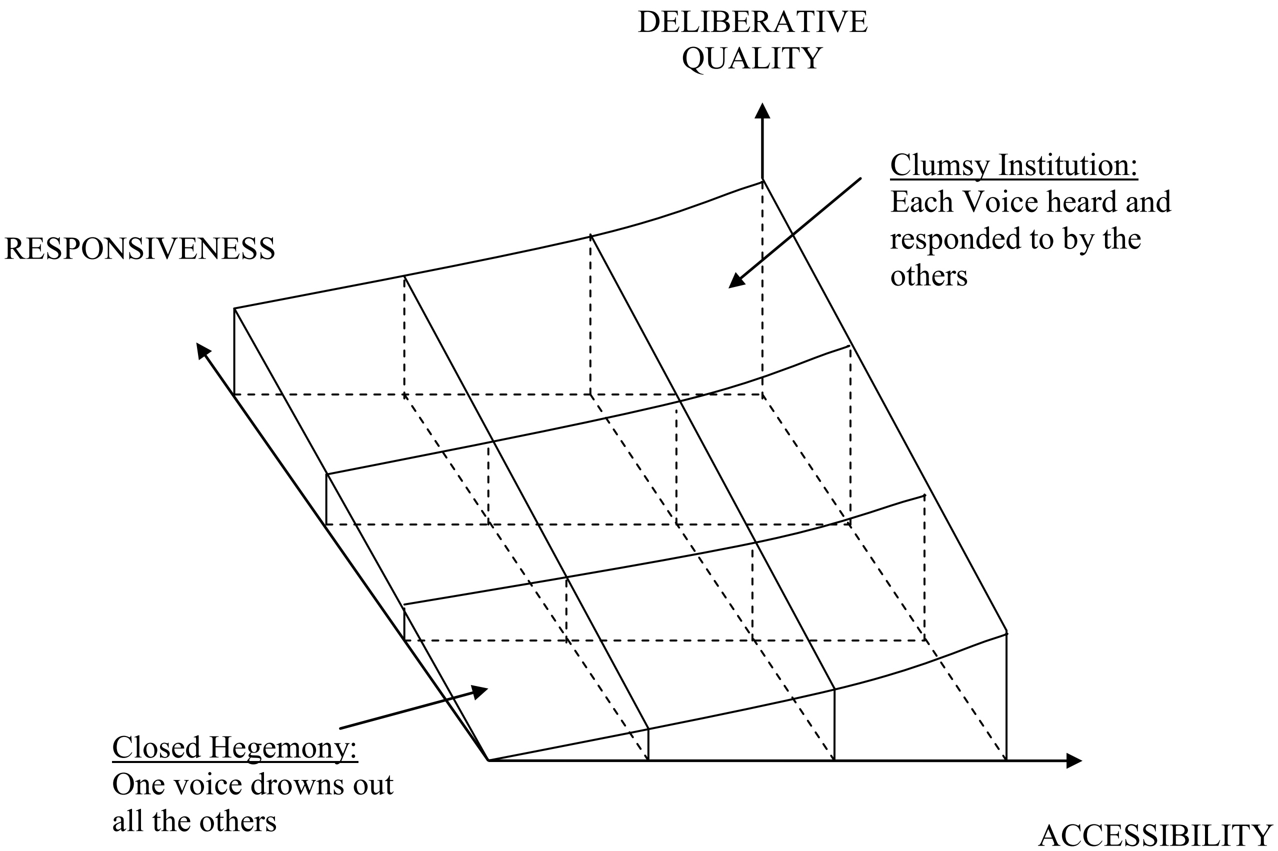

Figure 1.9 The three dimensional refurbishment of clumsy institution (After Thompson, 2008).

At this point in the thesis, it might be worthwhile to re-focus attention on what we are trying to achieve with all the policy frameworks to begin with. Thompson (2008) argues that in moving from elegant solutions based on single solidarities or dualistic mixes of solidarities, we are trying moved towards *clumsy solutions* and thus avoid the “pits” of policy development (i.e., science for policy). The pits exist within a closed hegemony of *elegant solutions* based on one or two solidarities. *Clumsy solutions* involve moving up the hill toward a high deliberative quality by engaging diverse stakeholders to benefit from, at least three, but ideally all five of cultural theory’s social solidarities. As mentioned, one of the great challenges to holistic study of natural hazards is the lack of a transdisciplinary framework. This thesis demonstrates that a development mixed method triangulated approach using cultural theory as a foundation is a useful first step to enhance the viability of human systems in the face of compounding natural hazards.

1.5 Goals and Objectives: Three questions needing mixed methods

> To support sustainable hazard mitigation, researchers and practitioners need to ask new questions as well as to investigate traditional topics. Important efforts will include interdisciplinary research and education, and the development of local hazard assessments; computer generated decision-making aids, and holistic government policies (Mileti, 1999).

The thesis has four key goals. Each of the goals has four overarching questions to be answered and each of the questions has respective process objectives to consider in an attempt to integrate the investigation. The first goal is *to assess the consequences of earthquakes for alpine ski areas* (both informed by empirical evaluation through geomorphic assessment and through social evaluation by asking people’s perceptions of the consequences). The second goal is *to understand how stakeholders of alpine ski areas* (e.g. mountain managers, ski industry workers, and snow riders) *think about the risks associated with natural hazards*, from common hazards, such as severe weather, to more rare hazards, specifically earthquakes. The third goal is *to integrate the mixed methodology using neural networks based dynamical systems simulations to identify opportunities for improving policy and practice.* In order to achieve the first three goals, the study applied an integrated mixed-method multi-site case study viewed from a transdisciplinary lens. A fourth goal that emerged during the writing of the thesis is to apply cultural theory as the philosophical foundation of the thesis. In a methodological sense, the purpose of the thesis is to provide an integrated conceptual framework that functions as an initial step in improving the study of resilience of mountain communities to infrequent (e.g. low probability high consequence) natural hazard events.

To attain the first goal of the research, the following question is asked: What could happen if a high magnitude earthquake affects alpine ski areas? Answering this question requires breaking down the goal into three process objectives:

1) Identify possible consequences of an earthquake in mountain landscapes via geomorphic assessments (GA).
2) Assess different types of ski areas (e.g. commercial and club) to understand differences in development of infrastructure and their respective vulnerabilities to natural hazards.
3) Use the results of the GA to develop interview questions to pose to stakeholders of alpine ski areas.

Hence the starting point for data collections was GA (i.e. field studies) of alpine ski areas to gauge the possible physical consequences of natural hazards. The results from the GA were then integrated into qualitative interviews and the interpretation of the results from simulating policy scenarios of social group fuzzy cognitive maps (FCMs).

The second goal of the research asks the question: How do stakeholders of alpine ski areas perceive the risks of natural hazards (severe weather, avalanche and earthquakes)? Achievement of this goal required the use of semi-structured qualitative interviews to satisfy four process objectives, and involved developing fuzzy cognitive maps to intensify the participants thinking. The five objectives were to:

1) Gather accounts of direct and indirect experiences with natural hazards in mountainous environments (e.g. severe weather, avalanches, and earthquakes).
2) Assemble participants' accounts of experiences regarding preparation, response, and recovery to these specific natural hazards.
3) Collect accounts of participants risk perceptions towards the specific hazards.
4) Organize the data to improve aggregation of participants into social groups, condensation of concepts into similar themes, and simulations of risk scenarios for policy development.

The third goal of the research is where the most significant amount of integration takes place. Hence, a crucial questions of this research is: Can the mixed-methodology be integrated using neural networks based dynamical systems simulations to identify opportunities for improving policy and practice? To assail this question, fuzzy cognitive maps and artificial neural network simulations were used to achieve the following five process objectives:

1) Gather fuzzy cognitive maps (FCM) of participants' perceptions of key considerations for preparation for, response to, and recovery from high magnitude earthquakes that can affect alpine ski areas.

2) Analyze participants' FCM in static form using indices from graph theory.
3) Use qualitative and quantitative methods of condensing and aggregating FCM for policy simulation.
4) Use auto-associative artificial neural networks to run simulations of policy considerations to identify opportunities for improving resilience of people and infrastructure in alpine ski areas to catastrophic natural hazard events.
5) Present the simulation results and comment on the efficacy of mixed method integration.

As mentioned above, the fourth goal that emerged during the writing of the thesis asks the question: Does the application of cultural theory add to the thesis - providing an integrated conceptual framework that functions as an initial step in improving the study of resilience of mountain communities to infrequent (e.g. low probability high consequence) natural hazard events? The process objectives for the fourth goal include:

1) Justify why cultural theory is more valid than other framings.
2) Apply cultural theory to demonstrate the important normative implications of different ways of organizing in the face of natural hazards.
3) Highlight the limitations of cultural theory and suggest how they can be overcome.

1.6 Summary of Goals and Objectives

This section summarizes the introduction and the goals and objectives of the research with an eye to adding purpose to the research and explaining how the chapter fits together to meet that purpose.

As a starting point, geomorphic assessments GA of mountain recreational areas were conducted to gauge the possible physical consequences of natural hazards (Strickert and Davies, 2009, 2011). The results of these GA were then used to develop questions to pose to people in mountain communities regarding their experiences with, and perceptions of mountain hazards. Individual experiences were collected with semi-structured qualitative interviews, capturing accounts of first hand experiences with mountain hazards over a diverse sample of stakeholders. The accounts of experience enable the development of 'horizons' for natural disasters with respect to different perspectives among social groups. The interviews activated memories through eliciting narratives of actual experiences with small- to medium-scale events (severe weather and avalanches) while focusing on applied preparation, response, and recovery. Subsequently, participants' guided the drawing of a fuzzy cognitive map (FCM) (Ozesmi, 1999, 2004) considering earthquakes of high intensity. Although the maps are a static glimpse of participants' mental models, they afford the opportunity to simulate simple scenarios of targeted policy considerations based on participants FCMs

(Axelrod, 1976; Kosko, 1992; Carley and Palmquist, 1992; Dickerson and Kozko, 1994; Palmquist *et al.,* 1997 and Ozesmi, 1999, 2004).

Today, there is a high interest in building resilient communities-through identifying and managing the risks of natural hazards alongside those communities who face compounding hazards first-hand. Alpine ski areas provide a unique context to study this challenging and complex process. The approach commonly taken to manage natural hazards is discipline-centric and focuses on common (e.g. high probability low consequence) natural hazards such as avalanches. While this thesis acknowledges the common approach is rational, it argues that we can extend our communities of practice to include rare (e.g. low probability high consequence) natural hazards such as earthquakes. The dynamically complex nature of these 'rare' hazards limits our understanding about them, but by seeking out the first hand experiences of people in mountain communities and applying them practically in the future, some knowledge can be gained to help improve our understanding of how to adapt. *Humans' adaptability to natural hazards may depend on the collective wisdom contained in the five viable ways of life, as laid out in the dynamic version of cultural theory.* This study focuses on such an approach, within the context of alpine ski areas prone to earthquakes, as a first step toward identifying key policy opportunities for hazard mitigation in general.

The next chapter outlines how we can examine the five viable ways of life within a triangulated mixed methodology for improving our understanding of hazard mitigation in a novel context.

Chapter 2: **Mixed Methodology**

2.1 Introduction

This thesis requires a methodological framework that does justice to transdisciplinary understanding. Hence, highlighting some of the methodological issues for studying complex and uncertain phenomena (e.g., earthquakes) is necessary. Given that such an approach is in an embryonic stage of evolution (particularly *in-situ*), an argument for a self-adjusting triangulated mixed methodology is presented. Then, support for three distinct methodologies is stressed by emphasising integration using a development mixed method triangulated approach. Short reviews of each methodology are sequential, in the order of geomorphic assessments, qualitative interviews, and fuzzy cognitive maps. As well, *in-situ* applications of each methodology are in sub-sections while noting adjustments to each approach. The characteristics of the sample are described. Lastly, a summary and interim discussion of the mixed methodology is provided.

2.2 Mixed Methods and Triangulation

> The best approximation to inferring causal relationships in one-shot field studies of disasters is triangulation. Partly what is meant by triangulation is the accumulation – metaphorically, the piling on top of one another – of more and more field studies until the common finding that runs through all or most of them stands out (Stallings, 2007, p. 64).

Within this thesis, there are four components to the mixed method transdisciplinary approach. The mixed methods chosen were an attempt to integrate different types of knowledge and information that can build upon each other through triangulation. The data collected in this study were gathered using an adaptive and triangulated methodology. Methodological triangulation is the use of multiple methods to study a research problem (Tashakkori and Teddlie, 1998). This study demonstrates *methodological triangulation* (Denzin, 1978) using a *development* mixed method approach (Green *et al.,* 1989) that identifies, analyses and evaluates the risks, and identifies possible treatments for those risks within an integrated framework. A development mixed method approach applies different methods sequentially, such that the first method informs the second, and so on (Green *et al.,* 1989). Triangulated methods can enable the weaknesses of one method to be offset by strengths of the others (Jick, 1979). Simply put, the analysis involves an integrated set of tools in a conceptual framework that helps identify policy opportunities for mitigating contextually relevant natural hazards.

The evaluations of risks in this study are based on naturalistic inquiry. Naturalistic inquiry sees the researcher as an adaptive instrument in a naturalistic setting, which requires flexibility in research design (i.e., Guba, 1981; Erlandson *et al.,* 1993 in Phillips, 2002). The adaptive nature of the researcher is didactic within an adaptive management paradigm. Naturalistic inquiry occurs in a natural setting (e.g. non-control environment), and depends upon the researcher's tacit knowledge. Changes to the research design are justifiable when the investigation is novel, the context demands it, and the researcher acknowledges adjustments that make sense.

In the first component of the methodology, the hazards in this study were evaluated via geomorphic assessments. The primary motivation of the geomorphic assessments was to identify lines of inquiry for integration of qualitative interviews and fuzzy cognitive maps into the mixed method framework. The qualitative interviews help harness value judgements of exposed objects and lives via experience with smaller scale hazards, while the FCMs allow simulations of perceived vulnerability or resilience of exposed objects to earthquake hazards.

This chapter provides an explanation of how the methods were undertaken in context. Each section will provide an explanation of the respective methods in a more general sense. The first component of the mixed methodology, geomorphic assessments, is presented first. Here, the application of small-scale hazard assessments is explained in context to address the first key goal of the thesis: *What could happen if a high magnitude earthquake affects alpine ski areas?* These are tied to the next component of the methodology, qualitative interviews.

The integration of qualitative interviews begins with a brief introductory summary of the results from geomorphic assessments. This compares the perceptions from 'expert' assessments of the consequences of earthquakes for alpine ski areas to triangulate the perceptions of lay-experts. The second goal is to answer the question, "*How do stakeholders perceive the risks of natural hazards (severe weather, avalanche, and earthquakes) in alpine ski areas?"* To approach this question, a deeper explanation of how qualitative interviews can capture narratives is provided. It outlines how smaller events are used to draw out perceptions (inferences on preparation for, response to, and recovery from) larger earthquake events that are rare. As well, the application of an adaptive method of data gathering is presented, outlining three situated approaches to semi-structured interviews. Next, an interim discussion on the multi-level integration of qualitative interviews is presented. Included in this discussion are such topics as: increasing consideration of events beyond worldviews; identifying emergent social groups for simulation; categorising participants accounts into archetypes of cultural theory for aggregating social groups; and adding qualities to critical themes (e.g. inferences on preparation for, response to, and recovery from earthquakes in ski areas) in participants' fuzzy cognitive maps.

The third section of this chapter deals with the application of fuzzy cognitive mapping (FCM), presented here as a central component of the methodology for enabling grounded simulations of policy scenarios. It begins with the justification for adapting the multi-step FCM approach of Ozesmi (2004) toward a problem focused FCM (Strickert *et al.,* 2009). Next, the application of the problem-focused FCM is explored in detail. The explanation of FCM prepares the reader for understanding the third goal of the thesis: *Can the mixed-methodology be integrated using neural networks based dynamical systems simulations to identify opportunities for improving policy and practice?* The simulations are based on FCM, thus the third section aims to provide a foundation for the before the simulations are provided in Section 2.2.6.3. Lastly, the chapter presents an interim discussion on the mix of methods outlining themes for the final discussion, which reflects on objectives, limitations, challenges and possibilities for integration, as well as suggestions for future approaches.

When using triangulation, selecting appropriate units of analysis can be challenging. However, as mentioned in Chapter 1, cultural theory is concerned with the *dividual*[18] as the unit of analysis. This means that each method will present results while highlighting how the five social solidarities are evident. A considerable challenge in this regard is to recognize that the results are a product of social solidarities, that is, the interpretation of the results will infer particular social constructions of nature, cultural biases, as well as implied behavioural strategies and social relations.

2.2.1 Overview of Integrated Mixed-Methodology

> The complex nature and structure of natural disasters …transcend the exact methods associated with traditional 'hard' sciences. In order to take into account all these factors, high levels of complexity and uncertainty, 'softer', and more flexible methods and tools are required (Weichselgartner, 2001, p.87).

Initially, several ski areas were visited during the summer season to conduct geomorphic assessments to determine the possible consequences of earthquakes with respect to topography, geology, social consequences, and infrastructure. The assessments helped develop targeted questions for qualitative interviews and inferences for scenario simulations. Subsequently, between January 2007 and February 2009, qualitative interviewing of stakeholders in the ski industry in both New Zealand and Canada was undertaken. The interviews consisted of semi-structured qualitative interviews and fuzzy cognitive maps (FCM). This study adapted the multi-step fuzzy cognitive mapping approach (Ozesmi and Ozesmi, 2003). Participants developed an FCM of the critical variables (important considerations) of preparation for, response to, and recovery from an earthquake that has a direct effect on the ski areas. Specifically, once they identified critical variables, their attention shifted to a series of questions about their experiences with natural disasters in general and then about experiences with severe weather, mass movements and earthquakes in alpine ski areas. Perceptions are implied through first-hand recounting of experiences. The questions intensified their thinking about a scenario, which, as many interviewees reported, they had never considered. The semi-structured interview also enabled the researcher to explore participant's expert knowledge and experience *in situ*. Once the questions were complete, the interviewer returned to the FCM, asking if they wanted to add any more

[18] "The unit of analysis is the form of the solidarity: the pattern of social relationships, together with the shared set of beliefs and values and the behavioural strategy that is rendered rational by those beliefs and values" (p. Thompson, 2008, p. 141).

variables. Once satisfied with their selected variables, they were asked to assign critical connections using positive negative neutral calculus (Kosko, 1986), with strength values in the range of [-1, 1] (-1 indicates a strong negative effect and +1, a strong positive effect).

This study proposes the use of FCM for capturing the perceptions of experts and lay-experts (stakeholders), and using auto-associative neural networks (Kosko, 1986, Reinman, 1998); these are also known as neural calculus methods (Ozesmi, 1999). This enables simulation of policy scenarios based on a natural hazard context using FCM. The analysis of scenarios can be made at the level of the individual, stakeholder group or combined social group cognitive maps. In the past, mitigating natural hazards was often equated with managing physical phenomena. Recently, there has been a significant shift toward managing social phenomena in order to mitigate natural hazards. The approach suggested here demonstrates the benefits of social research in providing a better understanding of stakeholder perceptions, as a means of assisting in the development of human-adaptive policies. One of the theoretical underpinnings of this problem-focused mixed-methodology, is an attempt to apply sustainable hazard mitigation (SHM) on a practical level within the research agenda. The holistic application of SHM in this context requires engaging stakeholders' horizons for policy development.

In a broader context, the mixed-method approach fosters stakeholder participation in the development of policies for sustainable hazard mitigation, by way of integrating three distinct methodologies: assessment of the physical context of hazards (geomorphic assessment); qualitative interviews, with the aim of developing fuzzy cognitive maps (FCM) that capture the perceptions of stakeholders involved; and auto-associative neural networks (AANN) for simulating policy scenarios based on the FCM. Results of the policy simulations may then be communicated to stakeholders in order to experiment, adapt policies and gauge confidence in the options to advance policy development. The fuzzy cognitive maps provide the researcher with an understanding of stakeholders' perceptions, and in turn provide stakeholders with increased confidence in the process of developing policy/management plans, as well as a sense of ownership and support for the plans that eventuate. The simulations add value to the adaptive management paradigm in three ways: 1) they identify similarities and differences in the perceptions of stakeholder groups, 2) they test policy options that are linked to stakeholders' perceptual models, and 3) they develop targeted policies that exploit the synergies and contradictory certainties between various stakeholder groups.

2.2.2 Geomorphic Assessments

Geomorphic assessments may be used as rough estimates of the physical consequences of a particular event on an environment (Strickert *et al.,* 2009; Korup, 2004). They bring the researcher out of the laboratory, enabling them to use their senses, their perceptions and their experience while subjectively assessing the possible consequences of a particular hazard *in-situ*. In this case, these assessments estimate the possible consequences of an earthquake on mountainous environments, such as slope-related hazards, loss of critical lifelines and impacts on infrastructure (Davies, 2006, pers.com.). As a starting point, assessments can describe how an area might change as a result of a natural hazard event. For example, an earthquake in a mountainous area can cause any isolated or combination of Sturzstroms, landslides, avalanches and rock fall (Sharpe, 1960; Varnes, 1978; Bulter, 1998; Kalvoda, and Roesenfeld, 1998; Bulter, Malanson,Wilkerson, and Schmid, 1998; Saunders and Glassey, 2007).

The first inferences are common sense, but moving toward deeper investigation requires experience and knowledge of both possible consequences and the physical context where events are likely. The level of depth pursued is contingent upon available resources, knowledge, time, and the research problem. If knowledge of the event and context are limited, seeking external expertise may require considerable expenditure and time, and should be undertaken only if it is essential for the research problem. The assessments lie on a continuum between *superficial* (i.e., looking for generic and emergent consequences across similar landscapes), and *intense* (i.e., specialized investigations of a particular hazard limited to one area such as geotechnical investigations).

2.2.3 Geomorphic Assessment *In-Situ*

> Geomorphologists are working to fill gaps in knowledge of the physical aspects of individual hazards, but use of the information by social scientists will only occur if information is presented in a format that is useful to them (Gares, Sherman, and Nordstrom, 1994).

This section presents the processes of geomorphic assessments as a component of a mixed-methodology for gauging the impacts of high magnitude earthquakes for alpine ski areas in New Zealand. The focus of this section is to explain how geomorphic assessments were undertaken to identify possible consequences resulting from earthquakes of high magnitude (i.e. >MM7[19]). The application of geomorphic hazard assessments are explained in context to address Objective 1 of the thesis: *What could happen if a high magnitude earthquake affects alpine ski areas?*

As a starting point, before beginning to interview and construct FCMs with stakeholders, several ski fields were visited to conduct assessments of the geomorphic consequences of natural hazards, such as slope related hazards and meteorological hazards, though the centre of attention was the possible consequences of earthquakes. In order for these areas to be accurately assessed, they were visited during the summer to enable viewing the topography, superficial-geology, and infrastructure when not covered in snow. The following areas and ski fields were visited during the summer to conduct geomorphic assessments: 1) the Mt Hutt Range and Mt. Hutt ski area (bottom), 2) the Craigieburn Range and Porters ski area, Mt. Cheesman ski area, Broken River ski area, Cragieburn Valley (Middle) ; and Temple Basin (Top) (Appendix).

The assessments conducted on these areas were superficial and not based on detailed measurements; rather, they used a naturalistic approach to develop inferences similar to those that may be present in stakeholder perceptions of natural hazards. The inferences do not represent probabilities, but instead perceived consequences of an earthquake. The assessments are based on expert intuition, which may overestimate or underestimate dangers.

The initial plan for assessing the ski areas was to use Geographical Information Systems (GIS) to conduct computer-based risk assessments. However, during the PhD proposal seminar, an advisor outlined the possible limitations of GIS. The limitations were threefold. First, the resolution of available data for the areas in question is not nearly sufficient. Second, the scales of the individual ski areas are not quite large enough for GIS to provide meaningful assessments. Lastly, the data in available GIS layers would not provide the details required for risk assessments because Digital Elevation Models are quite crude raster data at 25x25 metres. Furthermore, the vector data from Land Resource Inventory New Zealand, which provides geological data, are better for regional assessments, again a problem of scale. Aerial photographs of research areas were also not available to the researcher, and

[19] This means earthquakes above seven (VII) on the Modified Mercalli intensity scale, defined as “General alarm”. Furniture and appliances may be shifted and unstable items overturned. Unreinforced stone and brick walls cracked. Some pre-earthquake code buildings damaged. Roof tiles may be dislodged. Many domestic chimneys broken. Small falls of sand and gravel banks. Some fine cracks appear in sloping ground and ridge crests. Rock falls from steep slopes and cuttings are common. A few small to moderate landslides (e.g. 1000 to 10,000m^3) occur on steeper slopes. Some instances of liquefaction at susceptible sites” (Forsythe, et al., 2003)

the digital photo program KiwiImage[20] had not yet begun. Moreover, the capture plan for KiwiImage will cover areas of interest quite late in the process. Hence, a better approach to assessing the risks, or more appropriately "gauging the possible consequences of earthquakes…is simply to go out there and have a look." (Tim Davies, Pers.Com. November 2007). It was determined that the best approach would be to get permission from the ski areas to access the site for conducting geomorphic assessments.

Permission to access the site was requested via telephone (Appendix 2.A). Only one site declined participation. The others were very accommodating, providing keys to locked gates, point of contact, and helped with sampling by suggesting key people to help with later stages of the research. The ski areas were accessed via a four-wheel drive vehicle. This enabled greater coverage of areas in a shorter time, and extended the assessment area to include the access road. Upon reaching the main ski area, the vehicle was substituted for hiking, which facilitated better viewing and use of the senses. Digital photographs of sites were taken. The photographs helped capture high-resolution pictures of the overall site characteristics as well as key vulnerabilities. Field notes were taken in a notebook. Discussions of assessments also occurred on site and during post trip meetings.

After conducting the first two field assessments, the principle researcher and his advisors felt he had a good handle on assessments and could conduct further assessments alone. As a safety precaution, assessments were always conducted with at least two people. Further safety precautions included a three-day survival kit, route plan and intentions left with colleagues, and always making sure to carry avalanche transceivers.

Geomorphic hazards are examined according to how changes to a landscape affect human systems (Gares *et al.,* 1994). One format for assessing natural hazards involves identifying the hazard according to seven physical parameters established by Gilbert White and his colleagues: magnitude, frequency, duration, areal extent, speed of onset, spatial dispersion, and temporal spacing (Gares *et al.,* 1994). However, as there is a high level of complexity associated with the consequences of an earthquake in alpine areas, knowing all of these parameters is not possible. Therefore, a different way to consider the consequences is to infer what impacts an earthquake could have on a specific area. It is for this reason that written descriptions of hazard possibilities were used. These descriptions also served to

[20] KiwiImage is a data capture project of New Zealand to support research in GIS by providing up-to-date high resolution aerial photographs.

provide rich details to use as examples for explaining the simulation results in an accessible manner.

It is useful at this point to highlight some of the knowledge on geomorphic hazards that are contextually relevant. Some mass movements are earthquake-induced, such as those that occurred during the 1888 Hope and 1929 Buller (Murchison) earthquakes (Rattenbury *et al*., 2006). In addition, during the 1994 Arthurs Pass earthquake (Mw 6.7)[21], a portion of the Otira Gorge collapsed blocking Highway 73 for nearly a week and partially damming the Otira River (Paterson and Bourne-Webb, 1994; Paterson, 1996; Bateman 2008). The largest coseismic[22] rock avalanche in historical times has been aptly named the Falling Mountain rock avalanche. Not noticed for two years until it was discovered by hikers, it occurred during the March 9, 1929 Arthurs Pass earthquake (Mw 7.8). The avalanche itself was estimated at shifting 60 million cubic metres down the Otehake River for 5 kilometres. The 1929 earthquake blocked roads and railway-lines to the west coast for months (Bateman, 2008).

The Craigieburn Range of New Zealand has been subject to large magnitude earthquakes on the Porters Fault prior to colonization. For example, the Ryton Valley rock avalanche, within the vicinity of four ski areas, was initially thought to be a single avalanche (Whitehouse, 1981). Later investigations, however, discovered two distinct avalanche events, which occurred approximately in the years 1422±96 and 1632±55 (Orwin, 1996). Correlations of the Ryton Valley rock avalanches with other events on the South Island show that there was a regional seismic event occurring between 1400 and 1500 (Burrows, 1975; Whitehouse, 1981; Whitehouse & Griffiths, 1983; Cowan *et al.,* 1996; Bull, 1996). A photograph of the Ryton Valley rock avalanche is shown in Figure 2.2.

[21] Mw denotes moment magnitude, a scale developed for severe earthquakes that takes into account both the energy released and the amplitude of an earthquake.
[22] Coseismic means induced by seismicity or an earthquake.

Figure 2.2 Ryton Valley rock avalanche. Photo taken from top of Porters Ski Field. (Photo: Graham Strickert, August 2007)

There are thousands of earthquakes in New Zealand every year, though the vast majority of them are too small to be felt. Some, however, can be large enough to have significant consequences for people and infrastructure. Despite their potential for destruction, each of these events has helped improve our understanding of the earthquake hazards in New Zealand and elsewhere. Furthermore, cumulative knowledge outlines that when the earthquakes occur in mountain areas there can be significant geomorphic consequences in the form of landslides, rock fall, and avalanches (Keefer, 1984; Rodriguez *et al.,* 1999, Irwin *et al.,* 2002).

A salient example of these consequences occurred on June 19th, 1994, when the Porter Heights Ski Area tragically lost their grooming machine driver to a co-seismic (earthquake triggered) avalanche (Irwin *et al.,* 2002). The earthquake was centered near Lake Coleridge and measured 4.5 on the Richter scale, an aftershock from the magnitude 6.7 Arthurs Pass earthquake that occurred one day earlier. The initial 6.7 event did not appear to have triggered avalanche activity. The combination of wind loading of heavy snow and the ski field's close proximity to the aftershock caused a size III avalanche (capable of burying a car and breaking trees) that flipped a snow groomer, crushing and killing its driver (Figure 2.3).

Figure 2.3 Flipped snow grooming machine.
(Source: New Zealand Mountain Safety Council, 1994)

If this avalanche had happened without people and infrastructure in harm's way, it would not have been a hazard, merely a natural process. This hazard event is also a prime example of compounding natural hazards. Each hazard (the wind, the snow pack, and the earthquake) considered in isolation might appear to be of low risk. However, when these hazards compound and mix with technological hazards (manufactured risks) the consequences, as this case indicates, can become severe.

In summary, the geomorphic assessments are a naturalistic approach to identify risks and natural hazards caused by earthquakes possibly resulting in disasters or catastrophic natural events. Risks embody the concepts of probability and magnitude, but do not insist that they be precisely knowable, rather, in order to navigate the sea of uncertainty, risks are broadly defined as unquantifiable danger and exposure to mischance or peril (Adams, 1995). *Natural hazard* is the potential threat from natural processes (e.g. geophysical, hydro-meteorological, and mass movements) that, when realized, will have consequences for people and infrastructure possibly resulting in a natural disaster. A *natural disaster* is the actualization of a natural hazard where severe consequences compromise the ability to respond resulting in loss of people's lives and damage or disruption to infrastructure. A *catastrophic natural event* occurs when the actualization of a natural hazard causes a natural disaster but also exceeds the ability to recover, resulting in a change of equilibrium from a desired domain of attraction to a new equilibrium where efficiency and/or existence of function are compromised.

The results of the geomorphic assessment will help to develop a sequential line of inquiry for conducting qualitative interviews to gather peoples' experiences and perceptions of natural hazards, natural disasters, and catastrophes.

2.2.4 Qualitative Interviews

> We can presuppose that humans have interviewed each other in some form or other for as long as they have mastered the use of language (Given, 2008, p.471).

Qualitative interviews provide rich data about peoples' experiences, perceptions, and worldviews. Qualitative interviews attempt to understand the world from the subjects' point of view, describe the meaning of peoples' experiences, and to uncover their lived world (Kvale, 1996). The quotations from the interviews reveal the way participants have internalized the world including their thoughts about what is happening in their world, their experiences, and basic perceptions (Patton, 1987). Qualitative interviews may also facilitate the development of FCM, particularly if the research problem is one that participants have never considered (Strickert *et al.,* 2009). In such cases, qualitative interviews may help intensify the thinking of participants prior to developing an FCM.

2.2.4.1 Qualitative Inquiry and Natural Hazards & Disasters

Despite their long history, qualitative interviews have received a great deal of criticism (Kvale, 1996; Patton, 1987, Patton, 1990; Sewell, n.d.).

> I'll never forget the reviewer who recommended that I get rid of "all those interview quotes." I always include interview quotes so that the reader can assess my findings and to help practitioners use them in making connections with their own situations. … My favourite review experience came a few years ago when one reviewer remarked, '[T]his would be a good project if only it was quantitative… (Stallings, 2006, p.197-198).

Phillips (2002) also notes some of the perceived weaknesses of qualitative interviews, stressing that some believe qualitative interviews are generalizable beyond the context under study. Yet, as Lincoln and Guba (pioneers in the modern approaches to qualitative inquiry) point out science grows through the accumulations of generalizable knowledge and generalizable knowledge may not even be desirable. An alternative to generalizable knowledge is to bound the study "within a deep contextual foundation emphasizing the time, place, and circumstances within which a disaster event, and response process occurs (Phillips, 2002, p. 199)". This may work in the case of disasters as they have occurred at a specified time, place and cause consequences which are measurable both in experiences and quantifiable consequences.

Natural hazards, especially unpredictable and rare ones, are much trickier. They have not happened at a specific time or place, and consequences can be different for different times and places. Thus, establishing a benchmark for 'bounded rationality' is difficult. However, the consequences of some hazards may be similar in their effect(s) on a given place. For instance, severe weather can affect people's experiences through loss of lifelines, consequences for landscapes, and increased awareness that coping mechanisms are needed to be able to adapt. In essence, the biggest challenge in natural hazards research is how to develop a framework to prepare for natural hazards, so that we may lessen their impact when they occur so as to avoid disasters. All too often, humans adapt to hazards post hoc. That is, after a hazard is actualized causing a disaster, reactive mitigation policies are rushed into place, and are often resistant to future adaptation (Mileti, 1999, and Mileti, 2006, pers.comm,). Qualitative interviews may facilitate thinking about strategies and policies for managing natural hazards, in an attempt to be proactive. A great deal of qualitative research in the hazards/disasters fields centres on inquiry into disasters, which by necessity has to occur after the fact.

It is interesting that qualitative inquiry is older than most scholars may realize, and some of its origins were in disaster-related research. Qualitative interviews have a rich and well-established history within disaster research (Phillips, 2002). The unofficial title of 'pioneer of disaster research' lies with Samuel Henry Prince (1920), who conducted an in-depth analysis of the Halifax ship explosion of 1917. Though Prince's work was not recognized until much later, he laid the theoretical foundations and position of inquiry for current disaster scholarship. His work is also significant enough to be described as "an application of 'grounded theory' ahead of its time (Drabek, 1986)", though Scanlon, who performed an examination of Prince's work, claims that the evidence does not support such deduction. Instead, Prince's basic thesis was theological:

> There are many lessons man will never learn unless he is taught in the school of pain…a world without suffering would be a world without nobility. (Excerpts from Prince's Titanic Sermon, in Scanlon, 1987, p. 225)

Though he may not have explicitly used grounded theory, Prince was indeed ahead of his time (Scanlon, 1987). Prince described social change as,

> …those rapid mutations which accompany sudden interferences with the equilibrium of society, break up the status-quo, dissipate mental inertia and

> overturn other tendencies resistant to structural modification (Prince 1920, p.15, in Scanlon, 1987, p. 226).

Furthermore, through *abductive reasoning,* Prince provided a theory of social change holding that society's conservative nature,

> …will go only if there is some sharp jolt (precipitating event) such as a disaster, that if that happens there is a state of fluidity opening the way to social change. Change is not necessarily positive: "the subject may 'fall up' or he/she[sic] may 'fall down'"(Prince, 1920, p. 19, in Scanlon 1987).

But perhaps his most profound statement that reverberates wisdom associated with hazards and disasters is,

> Under the stimulus of catastrophe, necessity becomes the mother of invention… (Prince, 1958, p. 110).

Prince's statement has been proven in the narratives of many conquests throughout history. Arguably, we can move out of a somewhat fatalistic viability, back-casting through so many catastrophes where learning (i.e., invention), whether technological, social or policy oriented, takes place only after disasters or catastrophes.

Qualitative inquiry within disasters and hazard management has ebbed and flowed. Phillips (2002) provides a historical review, and explains that the support for qualitative methods in hazard sciences was dominated by anthropology, sociology, political sciences, and psychology. However, with the rise of public opinion polling in the 1940s and 1950s, the qualitative inquiry was viewed less favourably. Its re-emergence came when Glasser and Strauss published their seminal work Awareness of Dying (1965), and then accomplished a qualitative first by explaining their work in detail in The Discovery of Grounded Theory (1967). A schism between Glasser and Straus sparked renewed interest in qualitative methods, and other pioneers provided viable pathways (Lofland 1971; Schatzman and Strauss 1973; Schwartz and Jacobs 1979; Spradley 1980 in Phillips, 2002). From the 1970s to the 1990s, several journals dedicated to qualitative methods of inquiry were established and remain influential; importantly, the challenges for qualitative research in general and within the discourse(s) of hazards and disasters offer many opportunities. Chief among these opportunities, I believe, is linking qualitative methods with quantitative methods to derive benefit from modelling and simulation tools.

The goal of this component of the research was to understand how people in mountain communities, and specifically, alpine ski areas, think about natural hazard events. The aim is to contribute rich and grounded data for building industry policy opportunities and general community preparedness. A further goal of this research is to develop a methodology that could link qualitative data with fuzzy cognitive maps and contribute ‘soft’ data to neural network simulations of policy considerations. Due to the requirements of these tasks, this study needed to be carried out using not just cognitive map data, but actual discourse of the participants’ in order to accurately describe the context. Qualitative interviewing allowed for the required detail without divorcing the data from the process that created it.

The application of the qualitative interviewing method is described below. This chapter then describes sampling considerations, and the categorization and identification markers for participants. The chapter ends with an explanation as to how qualitative interviews and the subsequent results were integrated into the qualitative data from the cognitive maps and the results from simulations of policy scenarios.

2.2.5 Qualitative Interviews: Application *in situ*

Prior to any data collection, this study was assessed by the Lincoln University Human Ethics Committee (HEC). The application detailed confidentiality, security of data, obtaining informed consent of participants, and the explanation of their rights throughout the study. The application also included the telephone scripts used to arrange interviews with managers, which included the acquiring of permission to conduct interviews with staff and clients at their facility (Appendix 2.B). Once the managers agreed to participate in the interviews, they were mailed or emailed a research information sheet; an informed consent document and permission form (See Appendix 2.C). When devising the line of questions for the interviews, I also sought to ensure that my questions and probes used accessible terminology, and reflected possible scenarios as established through geomorphic assessments. Thus, questions needed to reflect participants experiences with common hazards (e.g. severe weather, and snow avalanches), as well as rare hazards (e.g., debris flows, rock avalanches, landslides and earthquakes).

The interviews were conducted in three different ways depending on the amount of time participants could devote to an interview. One type of interview was comprehensive; it included a full-length interview and fuzzy cognitive mapping exercise (See Appendix 2.D). The second interview type was an in-depth interview without the fuzzy cognitive mapping exercise, hereafter referred to as ‘partial’ interviews (See Appendix 2.E). The third was a condensed interview with only key questions to elicit themes that were common in the fuzzy cognitive mapping exercise in the full interviews (See Appendix 2.F).

The interviews were recorded on an Olympus DS-2300 digital voice recorder. Recording the interviews allowed for transcription and audio review, followed by open and thematic coding. Several interviewing policies were used to ensure that participation was not too disruptive to people's recreation or employment. At the beginning of the interview, participants were asked how much time they could allot to the study. This enabled the interviewer to select the appropriate interview as comprehensive, partial or short. Since optimal skiing conditions (i.e., 'powder days') are infrequent, participants were not recruited on these particular days as they could interfere with the enjoyment of the stakeholders and undermine the researcher's rapport and reputation in a small community. At the beginning of the research project, one participant exclaimed, "Are you kidding? An hour…on a powder day? Good luck!" The duration of the interviews were also limited to one hour and fifteen minutes when conducted during the day at a ski area, since the interviews also hinder the ability of participants to do their jobs. Ski patrollers, for example, were called out for rescues during three interviews and mountain managers often only allotted 45 minutes for the interviews. As for ski area patrons, they also wanted to 'get their money's worth' out of the day; as a result, several of their interviews were organized during the day, and then conducted after hours in ski lodges.

When really pressed for time, participants were asked targeted questions in a condensed interview focusing on key questions and identified the concepts/variables (i.e. key considerations of preparation for, response to and recovery from earthquakes). In most scenarios, participants were interviewed on site in order to elucidate responses that were grounded in the context and experiences of the respondent's worldview (*in situ*). However, the human ethics committee review prohibited interviews taking place on ski lifts as this could rouse fear in participants, given the topic of investigation, and also it would invariably make it impossible to escape from the interviewer for the duration of the lift ride (HEC, 2007).

The other ethical issues considered before conducting interviews included confidentiality, informed consent, risk assessment, promises and reciprocity, data storage, and interviewer mental health and personal safety. In addition, an environmental policy and a hazard management plan were developed and implemented during the data collection. The interviews were all conducted in accordance with the Lincoln University Human Ethics Committee guidelines. The project received approval in December 2007, and investigations proceeded shortly thereafter.

Qualitative interviews for research have a number of disadvantages: interviews may prove to be more intrusive and time-consuming to participants than are quantitative approaches; participants may say more than they intended to say, and later regret having done so; and participants may be more reactive to personalities, moods, and interpersonal dynamics between interviewer and interviewee than methods such as surveys. Furthermore, conducting interviews can be expensive and time-consuming, because qualitative interviewing requires considerable skill and experience. As the principalresearcher, I had neither. Furthermore, analysis and interpretation of qualitative interviews can be particularly time-consuming. In addition, qualitative interviews are more subjective than quantitative methods because the researcher decides which quotations or specific examples to report (Kvale, 1996; Patton, 1990; Creswell, 2003). The research information sheets, questions, tone of voice and demeanour of the interviewer can have a framing effect on participants' responses. The framing effect is a cognitive bias that results from presenting the same questions in slightly different formats that can alter people's responses (Kahneman and Tversky, 1982). Due to these factors, attempts were made to be as consistent as possible during the interviews and remain alert to both the respondents, and my own fatigue and biases.

Despite these limitations, qualitative interviews provide rich data about peoples' experiences, perceptions, and worldviews with respect to a given phenomenon. In order to add meaning to the variables indicated by respondents as key for preparation for, response to, and recovery from natural hazards, semi-structured interviews were conducted alongside the drawings of cognitive maps.

Creswell (2003) explains that qualitative interviews may be used as an exploratory step before designing more quantitative, structured methods (i.e. surveys, questionnaires, etc.) to help determine the appropriate questions and categories. Qualitative interviews also facilitated the development of FCM, particularly because the research problem is one that participants have rarely considered (Strickert *et al.,* 2009). In such cases, qualitative interviews may be used to intensify the thinking of participants prior to developing an FCM.

2.2.6 Fuzzy Cognitive Maps

Fuzzy Cognitive Mapping (FCM) are symbolic representations and can serve as a qualitative model of how a given system operates and thus can provide a potential framework for understanding decision-making and conceptions of complex systems (Ozesmi and Ozesmi, 2003, Craiger *et al.,* 1996; Dickerson and Kosko, 1994; Kosko, 1986). Furthermore, “Cognitive maps can serve as a basis for discussion when policies and management options are formulated” (Ozesmi, 1999, p.144). Cognitive maps have been used as a decision aid for complex social systems (van Vliet *et al.,* 2010; Ozesmi 2006; Ozesmi 2004; Ozesmi and Ozesmi 2003; Ozsesmi, 1999; Brown 1992; Carley and Palmquist 1992; Cossette and Audet 1992; Klein and Cooper 1982; Nakamura *et al.,* 1982; Bougon *et al.,* 1977; Axelrod, 1976; Bauer, 1975).

Ozsemi and Ozsemi (2003) provide a succinct historical overview of FCM. The lineage of fuzzy cognitive maps can be traced to directed graphs or digraphs, which are products of graph theory, which began with Euler in 1736. (Briggs, et. al, 1976; Ozesmi, 2004). Advances that are relevant to this dissertation begin with Axelrod (1976). Though Tolman (1948) was the first to use the term cognitive map, Axelrod (1976) used cognitive maps to capture causal relationships among variables described by lay-experts (i.e. people) rather than experts (i.e. researchers). The transformation from binary cognitive maps to fuzzy cognitive maps (FCM) was made by Kosko (1986). In the latter, connections (i.e. weights) are fuzzy causal functions with any real numbers in the range [-1, 1].

Fuzzy cognitive maps have proven to be a participatory method that is easy to use and understand in a short period of time, and an FCM “provides a structured, semi-quantitative understanding of the system perceptions of a group of participants” (van Vliet, *et al.,* 2010, p.1). Moreover, FCMs are recognized as a useful and flexible technique to assist problem solving where many decision variables are causally interrelated (Stach, Kurgan, and Pedrycz , 2010). FCMs use an expedient graphical representation based on nodes (i.e. concepts) and weighted casual edges/archs (i.e. relationships) to represent knowledge that is easy to visualize and manipulate to aid decision-making (Aguilar, 2005).

The underlying assumptions behind cognitive maps are that individuals have cognitive (mental) models that are internal representations of a partially observed world (Norman, 1983; Bauer, 1975), that cognitive structure can be modelled using symbols (Carely and Palmquist, 1992), and that they can be represented as networks (Joanssen *et al.,* 1993). Key assumptions that support mental models as stated by Carely and Palmquist (1992) include:

1) Mental models are internal representations.
2) Language is key to understanding mental models; i.e., they are linguistically mediated.
3) Mental models can be represented as a network of concepts.

4) The meanings for the concepts are embedded in their relationships to other concepts.
5) The social meaning of the concepts is derived from the intersection of different individuals' mental models.

Though these assumptions have been supported by cognitive psychologist (Anderson, 1983), some have questions regarding the underlying assumptions behind mental models (Jonassen, 1994; Sasse, 1991; Downs and Stea, 1980). Downs and Stae (1980) believe that a cognitive map exists if an individual behaves as if a cognitive map exists. Jonassen (1994) explains that mental models are a complex and inherently epistemic as they form the bases for expressing what we know. Given this assumption of their epistemic nature, they are not readily known to others, and not necessarily comprehended by the knower. Therefore, like all knowledge, they must be inferred from performance of some sort – that is, they are validated based on their outcomes (Jonassen *et al.,* 1994). In any event, fuzzy cognitive maps extend the capability of other qualitative techniques by using quantitative tools (Bachofer, 2009; Ozesmi, 1999).

FCM is very useful in four types of problems where gaining insights or predicting system behaviour is not obvious or easy. These four types of problems are: 1) Prediction; which involves human behaviour and how human actions can unknowingly affect ecosystems, 2) Where detailed scientific data are lacking but local knowledge of people adapted to an ecosystem though less awareness and acceptance of knowledge systems is prevalent, 3) "Wicked" environmental problems…are complex, involve many parties, and have no easy solutions or right answers, 4) Issues in ecosystem management where public involvement is desired or even mandated by law." (Ozesmi and Ozesmi, 2003).

The multi-step fuzzy cognitive mapping approach is a synthesis of relevant useful techniques from many disparate disciplines on cognitive mapping (Ozesmi, 1999, Ozesmi and Ozesmi, 2003). It can help compare and contrasts the perceptions of different people or groups of stakeholders.

In the multi-step approach, FCMs are condensed prior to simulations. Typically, participants generate a large number of variables (i.e. key considerations), some of which are greatly related, and therefore, are amenable to condensation into high level concepts and considerations (Ozesmi and Ozesmi, 2003; Nakamura *et al.,* 1982). Condensation simplifies the subsequent model development and enhances the understanding of the outcomes. The condensation is a subjectively qualitative process, categorizing the conceptually similar key considerations in respondents' FCM into high-level categories (Kosko, 1988, Ozesmi &

Ozesmi, 2003, Ozesmi & Ozesmi, 2004**;** Strickert *et al.,* 2009; Strickert *et al.,* 2010). The qualitative portion of the condensation is based on the quality of the nodes, also known as, neurons[23]; that is, the variables and or concepts included in the FCM. In effect, this qualitative condensation process is similar to open and thematic coding of transcripts from participants' interviews where themes are grouped into upper level concepts.

Condensation can also be achieved through quantitative methods such as additively superimposing connections between concepts (Lazslo, 1996). The quantitative portion of the condensation centers on the links between the concepts that participants choose to include in their maps. This simplifies the subsequent model development and thereby enhances the understanding of the outcomes. The quantitative element of condensation is less concerned with the qualities of the neurons in the FCM (i.e. words, phrases, and details used to describe a given phenomenon). Instead, it focuses on the transactions (i.e. links, connections, or weights) between the concepts of the FCM. The transactions are often multi-directional between the concepts and provide the architecture or structure of the FCM. Condensation organizes many variables and connections into manageable and consistent higher-level categories that reflect the parallels between participants' perceptions and the subjective 'coding' of the researcher.

Once individual FCMs are condensed, they can be aggregated into Social Group Fuzzy Cognitive Maps (SGFCM) of targeted stakeholder or participant groups, or emergent groups, using quantitative tools. In addition, FCMs can be aggregated into one SGFCM that represents the entire social group, herein referred to as the Total Social Group Fuzzy Cognitive Map (TSGFCM). Once the SGFCMs are created, they no longer belong to any one individual. Instead SGFCMS are a representation of collective horizons (Ozesmi, 1999). Once SGFCM are created, their structure can be examined using a variety of quantitative tools that provide an understanding about them. These include graph theoretical indices, statistics, content analysis, cluster analysis, factor analysis, and a novel tool--unsupervised neural networks.

2.2.7 Fuzzy Cognitive Mapping *in-situ*

My study adapted the Ozesmi *et al.,* (2004) multi-step approach for fuzzy cognitive mapping (FCM). Prior to this research, FCM had not been used as part of a study on how people perceived natural hazards. Participants developed an FCM of the critical variables

[23] A neuron is a unit that is connected to other units that can receive and/or send information.

(important considerations) of preparation for, response to, and recovery from an earthquake that has a direct effect on the ski fields. The first few attempts at calibrating the adapted approach were what might be termed successful failures. I realized that participants needed a benchmark, given that they had not really considered an earthquake affecting a ski area. To overcome these challenges, successive interviews were conducted by beginning with the critical variables. Specifically, once they identified critical variables, their attention was shifted to a series of questions about their perceptions of and experiences with natural hazards and disaster events (i.e. natural disasters, severe weather, mass movements, and earthquakes). Once the questions were complete, the interviewer returned to the FCM, asking if they wanted to add any more variables (concepts). The questions intensify their thinking about a scenario, which, as many reported, they had never considered. Once satisfied with their selected variables, they were asked to assign values to the critical connections with strength values in the range [-10, 10 then scaled to -1, 1] or to use linguistic variables (e.g., weak, strong, or their own words). If they chose to assign values to connection strengths, at the end of the mapping process they were asked to assign linguistic definitions to the values they assigned.

The fuzzy cognitive maps were drawn on a roll-out white board with dry erase markers. This set of tools allowed the researcher to access remote locations (a rigid white board was nearly lost during the calibration interviews, as it was blown out of the researcher's grip and across the parking lot in a strong wind gust). The markers included black for drawing variables, red for positive connections, blue for negative connections and green for the rare occasions when participants could not decide connection type but did provide a weight. The markers and white board allowed for quick corrections when needed, and for conducting the FCM exercises. In later interviews, green was eliminated in favour of clarifying the details of the variables and handling the green connections was difficult at the simulation stage. The earlier uses of the green connections were transformed to negative connections in a meagre effort to consider worst-case scenarios. This could lead to anomalies in the scenario simulations but the existence of only a very small number of these connections in the maps suggests that any effect should be small or insignificant.

Some of the participants may have been confused by the positive, negative, or neutral calculus. Specifically, with the negative values, some participants viewed them as having a decreasing physical effect on a phenomenon whereas four participants saw this as a negative (i.e., bad influence). The remainder of the interviews overcame this issue in two ways. If participants were unsure about connection weights between concepts as being positive or negative, the researcher inquired as to whether it would help if the meaning of the concept sending a signal is clarified. For example, if a participant selected power as a concept and they were unsure if it had a positive influence on another concept (i.e. communication), clarifying the concept of power could be for example ‘power loss’, which was perceived to have a negative influence on communication whereas ‘restore power’ had a positive effect/influence on communication. This step was important for helping the participants to complete the fuzzy cognitive mapping exercise. It also greatly helped the researcher to understand and process the maps prior to simulation.

Thirty-eight FCM were collected from fifty participants. Of these maps, only thirty-five were deemed appropriate for use. Those that were not used included two participants who were part of the calibration group too far removed from the context. Another example was a participant whose FCM was not used as they initially noted 27 variables, and the attempt to draw connections with the matrix focused approach was lengthy. During the process, this participant began to provide connections in an impulsive manner, perhaps due to fatigue. After this particular interview, later FCMs in the study were limited to 15 variables. I refined my methodology based on the need to be sensitive to the participants, and to myself as the main instrument of the research.

A sample FCM from the case study demonstrating the key considerations for preparation, response and recovery and their relationships in relation to an earthquake that affects a ski area is provided in Figure 2.5.

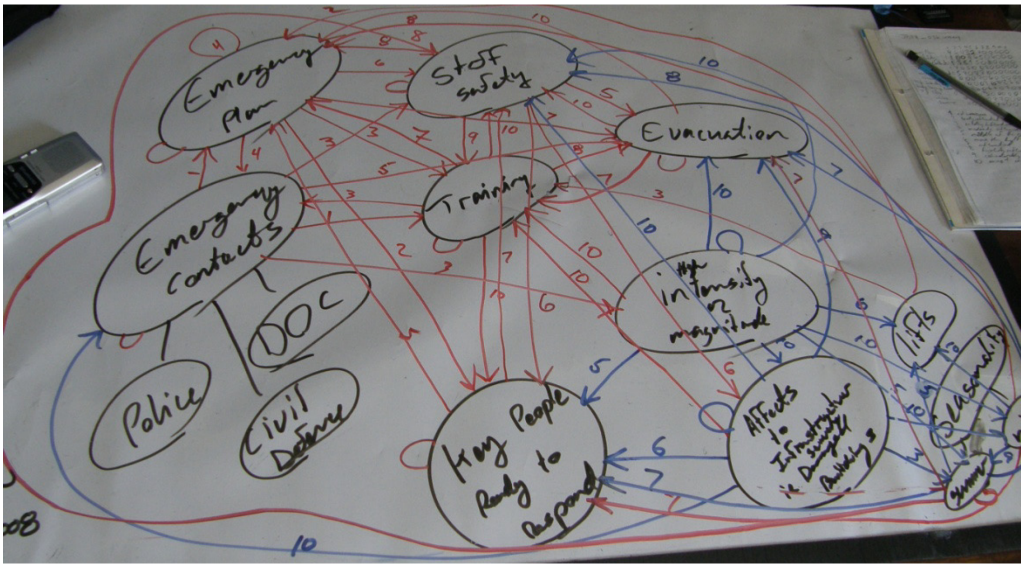

Figure 2.5 Example FCM from the case study

The graph theoretical indices in the study were calculated on Matlab. A Matlab script was developed which could calculate all the indices for an FCM or SGFCM simultaneously. Next, each index was stored in a data structure so that they could be extracted for comparing individuals, groups and all the participants. The Matlab m-file script for calculating graph theoretical indices is available in Appendix 2.G. An example of a script for extracting data (i.e., Density) from the individual data structures is available in Appendix 2.H.

2.2.7.1 Summary of FCM in Application

When processing FCM, one has options for condensing and aggregating, as described previously, but the choice depends on the purpose or function the FCM. The purpose of this study was to demonstrate an adapted and adaptive application of FCM in a novel context, as well as to use the procedure as a means to get stakeholders to consider a rare hazard. The FCMs gathered from participants can then be used to draw inferences about their perceptions in an attempt to identify opportunities for improving policy, while considering the differences between particular social groups. It must be stressed that inferences drawn should not be used as a direct means for developing policy; rather, they should be used in further engagement with stakeholders to highlight possible differences as well as similarities between participant groups. Furthermore, they should be validated through an iterative process of continuing dialogue with relevant stakeholders to facilitate policy creation. The latter is beyond the scope of this thesis.

2.3 Sample characteristics

Participants were recruited for the study in two ways. Ski field managers were recruited using telephone scripts and subsequent emails. When the initial interview conducted with the manager at each ski field was complete, permission was then sought from that manager to interview patrons of their resort. Then, participants were recruited via face-to-face contact on the ski field. Stakeholders were asked to read the research information sheets, if they wished to participate, and to provide informed consent. All participants were informed that their personal anonymity would be preserved during the analysis and reports of the research findings. Furthermore, after discussion with participants, a decision was made to keep the identity of ski areas confidential, as much as was practically possible. These steps attempted to foster trust and open communication during the interviews. Critically, protecting the reputation and future liability of the ski area was important; hence, the names of the ski areas are blanked out in the extracts from the interviews.

Between the months of January 2007 and April 2009, interviews were conducted with ski field stakeholders in New Zealand and Canada. The interviews were conducted with three different participant groups: Alpine Snow Riders (ASR), Ski Industry Workers (SIW) and Ski Area Managers (SAM). Alpine Snow Riders consisted of both skiers and snowboarders with varied levels of experience. Ski Industry Workers consisted of people employed in the ski industry, both at ski areas and in towns in close proximity to ski areas. Ski area managers were in high-level positions such as Mountain Managers and Operations Managers, and, in two cases, owners.

Stratified sampling was used as three strata (Groups) of ski industry representatives described above were identified for interviews. It was attempted to find a random sample for each by group. Ski areas were telephoned for the preliminary contact, permission and then recruiting participants. As circumstances dictated, snowball and purposive sampling was also used, as respondents provided the names of other ski field stakeholders who they thought would be interested in contributing, or would have sympathetic commentary to add to the study. Initially, the aim was to cover all of the 26 ski fields in New Zealand, but due to cost, manager refusal, and remote location of some fields, seven of the New Zealand ski areas were not included in the sample. Interviews also included four locations in Canada. The emphasis for consideration of snowballing was to seek people with high levels of experience in the industry. This was the most effective manner to gather lay-expert participants. Snowball sampling occurred often after interviews with managers where they suggested participants within their or other organizations who would add value to the study. This form of snowball sampling was highly valuable as it enabled the researcher to interview key staff members responsible for safety and emergency services at various ski areas.

The purpose of the sample was to demonstrate an application of FCM within a novel context and framework. In total there were 51 participants originating from 12 different countries. Forty-one interviews took place in New Zealand while 10 took place in Canada. The Alpine Snow Riders (ASR) group consisted of 13 participants (both skiers and snowboarders), with 2 experts and 11 lay-experts across the full range of experience levels from 6 distinct ski areas. The Ski Industry Workers (SIW) group consisted of 19 participants, with 12 experts and 7 lay-experts of medium to high levels of experience, including ski instructors, safety services, ski patrollers, services staff, technicians, avalanche controllers, and operations staff from 12 distinct ski areas. The Ski Area Managers (SAM) group consisted of 14 expert participants, including mountain managers, operators, and owners from 14 distinct ski areas. Given the purpose of the sample, the qualitative sample was sufficiently stratified, random, and displayed reasonable heterogeneity.

The participant identification codes and summaries of the total sample are shown in Table 2.1. Participants were each given a participant code depicting their stakeholder type and number. They also identified their gender and age in a given range. In the table, occupation was classified based on the respondents' job titles. Each of the participants also identified either their home community (i.e. where they live), or the host community (i.e. where they were staying) if they were visiting tourists. To gather participants' transportation types, participants outlined the distance they travel from home to the ski area and the method of travel (e.g., car, bus, or four-wheel drive vehicle). Participants were also identified by their country of origin and the location in which the interview took place. The final three columns outline the type of interview, level of expertise with hazards, and their level of experience in mountain environments and/or ski areas.

Table 2.1 Identification codes for participant tables.

	Description of Code	Key for Symbols
PartCode	Participant Code	ASR = Alpine Snow Rider, SIW = Ski Industry Worker, SAM = Ski Area Manager
Gnd	Gender	m = Male, f = Female
Age	Age Range	Age described as a range
Occupation	Occupation/Employment	Shortened descriptions of current profession
Hm/Hst Comm	Home/Host Community	Home town or host community
DistTrav	Distance Travelled	Approximate distance traveled to ski area in kilometres
Trnsprt	Transport Type	Car, Van, Hitchhike, or four-wheel drive
Cntry	Country of Origin	Country of Citizenship
ItLc	Interview Location	Where the interview took place
IntTp	Interview Type	1 Comprehensive, 2 Partial, 3 Condensed
PtcTp	Participant Type	LE = Lay Expert, E = Expert
ExpLv	Experience Level	Low, Med (Medium), or High level of experience

The demographic data collected from each of the participant groups is shown in Tables 2.2, 2.3, and 2.4.

Table 2.2 Alpine Snow Riders Participant Group

PartCode	Gnd	Age	Occupation	Hm/Hst Comm	DistTrav	Trnsp	Cntry	ItLc	PtcTp	ExpLv
ASR 1	m	18-20	Builder	Christchurch	130	4x4	CAN	NZ	LE	Low
ASR 2	m	20-25	Student	Lincoln	120	4x4	USA	NZ	LE	Med
ASR 3	m	20-25	Builder	Queenstown	450	Car	UK	NZ	LE	Low
ASR 4	m	30-40	Mountaineer	Christchurch	140	Car	AUZ	NZ	LE	High
ASR 5	m	26	Holidayer	Sweeden	na	Van	SWD	NZ	LE	High
ASR 6	m	20	Student	Christchurch	130	Car	USA	NZ	LE	Med
ASR 7	f	26	Pro Athlete	Wanaka	45	Van	CAN	NZ	E	High
ASR 8	m	25-35	Student	Christchurch	135	4x4	SPA	NZ	LE	Low
ASR 9	m	20	Student	Dunedin	220	Car	NZ	NZ	LE	Med
ASR 10	m	30-40	Osteopathy	Wanaka	30	Hitch	FRN	NZ	LE	High
ASR 11	m	35-40	Dr. GP	Christchurch	115	Car	NZ	NZ	E	High
ASR 12	m	22	PG Student	Riccarton	130	4x4	NZ	NZ	LE	High
ASR 13	m	33	Plumber	Broken River	2	Walk	NZ	NZ	LE	High

Table 2.3 Ski Industry Workers Participant Group

PartCode	Gnd	Age	Occupation	Hm/Hst Comm	DistTrav	Trnsp	Cntry	ItLc	PtcTp	ExpLv
SIW 1	m	22	Ski Area Services	Mt Cheesman	0	NA	NZ	NZ	E	High
SIW 2	f	28	Student & Avi Instructor	Chirstchurch	140	Car	NZ	NZ	E	High
SIW 3	m	31	Ski Patrol Manager	Temple Basin	0.5	Walk	CAN	NZ	E	High
SIW 4	m	35	Avalanche Forcaster/HeliGuide	SpringFeild	4	4x4	USA	NZ	E	High
SIW 5	m	28	Safety Services Manager	Raurimu	25	Car	CAN	NZ	E	High
SIW 6	m	35-45	Chill Owner Manager	Christchurch	120	Car	NZ	NZ	E	High
SIW 7	f	25-35	Ski Service Worker	Wanaka	30	Van	FRA	NZ	LE	High
SIW 8	m	35	Ski Tech, Ski maker/builder	Lyttleton	105	Carp	NZ	NZ	LE	High
SIW 9	m	45-50	Lecturer	Christchurch	140	Car	NZ	NZ	E	High
SIW 10	m	25-30	Ski Industry Worker	Wanaka	40	Car P	NZ	NZ	LE	Med
SIW 11	m	30-40	Snow Safety Officer	Darefield	45	Car	NZ	NZ	E	High
SIW 12	m	25-30	Outdoor Educator/Ski Tech/Canoe Guide	Golden	20	Carp	CAN	CAN	LE	High
SIW 13	f	20	Varied Ski Industry	Craiggieburn	8	Car	NZ	NZ	LE	Med
SIW 14	m	34	Aviforecaster/Emergency Program	Golden	24	4x4	CAN	CAN	E	High
SIW 15	m	38	Ski Patrol Manager	Wanaka	25	Van	NZ	CAN	E	High
SIW 16	m	36	Chef/General SIW	Broken River/Ca	2	Walk	JAP	NZ	LE	High
SIW 17	f	35-40	Accomodation Manager/Internet Analyst	Broken River/Ch	2	Walk	NZ	NZ	LE	High
SIW 18	m	37	Aviforcater/Bomtrams/Weatherstation	Revelstoke	10	4x4	CAN	CAN	E	High
SIW 19	m	34	Snowschool Manager	Revelstoke	10	4X4	CAN	CAN	E	High

Table 2.4 Ski Area Managers Participant Group

PartCode	Gnd	Age	Occupation	Hm/Hst Comm	Dist Trav Kms	Trsp	Cntry	ItLc	PtcTp	ExpLv
SAM 1	M	25-35	Ski Area Manager	Wanaka	40	4x4	NZ	NZ	E	High
SAM 2	M	46	Ski Area Manager	Queenstown	26	Car	NZ	NZ	E	High
SAM 3	F	25-35	Ski Area Manager	Broken River	0	NA	CAN	NZ	E	High
SAM 4	F	35-45	Ski Area Manager	Alexandra	150	Car	NZ	NZ	E	High
SAM 5	M	45-50	Ski Area Manager	Queenstown	14	Car	NZ	NZ	E	High
SAM 6	M	35-45	Ski Area Manager	Methven	30	4x4	NZ	NZ	E	High
SAM 7	M	50+	Ski Area Manager	Whakapapa	6	Car	NZ	NZ	E	High
SAM 8	M	45	Ski Area Manager	Wanaka	35	Car	NZ	NZ	E	High
SAM 9	M	32	Ski Area Manager	Arthurs Pass	6	Walk	NZ	NZ	E	High
SAM 10	M	43	Ski Area Manager	Golden	15	4x4	CAN	CAN	E	High
SAM 11 *	F & M	40-45	House wife & Ski Resort Owner Operator	Lake Tekapo	12	4x4	NZ	NZ	E	High
SAM 12	M	60+	Ski Area Manager	Fairlie	30	4x4	NZ	NZ	E	High
SAM 13	M	35	Ski Area Manager	Tekapo	32	4x4	NZ	NZ	E	High
SAM 14	M	40-50	Ski Area Manager	Canmore	14	4x4	CAN	CAN	E	High

- **Note: the SAM 11 participants indicated a preference to conduct the interview together.**

The participant sample was functional for the goals and objectives of the research. Of the 51 participants, four interviews from the general calibration group were not included in the analysis. They were not included because the participants had limited experience *in situ*, and were not able to contribute detailed information, although their participation did provide a helpful step in calibrating questions and the FCM process for later interviews.

The process of interviewing managers, staff, and other participants and thematically coding their interviews took approximately 24 months, with a break occurring over the summer season when ski fields were non-operational. The semi-structured interviews ranged in duration from a few minutes to almost three hours, with a median of 45 minutes. The interviews followed an interview guide consisting of thirty to forty open-ended questions and probing questions in order to elicit more detail, but at times, the questions were altered for targeting purposes during certain periods, or with certain stakeholders in order to ensure a cognitive map was completed. Interviews were transcribed and sent to the interviewees electronically for verification. Verification of the transcripts and/or fuzzy cognitive maps occurred in most of the cases. In future studies, the researcher believes mailing transcripts with return postage would have facilitated better review of these transcripts, as none of the participants asked for any changes to be made. It is possible that they did not desire changes, or that they did not diligently review the transcripts (McLellan, MacQueen, Neidig, 2003). The interview transcripts were analysed by open- and thematic-coding with QSR NVivo software. Interviews were solicited until thematic saturation (no or limited new themes) was achieved (Creswell, 1998). Saturation occurred after 19 interviews, further interviews were coded through audio review, visual review (reading of transcripts), and extracting accounts from key thematic areas.

2.4 Discussion: Integration and Triangulation

> Mixed methods is, simply, best suited for addressing many of today's complex research questions, which require context and outcomes, meaning and trends, and narratives and numbers. (Creswell and Clark, 2007, p. 184)

The geomorphic assessments help the researcher identify 'possible' objects of value that lie in harm's way or 'at risk' to natural hazards. The concepts from the interviews and the FCMs (i.e., considerations, objects and or concepts) performed two functions. First, they are a point of comparison between what the geomorphic assessments identified as exposed objects of value. Second, they add character to the objects in the form of nodes and concepts. The nodes may be similar among respective social groups both taxonomically (the condensed concepts) and transactionally given their weights (connections to other nodes). The social group fuzzy cognitive maps may represent solidarities of each of the sociocultural viabilities (ways of life) embedded in nested concepts (key considerations for preparation, response and recovery). These can help identify general perceptions of respective social groups to help mountain communities identify opportunities for adapting to the possible consequences of compounding natural hazards. Each group can identify essential elements of preparation, response, and recovery that other might miss. Once the concepts are identified, we may be able to get them to cooperate, compete, and subvert each other, striving for '*clumsy solutions'* that fill existing gaps in hazard mitigation policies.

2.5 Summary of Mixed Methodology

This chapter has explored the use of four methodologies, and the synergy of their integration as a means of bridging some gaps identified in the previous approaches for the study of risk management in social and physical contexts simultaneously. I described the use of geomorphic assessments, qualitative interviews, and fuzzy cognitive mapping in both separate and combined modes, with emphasis on some of the required processing, strengths, and weaknesses of the approaches.

Chapter 3: Results

3.1 Introduction

This chapter presents the results from the first three components of the mixed methodology. Initially, the results from the geomorphic assessments are presented, highlighting vulnerability from the perspective of primary, secondary, and tertiary consequences of earthquakes at commercial and club ski areas. Several figures are shown to illustrate exposed objects that ski field stakeholders value (e.g. infrastructure, human lives, and physical features). The first two levels of integration into the mixed methodology are presented linking geomorphic assessment and qualitative interviews. Qualitative interview results are presented highlighting participants' perceptions regarding preparation for, response to and recovery from three natural hazards. In addition, the chapter flags how participants' accounts can be indicative of the five ways of life according to cultural theory. Results from the FCM are then presented first at the static level of individual participant maps using indices from graph theory. Next, in a novel set of scenarios based on self-organising feature maps, the results are presented to further elucidate the five social solidarities. Finally, the chapter concludes with a short summary to provide a transition to the discussion.

3.2 Results – Geomorphic Assessments

This section discusses the results of field based geomorphic assessments at six distinct ski areas. It opens with an explanation of the likely primary consequences of earthquakes. Next, the section presents the likely secondary and tertiary consequences of earthquakes, followed with a focus on disruption to critical lifelines. Last, there is a discussion of how the results demonstrate preferences for particular ways of organising, based on models of consent, latent strategies, and engineering aesthetics.

3.2.1 Introduction to the likely consequences of earthquakes

The terrain and infrastructure in which alpine ski areas are located are subject to consequences from earthquakes. Earthquakes can activate slope movement in the form of snow and rock avalanches, landslides, and rock fall. The consequences of high magnitude earthquakes for the infrastructure at alpine ski areas may also be severe. Primary, secondary and tertiary consequences (discussed in the next section) can affect lifts, buildings, parking lots, and especially roads. Primary consequences result from shaking (e.g., *ground acceleration*) leading to secondary effects such as rock fall, avalanche, and landslide. The compounding secondary effects on infrastructure result in tertiary effects such as fire or other impacts and disruption of the critical lifelines (i.e., services deemed necessary for survival by humans in remote alpine environments).

3.2.2 Primary Effects

Primary effects of hazards occur as a result of the processes itself. For example, water damage from a flood or collapse of a building during an earthquake. The primary effects of earthquakes result from consequences caused by the shaking of the ground. These effects can cause damage to elevated structures such as lift towers, buildings, and parking lots and roads. The commercial fields may experience more significant consequences from primary effects, due to their greater level of infrastructural development, and its use by patrons. Though more modern infrastructure is engineered to higher building standards, there exists some uncertainty as to the magnitude and intensity that structures can handle, particularly when considering *topographic amplification* (increase of acceleration or "shaking" due to focusing of energy on peaks or ridges). Topographic amplification can have a strong influence on ground response during an earthquake, which can lead to amplification and deamplification effects of the resulting ground motion (Buech *et al.,* 2007). Field studies on amplification have shown that

> i) Amplification of ground motion at the top of the hill occurs relative to the base of the edifice. The amplification is frequency dependent and has its maximum at the resonant frequency of the edifice; ii) Amplifications for motions perpendicular to the direction of elongation of the edifice are larger than that for parallel motion, and amplifications are higher for the horizontal component than for the vertical component; iii) Observations show significantly higher amplitude of amplification (up to greater than 10) than numerical simulations predict; iv) Next to the pure topographic effect, amplified ground motions at the top of an edifice can also be related to the presence of deeply weathered rocks acting as a low-velocity layer on top of the bedrock (Havenith *et al.,* 2003 in Buech *et al.,* 2007).

The drive stations and lift towers for chair lifts at two of the sites were found to be vulnerable to increased levels of acceleration due to being located on ridges or peaks. When lift towers are shaken out of alignment, the lift must be stopped and people evacuated. Moreover, structural engineers are required to assess lifts before re-starting. The worst-case scenario for a commercial field in the wake of ground shaking would result from structural failure of drive stations or lift towers. The lifts at the club fields are ground-based (e.g., T-bars & “Nut Crackers”). Hence, the snow riders are able to self-evacuate from these lifts with ease. Furthermore, these lifts can require re-alignment but are simple and easy to repair.

The more significant concern for some of the club fields is the age of the buildings, which, by and large, are not built to current standards with respect to earthquake safety. Furthermore, many of the club fields cater to overnight guests, increasing their exposure from daytime usage to a full 24 hours. One positive note regarding the stability of the older club field buildings is that they tend to be built from traditional timber framing, which can survive shaking due to significant moment capacity (Gotz *et al.,* 1989; Foliente, G.C, 1997).

Commercial fields may be less vulnerable to earthquakes with regard to buildings that are constructed to more modern seismic standards, but in high intensity events, the elevated lifts are a primary concern for evacuation and repair (e.g., lift evacuations and alignments). The club fields, on the other hand, are more vulnerable to building damage and collapse, but their lifts are easier to evacuate and repair after a large earthquake. Yet the ground-based lifts are more vulnerable to mass movements induced by earthquakes. Repairing the ground-based lifts is much easier than elevated lifts without external expertise. The overall picture of ski area vulnerabilities to primary effects from earthquakes is, therefore, not a straightforward one, nor one that can be solved with an elegant solution. Perhaps considering secondary effects will shed further light on the situation.

3.2.3 Secondary Effects

Secondary effects of hazards are those consequences that follow the main hazard event -activation of slips during a high rain event, for instance, or avalanches resulting from earthquakes that occur in mountainous areas. The possible secondary effects of earthquakes also highlight different vulnerabilities between commercial and club ski areas with respect to infrastructure (lifts, buildings, and lifelines), and their location with respect to hazards.

Elevated lifts at commercial fields may actually help reduce vulnerability to secondary effects by virtue of elevating people above avalanches and rock falls. However, when the lifts are damaged or collapsed, they can actually exacerbate the risk to secondary hazards by trapping people on elevated structures, leaving them vulnerable to exposure. Most chair lifts are fitted with emergency kits on each chair to facilitate evacuation due to lift malfunction.

With respect to buildings, at both commercial and club ski areas, some are located in avalanche run-out zones (i.e. the course an avalanche will follow) which increase their susceptibility to these hazards. Both types of ski areas also face isolation as a result of secondary effects, due to the potential for roads to be blocked and the disruption of other critical lifelines.

Thus, there are similarities and differences between commercial and club fields respecting secondary consequences. At the commercial fields, people on lifts may be less vulnerable to avalanches and rock fall because they are elevated. However, this can also lead to exposure. At the club fields, ground-based lifts are more exposed to avalanches and rock fall, and therefore patrons may be more vulnerable. Both types of ski areas have some infrastructure located in the likely run-out paths of avalanches and rock fall. The general picture of ski areas vulnerabilities to secondary effects from earthquakes highlights situated-risks based on design and location of infrastructure. The next section will further illustrate this point by showing tertiary consequences; the disruption of critical lifelines is a salient risk at both types of ski areas.

3.2.4 Tertiary Effects

Tertiary effects from hazards are consequences of primary and secondary effects, such as fires from broken gas mains and electrical conduits resulting from earthquakes, or death associated with disease and starvation after a massive flood. The tertiary effects of earthquakes on infrastructure at both club and commercial ski areas include the possibility of fires, and loss of critical lifelines, including disruptions to energy, communication, transport, water, sanitation, and shelter. Chief among these lifelines is energy, as without power, many other lifelines are not operational. Many of the fields have back-up diesel generators, but these are limited by fuel stocks, which may not be easily replaced due to disruptions to the transportation network. Moreover, if electrical conduits in buildings are damaged, then generators may be of limited use. Communication is also paramount to aid in the response effort, the caveat of this being that modern communication technology requires power. Major earthquakes tend to disrupt landline telephone services, cellular telephone towers and internet connections. Moreover, in an alpine context, short wave radio repeaters can also be disrupted by power outages or damage.

With water as the most basic need for survival, the effects of earthquakes can make it difficult to retrieve potable water. Damage to underground piping can make tap water inaccessible or polluted. By virtue of snowmaking, commercial fields also make melt water in streams questionable for drinking due to contaminants.

Some of the alpine roads leading to New Zealand’s ski areas are also rudimentary (i.e., consisting of dirt-based, single or, occasionally, two-lane roads) (Appendix 3.B). In a major earthquake, many sections of these roads can become inaccessible due to slope hazards such as avalanche, landslide and rockfall (Appendix 3.C). Therefore, evacuations, particularly during aftershocks, might be a challenge. Shelter may be damaged badly, and re-entering buildings may be dangerous due to the high likelihood of aftershocks.

Both commercial and club ski areas are therefore vulnerable to the tertiary consequences of earthquakes, which can disrupt critical lifelines challenging response efforts. In addition, the field investigations revealed two novel findings that suggest further challenges facing alpine ski areas, specifically regarding their ability to adapt to earthquakes, as discussed next.

3.2.4.1 Emergent Results - Reservoir Collapse

Perhaps the most significant finding of the geomorphic assessments is the location of large water reservoirs and/or lakes, some of which are for snowmaking. Marnezy (2008) highlights the growth in the use of reservoirs for making human-made snow since the 1980s, for climatic and commercial reasons. Seven ski areas have water bodies that are subject to collapse with outflow paths running through critical infrastructure with possibility of casualties both in lives and property (Figure 3.1.a, b, c). In high magnitude earthquakes or other natural hazard events, the potential scenario is aptly termed “disaster(s) by design” (Mileti, 1999).

Figure 3.1a Reservoir elevated above ski lift loading station.

Figure 3.1b Reservoir elevated above ski lift loading station.

Figure 3.1c Reservoir with outflow path through critical infrastructure.

Other ski areas have actually located reservoirs below critical infrastructure (Figure 3.2).

Figure 3.2 Water reservoir at Porters Ski Area. Note the location below critical infrastructure. (September 19th, 2008)

Potential mechanisms for reservoir collapse include displacement of water, via seismically induced rock or snow inundation into water bodies; reservoir wall failure, and possible seiching during seismic events. The term seismic seiche was first used by Kvale (1955), who investigated the oscillation of lake levels in Norway and England caused by the Assam earthquake of August 15, 1950 (McGarr *et al.,* 1968). Serway and Jewett (2006) explain that "During the Northridge earthquake of 1994, swimming pools throughout Southern California overflowed as a result of seiches set up by the shaking of the ground" (p. 451). Interestingly, reservoirs can help in monitoring earthquakes (McGarr *et al.,* 1968; Barberopoulou, 2008).

Given that there are seven ski areas in New Zealand that have safe zones, people and infrastructure located below lakes and reservoirs, steps could be taken to implement policies, strategies and response plans to mitigate the danger of these designed hazards.

3.2.4.2 Emergent results - Topographic Amplification

Another issue that merits investigation is the impact of topographic amplification on facilities located near peaks or ridges. During an earthquake, maximum ground acceleration (i.e. “shaking”) is the most pronounced on peaks and ridges. When earthquakes affect buildings, the tops of the buildings move more than the bottom. In mountains, the process is more complex and compounding than for engineered structures. Hence, the consequences of topographic amplification on infrastructure in alpine ski areas merit investigation from, at the minimum, geological engineers in collaboration with civil engineers when designing infrastructure and building codes for construction in high alpine areas. Monitoring of reservoirs may also be a helpful tool for studying topographic amplification.

3.3 Summary and Integration

The main issues found in these GA assessments reflect development of ski fields without due considerations for seismic events. This type of development may place high numbers of people at unnecessary and involuntary risk, and as such steps should be taken to avoid such vulnerable developments in the future. Avoiding the development of alpine ski areas altogether would be tragic. Instead, a key question is, what can be done to improve current and future developments with respect to seismically induced hazards?

To reduce risks, mitigation measures can be implemented. The main critical geomorphic issues as related to co-seismic events were: snow and rock avalanche, landslide, rock fall, and infrastructure collapse (including reservoir failure, road section collapse, building collapse, and loss of critical lifelines). Snow and rock avalanches in association with seismic events have been recorded, and are well documented in New Zealand.

3.3.1 Social Solidarities – based on geomorphic assessments

At this point, it is useful to tease out social solidarities in an effort to implant the *dividual* as the unit of analysis. Thus, what solidarities are emerging based on the geomorphic assessments? With respect to the primary effects of earthquakes, there appear to be three solidarities implicit in the design or layout of ski areas. The most obvious solidarity is the hierarchist solidarity, which is apparent from the centralization of infrastructure (buildings, lifts, and operations facilities) that was prevalent in the commercial fields. The centralization of infrastructure affords an ability to manage the operation of the facilities efficiently, and to shelter staff and clientele from severe weather, avalanches, and other hazards, thus inferring a social construction of nature as perverse and tolerant. However, with some infrastructure located on peaks and ridges, this could be misconstrued as nature ephemeral when it is, in fact, nature capricious. The location of infrastructure is potentially a more fatalistic way of organising, because there is considerable uncertainty regarding the effects of topographic amplification on precariously placed infrastructure. Yet the design of infrastructure (i.e., chair-lifts in particular) to withstand wind loading and basic seismic loading (i.e., elegant solution) is an example of high-tech virtuosity; the engineering aesthetic of hierarchical forms of organising.

There is also a view of nature as benign given that much of the overnight accommodation in the club ski areas consists of older timber structures which can handle significant moment capacity, despite being built prior to rigorous seismic standards.

The elevated lifts can reduce exposure to secondary effects, again casting a view of nature as benign. Yet if these structures fail, people could actually be trapped in the path of avalanches or rock fall, thus changing one's perspective to nature as capricious or ephemeral, depending on one's latent strategy. For example, the view of nature is capricious if one prefers individualized survival. Conversely, the view is ephemeral if one prefers collectivized survival. That some lifts are fitted with emergency kits to support lift evacuations leans more toward collectivized survival, though this would be supported through a hierarchical response. On the other hand, the fact that some infrastructure is in harm's way from secondary hazards might infer a fatalistic solidarity. In fact, some buildings have been destroyed by avalanches. This point highlights a strongly held belief among hazards scientists that the worst-case scenario is exceeded (i.e. unexpected surprises), which can lead people to select fatalism as a way of organising. However, the noted tertiary consequences indicate manners of organising that show preference for a mix of solidarities among a variety of situated risks.

The tertiary effects of earthquakes for alpine ski areas include the possibility of fires and loss of lifelines. Both of these consequences seem to push one toward a hierarchical solidarity. The reason for this is that they infer responses that nestle the ball between the two humps by virtue of prior experiences with these particular consequences. First, with a history of fires, there are policies, building codes, and emergency procedures to reduce the incidence of fire, and combat it should it arise. Second, the loss of critical lifelines caused by severe weather (a common hazard in New Zealand alpine areas) dictates that some levels of redundancy or adaptability is in place to cope. However, dealing with the consequences of earthquakes is more complex than other hazards, as it is possible for major earthquakes to disrupt all lifelines at once and for a prolonged period of time. Such a scenario might again lead one toward fatalism.

There were two emergent findings that occurred in the geomorphic assessments: (1) the location of reservoirs above critical infrastructure, and (2) the possibility for topographic amplification. Both of these findings are a selection of risk based on an egalitarian perspective. These reservoirs are an example of manufactured hazard (Beck, 1992, Giddens, 1999). Cultural Theory goes beyond Beck and Giddens by having a typology which shows the normative implication of reservoirs being manufactured as a result of the hierarchical solidarity. The reason for the reservoirs is to enhance the number of skier days per year by virtue of making machine-made snow, which distinctly suggests a view of nature as perverse and tolerant.

Perhaps the reason I anchored on this hazard is because it pushes several of Slovic's (2000) risk perception buttons such as: potential for high number of fatalities, unfamiliarity, lack of personal control, involuntary, children are vulnerable, victims are identifiable, a sense of dread, selective benefits of the technology, feeling of personal exposure to the risk, at risk and even trapped (i.e., in the lift-line), it is human[sic]-made, and given our inability to predict earthquakes, the threat can be said to be immediate.

In summary, the geomorphic assessments made social solidarities apparent, and revealed three significant differences between club and commercial ski areas: First, with respect to their engineering aesthetic, the club fields are more frugal and environmentally benign (e.g., simple lifts, buildings and facilities), while the commercial fields demonstrate a high-tech virtuosity (elevated high-speed chair lifts, modern buildings and snow-making). Second, the latent strategy of the club fields is somewhere between survival of the collective and survival of the individual, whereas the commercial fields are clearly designed for secure internal structure of authority based on centralized facilities. Third, the ideal scale of operations at the club ski areas was small, while at the commercial ski areas it was relatively large. Thus, the assessment of hazards at the club ski areas indicate that the club fields hold mostly egalitarian forms of organising, while the commercial ski areas seem to select hierarchical manners of organising.

The management of these risks cannot be solved solely from one or even two social solidarities (i.e., an elegant solution). Rather, all of the risks/hazards that were mentioned above may benefit from practices, policies, and procedures that arise from a mix of solidarities; that is, clumsy solutions/institutions. Thus, some pressing questions emerge which could not be answered by *geomorphic assessments alone*. What do stakeholders of ski areas think about earthquake risks and other hazards? Are they aware of similar hazards as outlined in the geomorphic assessments? Do their perceptions highlight preferences for particular ways of organising with respect to hazards? Do they suggest elegant solutions from particular solidarities? Or, do they seek solutions that require a mix of solidarities? These questions will be examined in the next section which presents the results of qualitative interviews with stakeholders of alpine ski areas.

3.4 Results - Qualitative Interviews

Thematic results from the qualitative interviews are presented in this section. In order to remain true to participants' accounts, extensive sequences from the original data in the form of quotations are provided throughout this part of the analysis. Efforts are made to keep the number and length of quotations to only what was necessary to illustrate common threads in the interview data. Some lengthy quotations are included because of their illustrative properties.

Initially, the broad themes cover general knowledge about natural hazards and disasters. Thereafter, direct and indirect experiences with natural hazard events in ski fields are highlighted. Then, more detailed aspects related to specific natural events (in line with the interview guide) are provided. Social solidarities are tied throughout the chapter, weaving interpretive commentary to highlight archetypes of cultural theory's five ways of life. They are based on some key elements that make up distinct ways of organising, including rejection of information, social constructions of time, and the myths of nature. Finally, an explanation is provided on the efficacy of qualitative interviews in terms of answering the research objectives for this segment of the study.

3.4.1 General Perceptions of Natural Hazards/Disasters

All of the participants had some level of awareness of natural disasters. Their accounts highlight some similarities, while there was also a wide assortment of different views. Many of the participants' accounts highlight the discernment that natural disasters are unpredictable. To wit:

> They're unpredictable, and they're no one's fault and so there's no use pointing the blame. ASR 6
>
> Well, we, um, can't really predict them. They can strike at any time… SIW 8
>
> Um, they're unpredictable, um, they [pauses] they're unpredictable for me, and I guess, and can be wide range of magnitudes I guess, you know. SIW 4
>
> Ah, they usually are a surprise…without warning. SAM 11
>
> In general, they usually occur…they either occur with no warning or they occur with obviously no warning? Like, thinking about an earthquake, tectonic plate movement, sometimes it's predictable, other times it's not predictable, so very unpredictable. SAM 5

The exemplars above outline a perceived difficulty of predicting natural disasters. This highlights a common perception from participants' that there is uncertainty associated with natural disasters. Some participants highlighted that the uncertainty arises from their low frequency. Consider for example the following descriptive accounts:

> What can I tell you about them? A broad question. Well, there is a range of different types and I think New Zealand is particularly in the firing line for some. In particular, we are in a geologically young country, with you know, we have got fault lines that are still on the move, and we have got active volcanoes and we have got offshore underwater potential for landslides, like tsunami, and a lot of big cities are right by the ocean. And so I think we are quite vulnerable. I don't consider there has been a major natural disaster in recent, in New Zealand in the last 20 years. So is it in the national psyche? I think we have had them in the past before that, but for people of my age group, we have never really lived through anything basically major. So I think there is, you know, people probably aren't quite as on their guard as they might be. SIW 2

> They're pretty unpredictable and learning how you're going to handle it, but they happen pretty irregular I suppose in New Zealand. I think we've probably never thought or included it in our emergency plans about a big natural disaster. SIW 20

Some participants presented a belief that people are not prepared for natural disasters, and knowing how to respond is difficult until a natural disaster occurs. For example,

> Well, I would say that generally the population is very unprepared for a natural disasters. We're sort of looks like, ah, "it won't happen to us" and you know. If it does happen, you know, I don't think people have any idea of the scale or the magnitude of these events. And how, well you don't know what sort of happens until it happens. Unless you've experienced something major, I mean I haven't been in the middle of a major natural disaster myself so. SAM 9.

Participants' accounts indicated an awareness highlighting that natural disasters were often unpredictable, and thus may challenge the ability of people to respond.

Overall, the accounts above portray a sense of fatalism with respect to participants' perceptions of natural disasters; that is, natural disasters were described as unpredictable, uncertain, and generally people do not prepare for them until they have had some direct experience with a disaster/hazard event. The latter indicates fatalism based on risk handling style, latent strategy, and myth of nature. The risk handling style was characterised by acceptance and absorption, demonstrated by how the participants explain a level of awareness, but indicated limited action of the collective. The accounts above also highlight a latent strategy which appears to be survival of the individual. The consistent view that natural disasters are unpredictable is also an indication of the fatalistic solidarity based on the myth of nature as capricious. The fatalistic view might be due to a lack of experience with disasters.

Many participants had not directly experienced a disaster. Nonetheless, they did describe how distant disasters influenced their perceptions. Stories from other people, observations of media (e.g., books, television, movies), or other means of mass communication has an influence on their perceptions of natural disasters:

> Yeah, I don't like the sea too much, and after the Tsunami news I like it even less (Chuckle). SAM 12

> Um, [pause] the closest I've personally been to a natural disaster is probably watching, watching it on TV, of any natural disaster of great extent. Well, I mean, we've all been experienced by natural disasters in some way or another. Ah, I've never actually been in a natural disaster. But, you know, I've heard of them. And, you know, like that Boxing Day tsunami in, uh, where was it? Uh, Indonesia somewhere, yeah. And, you know, that has an effect on people, no matter who you are or where you are. Yeah. It certainly is an experience to some degree, yeah. Sure, yeah. SIW 1

Several participants mentioned disasters that were covered in the media. They focused on particular events including The Boxing Day Tsunami 2004; Hurricane Katrina 2005; or the Pakistan Earthquake 2005. Some of the participants connected these distant events with how it can occur in New Zealand, and how seeing it in the media impacts them personally. The following account is an exemplar where a participant describes this affect.

> What else? Obviously there have been some major natural disasters in the world that have made headlines, like the Big Tsunami and volcanic eruptions and things like that, which have devastating impacts on communities. And yeah, I would not be too surprised if it happened to New Zealand at some point. I have not been involved in any major natural disaster myself, but I think that as I've grown up and been exposed to other types of accidents and that type of thing, it has probably increased my sensitivity to what it actually means to have a disaster occur. So I think for me, that is how my life experience has changed my perception. So when I see the news and see that so many people have died in a natural disaster, it actually means something to me, whereas when I was younger it was just TV, yes. SIW 2

The account above highlights how perceptions can be altered by indirect experiences with natural disasters. Yet some accounts did express that there is a difference between indirect experience and witnessing something firsthand.

3.4.2 Summary of Perceptions of Natural Disasters

In the accounts of direct experience with natural disasters, more localized events that were often mentioned included floods, storms, and alpine-based accidents such as the military disaster of 1991 on Mt. Ruapehu. Several participants described direct experiences with disasters, but their accounts are more appropriately termed natural hazard events. As in most cases, the events did not compromise their individual or collective ability to respond. These were most often severe weather, snow avalanches, as well as a few accounts of moderate earthquakes. The next section demonstrates how participants' accounts show a mix of social solidarities in their recollection of experiences with natural hazard events through accounts of preparation, response, and recovery.

3.4.3 Severe Weather

Most of the participants' accounts confirmed experiencing severe weather while at the ski field or other recreation venue in the mountains. Though the level of severity is certainly a subjective experience, the participants described experiences with severe wind, poor visibility, heavy or unexpected precipitation, and unexpectedly cold temperatures. They also provided detailed accounts of how they prepared for, responded to, and recovered from those situations in the past, and also how they plan to adapt to them in the future.

First, the context is set by an exemplary account of the experience with severe weather in the New Zealand Alps.

> Yeah, I've been caught out. Um, not necessarily by not knowing something was coming in, but perhaps some in the group or myself have moved slower. Maybe they are ill or there is breakage of their gear, so we've been out longer than we originally planned. And that's maybe pushed us into an area where we've had to experience bad conditions. Um, and that, um, might have become larger on a couple of occasions. But it comes from your training and people knowing where we are, what our expected times where, we had contacts, we had methods of communicating, and letting people know where we were so. It was really not putting any one else at risk apart from what was a recreational….we were choosing to go somewhere, it was not as if something came and got us out of the blue.
>
> On the ski fields though, um... Responding to or being in marginal days where we are trying to commercially operate. We are limited to how the lifts can work and how we can have visibility to find our way around safely. Ah and at times that, um, can change quickly from being just on the good side of marginal to being over protocol. And ideally we can keep tabs on that and, um, catch it before it comes on the wrong side. Not just for ourselves who are very familiar with the

> ski field, but for the public moving around. But occasionally it happens really quick, especially in New Zealand mountains, um and yeah I mean sometimes that commercial pressure is seeing those margin eradicate. And we should pull things back a bit. SIW 15

Both of the quotes above demonstrate that situational factors force the need to adapt. The ability to adapt is contingent on training and experience. Moreover, the participant highlights that there is a difference between going willingly into the backcountry, with an understanding of the requirements for small-scale adaption to the risks, versus staying within the boundary of the ski area, where there is a precarious balance between commercial pressure and protocols to enable safe operations. As well, the dynamics of the New Zealand weather (swift changing) dictates that preparations must be in place.

3.4.3.1 Preparations for Severe Weather

Participants discussed their preparations for severe weather by describing how they pay attention to forecasts and changing weather conditions, and knowing how to adapt.

> Uh, well, we've got weather forecasts. Everyone thoroughly looks at the weather forecasts no matter what your position is. Everyone's got a fair idea of what weather is doing. People have a good knowledge of weather, I should say. Um, and I suppose if you can predict the weather to some extent, then you can, uh, make the necessary precautions, such as— so, we're expecting a big storm and lots of staff coming in. And we'll go take down half the Ts on Ridge tow, you know, just so it doesn't get coated in ice and break off and, yeah. SIW 1

Individual preparation considerations included descriptions of appropriate equipment such as winter clothing, a change of clothes, and an overnight kit (e.g., sleeping bag).

> I put clothing – I have some merino clothing, they call it Icebreaker stuff. So I prepared that way. For weather wise and for the cold, yes, I've got a sleeping bag and just basic – some good gloves, good hat, good jacket, yes. That's pretty much me when I'm exposed to the elements. ASR3

Other participants noted that in addition to personal equipment being mentally prepared was important:

> As I said before, we have always got sleep equipment with you, change of clothes, you have got to be mentally prepared for if you, I think it is essential to be mentally prepared for a bivy[24] or to stay out, to spend a night out - - - psychologically prepared if you, because it is just, yeah because you can be prepared but then if you are not psychologically prepared. It is just going to, it is just hard to take in. So always have in the back of your mind the reason could go pear shaped and you might have to spend the night out, so evaluate things. ASR 4

[24] Bivy: is an emergency shelter.

In addition, several participants noted that experience and training was important to help deal with severe weather:

> I think the same types of things that I said before, so it is experience and training and having somebody making the decision and, I mean there are some other things that we do on the ski fields as ski patrollers, to make it easier for the public up there. Like if it is a white out, to put out markers so people can find their way. Or, only limiting what is open. Or, if it is too windy, which is something that we get a lot of, bringing in all the equipment so we do not lose it. Or, you know, sometimes you can't run the lift at the top of the ridge. Or, those types of things. If it is too stormy and the avalanche hazard is too high, just either waiting for the storm to pass and leaving that area closed, or doing control work. SIW 2

Other important considerations mentioned for dealing with severe weather included communication, safety, keeping track of personnel and clients, and looking ahead to consider contingencies. Consider a manager's perspective:

> Making sure that everyone is being communicated with as to what's going on. Making sure that everyone is in a safe place. Making sure that everyone is accounted for. The next steps out from that, are through key staff maintaining communication with them, meeting every half hour, talking about weather conditions. Longevity – what are the contingency plans for the next 24 hours, with food, with warmth, anyone with medical conditions, making sure we are aware of those people. Again, we're lucky on the ski area that we have a medical facility. So although it's considered remote, we do have facilities to support that, meeting any - most needs that come up. SAM 2

This manager's account highlights at least two different solidarities at work. First, there is the notion of collectivized survival (e.g., egalitarian solidarity), through making sure there is good communication, a safe environment, and that people are accounted for. Second, the perceptions of time show a balanced distinction between short and long. Additionally, he believed the strategies that are mentioned can facilitate "meeting any – most needs that come up" which is characteristic of the perverse and tolerant myth of nature. Another manager notes a similar perspective:

> Basically, we have a monitoring programme for snow and weather and avalanche occurrences. We have all of our avalanche paths mapped, all of our terrain identified and we know pretty much what sort of weather and wind and snowfall creates problems for us. And we close areas, we use different forms of management control, passive control and active control, and weather events, really it's a matter of just shutting down the mountain progressively, and getting people into a safe location and then evacuating them…in control now. SAM 5

3.4.3.2 Summary of Social Solidarities with respect to dealing with severe weather

In summary, participants described preparations for severe weather that embody three of the active solidarities. First, hierarchy is apparent in checking forecasts and changing conditions to make required adjustments. Training was also featured as an important means of shepherding people to safety. Second, individualized preparation is visible in descriptions of the need for personal equipment and psychological stability (e.g., an awareness of being "caught-out"). Third, there is also discursive mixing of solidarities (e.g., collectivized survival which is an egalitarian strategy), though satisfied through hierarchical cultures based on the following certainties: Procedural rationality, a scope of knowledge that is almost complete and organized, desired system properties that are controllable through inherent order, and a learning style of anticipation. By having strategies in place, they are generally able to keep hazards at bay and provide safety when experiencing severe weather.

3.4.3.3 Responses to & Recovery from Severe Weather

Most of the participants' responses highlighted that they were able to respond to severe weather in a manner that ensured reasonable safety. For example:

> Yes. Everyone was safe. Certainly with bad weather comes potential problems. Like, you know, all the cases I've been involved with everyone has remained relatively safe you know. There is possibly the odd cut or bruise that might happen because of something, but in general everyone is safe. SAM 6

A few other accounts highlighted how in some severe weather incidences, there were near misses:

> On one occasion since I've been managing this area – sorry, two occasions we've manually evacuated people off the chairlift. SAM 4

> At (ski area name removed), when I was managing there, we had one bad weather situation where we actually had to stop the chairlift because it was too windy to run, and then we had to evacuate people manually and the wind chill temperature got down to about minus 20. So we were hauling people off the lift in various states of, you know, beginning to get exposure, and that would have only needed to go on for another 10 minutes longer and we potentially would have had probably 75 to 250 people with injuries…with hypothermia or frostbite. So what we did on that occasion, I just immediately, as soon as it started happening I knew that we were in the poo, I just got a hold of the police and we started getting response teams and that together, and we didn't need them at the end of the day, but you'd want to be making that call earlier rather than later so you've got a fine line between things going well and then things going absolutely horribly wrong – there's a fine line that probably 15 minutes to half an hour maximum in that time, so you don't want to be delaying any formal calls. SAM 8

Another worker notes the consequences of severe weather on the ability to do one's job.

> Yes, many times. Lots of different experiences, from just simply having to call the area closed to being physically blown over, losing equipment; what else? Staying extremely overworked and tired because it is being stormy and that's when all the avalanche work happens. Yes, I mean I think it is something that has

a huge impact on what I do on the ski field. SIW 2

The participant stressed that severe weather has a significant impact on professional actions by limiting their adaptive capacity to operate the business or, more importantly, challenging their capacity to respond to natural hazard events when exhausted. A similar response from a ski area worker, provides a comprehensive account of working in an extreme environment:

> Yep, regularly, severe weather I don't know what the criteria is for your definition of it, but for us, stuff where the weathers um, not really suitable for public and or staff to be exposed to up here. And um, what I can tell you is that it happens quickly up here and um we do have plans for it, and we always find that we could have acted sooner and that the best bet is actually to try and use as much of the information that's out there on current weather conditions, um to plan to avoid mixing people with severe weather. Now that comes at direct odds to trying to run a ski area up here. If you close for every sniff of bad weather you'd probably never get open. But there's a line there somewhere where we need to be…we are sort of finding it. And the best thing we can do is be really ready to sort of pounce on it as soon as it does change um, they're um, they require a lot of staff resources the severe weather events they um tax all of our resources. We very quickly get to the point where we say ah, …, man's power up here is coming to a close' and you need to just get people to shelter and um stop trying to do too much in terms of machinery. SIW 5

The account above also highlights a discursive mix of solidarities. The business perspective regarding severe weather (i.e., "not suitable for public or staff to be exposed to") is collectivized manipulation characterised by a hierarchical way of organising. Yet this heuristic can be at odds with running a business (i.e. "closing for every sniff of bad weather"). Such frequent closings would be a behavioural strategy characteristic of the egalitarian myth. The participant then said, "But there's a line there somewhere where we need to be. We are sort of finding it". This point is distinctly hierarchical solidarity showing a balance between nature ephemeral and nature benign. Through learning the transformational properties of the systems under consideration, they can function with the view that nature is indeed perverse and tolerant. The participant also noted, "…the best thing we can do is be really ready to pounce on it as soon as it does change". This again is indicative of the hierarchist solidarity, based on a latent strategy of secure internal structure of authority. Finally, the participant explains that at a certain point "man's power is coming to a close and you need to just get people to shelter". This last point is important, because although it may be characterised as fatalism, it also highlights how there needs to be a certain amount of humility in the face of natural hazards. Fatalism is not, therefore, an irrational response; rather it is quite the opposite. It is wholly rational in the face of events that participants perceived as not being able to control, avoid, or manipulate to desired ends. The notion may be an indication of the autonomous solidarity accepting that nature is resilient and we are a part of it.

Accounts from ski areas managers describe difficult experiences caused by severe weather. In the first example, a club field manager describes dealing with a very high amount of snow.

> Ah, I would say early on the season we had 2.5 meters of snow in four days. And that really made life very difficult. And, for example, for the first time here we had to call in a helicopter to place some explosives cause ski patrol could not move. Essentially they were skinning[25] into chest head high snow, light and fluffy; and they just couldn't make headway. (SAM 9)

Another manager details the actions that were needed to adapt to severe weather,

> Have I been affected? I've certainly had to manage situations where severe weather conditions have come in and forced us to close the area. At [Name Removed] ski area, over a 10 year tenure there, I've had to stay on site overnight on three occasions. And on one of those occasions there were 80 guests involved as well that didn't get off the hill. And that was a forced closure of the ski area which led to a forced closure of the access road, and everyone that was still there stayed on site. On all of those occasions, the ski patrol were still fully equipped on site, and it was through our management plan for the ski area that they probably had the strongest liaison with guests, with monitoring the weather situation or whether it was the circumstances at the time.
>
> Because the facility was still closing down there were other department areas where food and beverage was available. We rallied around for enough clothing or rugs or locations where warmth was obviously going to be a requirement, and maintaining that for guests and staff. I think because we had shelter we were probably pretty okay. That was the big one. But there was a management plan in place and there were no issues with the whole programme. There was another occasion where we didn't stay the night but we had to close the ski area early and the road closed with that because a storm came in and the road turned pretty chaotic really.
>
> It was safe to keep people in the shelter of the day lodge. We had 600 people on that occasion for 3 hours luckily. They only stayed for three hours before we could actually drive them or get them off the hill. SAM 2

Another manager reiterates the experiences of severe weather and the key consideration of getting patrons down the road safely:

> Well we've had a number of days over my six years or seven winters here where the weather has affected us in a number of ways. One with the operations on the mountain and two with being able to get everybody down the road and out safely

[25] Skinning is a manner of Alpine travel where ski-skins (i.e. fibrous covers for the bottom of the skis) enable uphill travel as they grip the snow.

> to home, and that's involved both snow and wind being the two key ones that have affected us and in general. But yes, they've been the two things that have affected us the most with regards to the weather. SAM 6

In fact, these were common themes among managers; here is another account:

> Certainly within an operating day at Ruapehu, four or five times, um, you know, I have been part of where we've had extreme weather change, to the point where we have to one, get people to this base area, which is relatively easy to do. Um, and then we have held them here while we either managed their exit down the road, um, or held them at this level for a 12- to 18-hour period until the weather abated. And, you know, been involved in the management and relocation of people from either full exposure outside to inside buildings, um, or in vehicles or from vehicles back into buildings and then shifting them, you know, once you knew that they were going to be here for the night. And then try to ensure that they were either in the most appropriate building where they got the greatest comfort.
>
> At [Location Removed] here there's a village, um, 50-odd club lodges that normally on a Saturday are full, but they have a responsibility to take unexpected guests, and so we spread anything up to 500 people in those instances within their own buildings, um, or facilities and then within these club lodges for the night.
>
> So yes, natural weather events would, in that context be part of it. Certainly we have experiences. You know, driving the road is probably the biggest thing. Um, you know, where the weather is extreme, I've had experiences moving around the ski area, in, um, groomers especially with machines where the, um, weather is extreme. And moving around myself, you know, just skiing or walking or whatever else, where, um, you definitely needed to get into a building relatively quickly and stay there. SAM 7

Thus, the accounts anchored on three key considerations for affording safety. First, there must be an awareness of fast changing conditions. Second, there is a requirement to get people and oneself into shelter. Third, facilitating the movement of people down the access road is critical. On occasion, however, the weather can change too fast (i.e. a miss-match between expectation and results), causing a shift in solidarities.

Two participants provided accounts of being 'caught out'. First, one of the managers above noted,

> Um, while moving around the Alpine regions of [Geographical Feature Removed], I've spent an unexpected night out on the mountain because the weather caught us. We hunkered down in a snow mound. Sat it out. Ten hours later, 12 hours later, we walked out. Um, I've been through that, um, some years ago. SAM 7

Another manager describes an experience of proximity to others being caught out by a severe weather event that resulted in disaster:

> Probably the - well [Location Removed] we - I was there when we had the eight army people die, that was out of the ski area, but both ski areas were heavily involved in that, same time as a guy called Georgie Wamahu was missing, so in a, you know, the weather related thing there that was probably the most extreme. Yes, they'd just died of exposure – in the wrong place, probably adequately equipped, but poorly trained. SAM 8

The account above describes a tragedy as a result of severe weather where despite being properly equipped, insufficient training lead to eight deaths.

Many of the participants' responses highlighted experiential learning -- first hand experiences with severe weather are common in mountainous environments. One similarity in the accounts is that participants describe improvements in adaptive capacity or improved resilience through each experience with severe weather. The following accounts are exemplars of learned resilience through successive events:

> I suppose every time you are in a situation you learn. Yes, maybe a bit more cautious about some things. Like be a bit more aware of what's happening in the environment around you, the weather conditions, and yeah, just basically try and keep one step ahead of it. ASR 3

> Uh, I guess after every storm you've got to— more knowledge of what weather can actually do.… that happens every day up here, no matter what the weather's doing. But certainly in a big event, like a big snowfall, then yeah, you learn bits and pieces here and there. SIW 1

> We certainly debriefed the situation that happened the night before or the day before, and just reviewed anything we may have done differently or any opportunities to be better prepared. SAM 2

The three accounts above highlight how participants learn from each experience and through reflexivity convey the concept of adaptive capacity.

3.4.3.4 Summary of Severe Weather Experiences and Perceptions

The reported experiences of participants confirm physical occurrences, such as high winds and snow, and their responses, such as finding shelter, leaving the mountains, and/or being "caught out". Indeed, all managers and some staff reported that severe weather is a common occurrence, which translates into responses such as evacuation of the ski lifts and/or entire ski areas; closing the ski areas and access road; and providing safe shelter for clients and staff. Managers and ski area workers accounts also show how their ability to operate their businesses hinges on the management team being able to provide safety in a dynamic environment through various adaptations. In each severe weather event, the descriptions of participants' experiences indicate that the four social solidarities do manifest in the context, possibly moving through a full eco-cycle or adaptive cycle.

The respective learning styles of the three active solidarities were apparent for dealing with severe weather. The learning style of trial and error (i.e., individualism) is applied through carrying and adjusting the equipment that is carried in the mountains. Sometimes, however, the weather can be so intense that trial must not result in errors (i.e. egalitarian) as these have proven to be fatal. Yet each successive event helps them to better understand what to do in the future to mitigate the risks, thus a learning style of anticipation (i.e. hierarchy) is justifiable.

Some participants noted that the businesses have heuristics about severe weather which leads to adaptations such as shutting down lifts, closing off areas, and in extreme cases, evacuation of the ski area. Some of the workers explained that the weather can change quickly, and that decisions to act should be made early enough to ensure that people's exposure is limited. However, such decisions are at odds with running the business. Striking such a precarious balance between individual safety, operating a business, and collective safety requires transactions between individualist, hierarchy and egalitarian manners of organising.

As the descriptions above have demonstrated, adaptation according to participants, requires mostly hierarchical strategies with nested individual strategies such as carrying personal equipment and being mentally prepared for managing severe weather. However, at certain points, the weather can become too extreme and people's worldviews may shift toward fatalism if they are not adequately prepared. Moreover, safety must be afforded for all stakeholders, thus justifying an egalitarian solidarity. Participant's accounts thus embody a mix of different approaches for dealing with severe weather. These different solidarities or ways of organising satisfy a requisite variety condition, which enables stakeholders to adapt to severe weather.

An emergent finding is that participants may select solidarities that are role specific. For instance, managers and workers select solidarities that are hierarchical forms of organising; appropriate rules or controls (e.g., guidelines and heuristics) that enable the ball (Figure 2.1) to be kept safely in the basin. On occasion however, the speed at which the weather changes can cause people to be 'caught out', thus the ball rolls off the hump and out of the basin of attraction to a system of capriciousness, wherein a different strategy of individualised survival is justified. This was more prevalent in the views of alpine snow riders' accounts, which inferred mostly individualist ways of organising through: personal equipment, getting to safety, and understanding the dynamics of the environment (weather can change in an instant) justifying a scope of knowledge that is sufficient and timely. The participants also noted an underlying aspiration to keep “everyone safe”, hence the desired system properties are sustainability (through inherent fragility), showing hints of egalitarian ways of organising caught; a view that during severe weather humans are the ball precariously positioned on a mesa. To cope in the precarious position, the system appears to continue to self-organize toward hierarchy by shepherding people to safety based on a predetermined set of rules. Thus, according to the combined views of the participants the cycle is completed satisfying requisite variety.

3.4.4 Slope Hazards: Rock Fall, Landslide, Avalanche

Participants’ accounts of slope hazards also indicate that different social solidarities are at work within the context. What is more, their responses to avalanche in particular demonstrate transactions as well as transformation between different ways of organising. As well, participants’ accounts of slope hazards show the impact the experiences have on participants’ perceptions toward risks. First, consider two accounts of ASR:

> I was on a tiny slab that went. It was only like 20 or 15 feet around me, but luckily it was fine snow and it just like brushed away. I was able to ride to the side of it and kind of just brushed off, but it was exhilarating being in it. ASR 6

> There was a bit of an exhilarated feeling, I don’t know, as I say recovery wasn’t, there wasn’t too much recovery, I was just pretty aware I suppose at the time. ASR 2

Whereas a snow safety worker with considerable experience observed,

> Um, yes I have, um, seen all of those and the experiences are quite humbling, you realize that they’re completely out of your control, you know, once one of those events begin, they’re very powerful. SIW 4

Then an SAM provides a view that posits avalanches as moving, exciting, or belittling dependent on their scale and the proximity of one’s experience.

> Yes, oh it’s certainly quite a moving experience when you are involved in one. Uh, I haven’t been involved in one that’s…just sort of a class one or maybe one and a half, myself. Just slide it on top of slab and that was definitely exciting, watching them from afar especially on [name of geographical feature removed], you can see some pretty massive events, some of them up to class fours. The whole valley slides and it’s quite spectacular. Um quite belittling in a way you realize the power of such events. SAM 9

The three accounts above show three different perspectives on slope hazards. The first accounts from snow riders recall the lucky brush with an avalanche as exhilarating. The ski area worker, on the other hand, describes them as humbling, uncontrollable, and powerful. And, the manager provides a poised description as moving, exciting, yet also belittling. Thus, based on the myths of nature, the accounts are individualistic, egalitarian, and hierarchical, respectively.

As well as the three active solidarities, some experiences with slope hazards resolved fatalistic views in the participants' horizons. Consider the following:

> Yeah I have seen numerous avalanches and rock falls, cirac collapses and such like. And have, first, things are frightening - things to witness; fear then immediately comes to your mind. Am I standing in a safe place? Then you start to walk around and see where you are standing. What is that slope doing? What is that? Or, whether to keep moving or stay put? You know, there has been various times where we have done both. It is just wait till colder conditions? Or, you know, in the case of avalanches, colder conditions which doesn't always help. But yeah, in the case of rock falls, there is not a lot you can do with rock falls, it is almost as if you have got…., your name on it so no. ASR 4

The account above highlights how different strategies of adaptation can be applied to different situated risk. Participants described confusions regarding their current location (stay or go). Sometimes a mix of strategies has worked, but with respect to rock fall the participant leaned toward fatalism.

Although the whole endeavour of avalanche control is hierarchical in principle, it is not the only solidarity evident in participants' accounts. For example, when describing their experiences, a worker and then a manager describe the hodgepodge:

> Yes I have experienced these, I have caused some of them. It's a…pretty humbling with power. I have been caught up in some of these while controlling. And it's um, I wouldn't say it was scary it's just um the potential is scary, but in reality the way we work is despite being caught we work in a team, so somebody is going to be there watching all or minimizing the risks. But they never get totally removed. Unless we don't go in there at all, And that that's. It can be a very risky job depending on how you approach it and how you've been trained, and the way we equip ourselves, and the protocols are good to keep people safe. SIW 10

The first account reiterates the notion of humbling with power, describing being caught in an avalanche as scary or potentially scary, but suffices that through a team approach risks are minimized but never eliminated. Overall, the protocols keeping people safe are based on how individuals are trained and the team is equipped. Though there is a mix of solidarities in the participant's view, it is mostly a hierarchical perspective. The next account is different.

> I've witnessed debris flow, I've witnessed avalanche, I've witnessed rock fall and again, they just get over it. It's something that when it happens it's usually unexpected. Or the avalanches aren't, we usually manage to control them with explosives….But we have had controlled avalanches that have caused damage, but again there's no people involved in them. The unexpected ones are the ones that really trip you up sometimes. Like rock fall, we've had rock fall over a road in the past. Not this particular road, but the area access road where there's no witnesses, and the whole road is covered with rocks. It's piled up so you don't know whether there's a vehicle underneath or anything like that. So that's always an interesting one. It's only happened to me in my thirty years, it's only happened once but it certainly makes you think about your response I guess. SAM 5

The participant describes how with slope hazards 'they' [staff] just get over it because it is unexpected. The participant then distinguishes avalanches as not unexpected hazards because they are controlled. However, some avalanches can get out of control and these 'unexpected' events are challenging, yet they also help to generate thoughts about response capability. The critical point of the account above is notion of *surprise*, which might cause a shift in solidarity from hierarchy (i.e. controlling avalanches) to events that are unexpected. The key example is rock fall over the road where without witnesses one is forced to question response capabilities, and in such an instance, a precautionary approach may be justified.

A distinguishing feature to cause a shift in solidarity appears to rest on whether events are manually controlled or uncontrolled events. Yet, consider the following statement;

> Yes. There's been multiple of them [avalanches]. And again some have been, you know, triggered manually controlled, and others were uncontrolled, and there's been, there's deaths involved and those sorts of things. So there's a whole process there. There's media involved. There's coroners involved. There's police involved. So there's a multiple, you know, it's yeah. It's unfortunately a function of the business. SAM 8

Regardless, when deaths occur as a result of avalanches, other players come into the fray to examine what went wrong. Though the participant does not delve deeper into the purpose served by other players, the comment suggesting that it is "unfortunately" part of the business of operating a ski area is a recognition that one function of such investigations is to assign blame. Blame can be assigned to the individual, the hierarchy, the collective, or in the fatalist position, no one. It appears that the total elimination of the risks according to managers and workers is not possible; and it may not even be desirable. This can be examined by delving deeper into accounts from participants who had a high level of experience.

Participants who had a high level of experience with slope hazards described avalanche incidents variously as beyond control, humbling, powerful, and frightening, while for others, interactions with slope hazard are exhilarating, exciting, and, as the next account displays, potentially tragic. After witnessing a snow avalanche that caused a death, a snow rider conveys how it changed their perspective.

> The one in there [Ski Area] I just really – I didn't go skiing the next day, I just didn't – I just kind of lost my "Zen" for it you could say, I just lost my appetite and I just didn't – I was looking at the mountain like a lot differently, like it didn't look like so much of a playground any more, it looked more of a kind of a death trap, and so I didn't ski for a day or two after the accident, yeah. ASR 14

The participant above describes a transformation of solidarities based on their risk handling style. Initially, the participant was individualistic in accepting the risks, but after witnessing the death, they changed to rejection and deflection; from individualism to egalitarian. Lastly, they reverted to hierarchy (that is, rejection and absorption) by not skiing for two days. Thus, in this instance the participant's account provides another indication of the transformational properties of the solidarities driven by a contextual experience after directly witnessing a tragedy from a hazard/disaster event.

Snow avalanches, and the weather sequences that contribute to them, were the most commonly reported natural hazards, and they were viewed with a mixture of humility and admiration. Slight undertones of fatalism are present, as sometimes these hazards exceed expectations; the goal of controlling them or minimizing their impact being reported as not at all an easy task. Hence, the approach to managing slope hazards, particularly avalanches, is viable from the hierarchist way of life, but if we look deeper, we can see that this way of life depends on transactions from other solidarities as well. This was evident by the way participants described a struggle to afford safety of stakeholders similar to that described in participants' accounts of severe weather.

3.4.4.1 Culture of Safety in Responding to Snow Avalanches

The participants' accounts indicated that there is an ingrained culture of safety in the ski industry for managing avalanches. The culture of safety will be conveyed, while also drawing attention to social solidarities.

Safety was a common theme among the SIW, especially those concerned with avalanche control, yet a worker notes how sometimes safety is trumped by fatigue and the need to open the area.

> I think there have been times that it hasn't been entirely safe, particularly during avalanche/ rock control work, and that generally is because of prolonged storms. Where I just end up getting over tired and not getting any sleep and working

> really, really long days and I think that fatigue is a really big factor in my job. And the other big factor for avalanche control work is that there is always pressure from either its management on other places I have worked or it's from the public or club members that want to get going, want to get skiing. So I think there has been occasions when that pressure has led to trying to do things in a rushed manner, yes. SIW 2

The tension between the snow safety teams (SIW) and the clientele (ASR) may be due to a lack of direct experience with the consequences of the slope hazards. Those whose primary responsibility is safety, such as ski patrol or personnel in the Safety Service Department , hold the view that personal safety is critical. This is logical--if personal safety is compromised, the patrollers themselves are not able to service an environment that is safe for others.

> Yep, that's always our main deal for the Safety Service Department is to keep your own safety as a priority. If the incidents already happened if there's no point in us…we can't help any further in a um injuring ourselves. When I think of clientele, I think of my staff as well, because they're customers of mine in some ways… And so if we had an avalanche activity…um problem in a gully or in some area then we would have to look at why that happened? Should we close some other areas? Have we missed something? You know. So I think yeah, we do maintain customer safety. SIW 5

3.4.4.1.1 Culture of Safety in Accounts from Club Field Participants

Maintaining the safety of customers and staff can be regarded from the perspective of cultural theory as a demonstration of a hierarchical worldview. The task of doing so is supported by individuals whose primary responsibility is their own personal safety, which is individualist; however, by looking after their own personal safety also provide a service to others. This was more apparent through accounts of alpine snow riders in the club fields who are more responsible for their own safety and in doing so, look after the club's interests too. Consider the following account:

> Always carry shovels, probes and transceivers….almost always, very rarely don't. In training we used the transceivers as well, a lot of people don't know how to use them so we have to be, muck around finding wood piles and things like that and when we're bored around on the beach sometimes, you know, so we do things like that. So always be prepared in that regard, you know, with your equipment and like simple things like know how your, know how your bloody probe line works so you can get onto it quick smart. And if anyone does go down in an avalanche that would, you know, if you were doing a grid-like fashion[26],

[26] Grid searches are used to locate people buried in an avalanche. "Once the search area is within about 2m, the searcher should hold the transceiver low (less than 1m above the snow surface). The searcher listens (or watches) for the signal becoming stronger, then weaker. When the signal begins to fade, the searcher

> doing it in a civilised fashion and not panicking. Yeah, stay on top of the situation, always try and remain calm, you know, this is an extraordinary situation so people will lose their focus and go a bit silly so yeah. ASR 4

Participants in the club ski areas noted that each person is expected to help if someone is buried by an avalanche. Therefore, though wearing a transceiver appears overtly individualistic, if you are buried, you are not able to rescue yourself. You depend on others to rescue you. This means that individualists (who have sufficient preparation and training for avalanche rescue) can help form a collective (egalitarian group) to commence a rescue if needed. Such was the case when an avalanche occurred at a club field, as described by two ski industry workers from club ski areas:

> They're a lot more prepared to dig in and know what to do themselves… yeah, that's what happened up at the ski area where we had the avalanche; it was amazing, everyone was there ready to go. SIW6

> The first avalanche I experienced and I had a um and avalanche experience at (Ski Area) where we were um waiting...it was quite a big snow day um they were bombing the hill and doing all their patrol work and it took'em three hours to open the ski area. And so once they opened it we all assumed that it was safe and they had done all the work you know and um...We were skiing sort of mid-mountain section and um we didn't even know it but an avalanche was coming down behind us and took me and another guy out. And it actually started from a very very tiny little couloirs.[27] A guy was just sort of at the top of that. Sort of just about to ski it and he triggered off a little sluff, which turned into a, which knocked off a bigger pocket, and that started a slide. Um but luckily we got sort of hit by it once it was at the bottom and sort of fanning out so it wasn't um, it wasn't too dangerous. Um, but that closed the hill down for the day. And um someone saw three skiers, but there were only two of us so um. Someone who was whiteness to it said that there were three of us skiing, but it was just me and my mate and I couldn't account for someone else. There may have been someone else there so they had to shut the hill down and bring in the chopper and dogs and probe lines and that was quite a mission, quite an adventure. We all sort of probed that avalanche debris for hours and hours and it turned up that everyone was accounted for and it was kind of just sort of…you know he thought he had seen three people but there were really only two. SIW 8

The above description provides considerable detail of the full cycle of an avalanche. First, the participant described a snowstorm that delayed the opening of the field. Once the area was

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immediately returns to the midpoint of the strongest signal bracket, makes a 90 degree turn, reduces the volume until the signal can just be heard (or watch for the lowest reading on digital display), maintaining the orientation for optimum signal strength, then walks in a straight line at a right angle to the original direction (See Appendix Z for illustration).

[27] French word for "passage" or "corridor" is a deep gully found in mountains which are prone to avalanches especially if their slope is sufficient (i.e., between 36 and 55 degrees) (Owens et al., 2002, and McClung and Schaerer, 2006).

open, the individual skiers assumed the area was safe based on a risk handling style of acceptance and deflection because the risks were been taken care of via avalanche control. The individualist's myth of nature benign was *surprised* as an avalanche, started as a small event that grew to a considerable size, hit them. A shift in perspective occurs; the two hit by the avalanche accept and absorb the risk, while recognizing that luck was on their side--a fatalistic perspective. Subsequently, the participant describes how the precautionary principle was selected, as witnesses were unsure as to how many were hit by the avalanche; hence, erring on the side of caution, they closed the hill and began the avalanche response. Many individuals heroically probed, but in the end it turned out that no one was buried. The participant questions the precautionary principle from a substantive rationality, and thus vindicates his solidarity of individualism, portrayed in the following statement:

> Um ohyeah, the one at (Ski Area),… ah that was it for the day they closed the ski hill and I thought that that was a bit of overkill, I think they could have...but that was just me um...They were very erring on the side of caution in a big way. They have an avalanche they thought someone was buried in it, they flew in dogs, they had probe lines, they didn't find anyone. Um...they could have quite easily opened up the ski area again and kept skiing. There was no damage to any of the facilities, but they um...I think everyone was so freaked out by it they just called it a day you know. Um... it was one of the best days of the season, so we were all a little bit antsy and wanted to get back out there. But no so that kind of did stop the whole process yeah. SIW 8

The vivid description highlights the participant's individualist perspective that is critical of others (i.e., outside of his worldview, constructing a *border*[28] between himself and "they", those making the decision to close for the day). This example is interesting because the "they" SIW 8 has referred to are employing the precautionary principle, which is characteristically an egalitarian way of life. Normally, those inside a high-group, low-grid solidarity based on collectivised survival create the border. This highlights that the individualist solidarity, which is normally not concerned with the border between themselves and others, recognized in this case a hybridized social solidarity, an egalitarian group employing the precautionary principle which is also imposing prescriptions hierarchically on others (e.g., high-grid). In this instance, "they" describes both hierarchists (e.g., ski field management), and egalitarians (e.g., club members) who organized against the views of the individualist. The results of their decisions to close the field forced the individualist to experience the "border" between him and those who hold power in the given circumstance.

[28] Border in this sense is, as Douglas and Wyldavsky (1982) highlight , a firm boundary between individuals based on their solidarities.

The result of this, the decision to close the resort, therefore, strengthened adherence of SIW 8 to the individualist solidarity.

3.4.4.2 Culture of Safety Accounts from Commercial Field Participants

The Culture of Safety in the Commercial Fields is different from that of the Club Fields. Specifically, a hierarchical perspective was overt in accounts from participants associated with commercial ski areas, with respect to their response to avalanches. For instance, consider a managers account of their preparation:

> Policies and, you know, so right from ringing the police, how to deal with the media, the next steps through the process, who actually takes control – all those sorts of things, because again they happen immediately and if someone gets caught in an avalanche you don't want to be spending 20 minutes arguing whose going to be in charge and whose doing what. You know, it's got to be instantaneous and it happens it absolutely happens like that. SAM 8

The manager's account above expresses the preference for a hierarchical approach: communication with external assistance; appropriate messaging; chain of command; coordination is essential, and it works. Overall, the manager's account conveys the desired system properties of controllability (through inherent orderliness). A ski patroller echoes this view and describes the elements of a hierarchical response as critical to ensure viability of the business:

> We have a whole mountain plan of how we go about gathering information. How we know about the geography of the actual terrain and um...knowing where these events happen when an avalanche happens. Which is just a map and um detailed of all the different avalanche paths that can slide. And that goes down the road a little bit for snow, doesn't go for rock slides and things, which we do certainly get a bit of erosion on the road um and that control plan also covers um how people are trained, how information is gathered, and how it is going to be taken care of. Meaning what sequence things need to be controlled. If there are any closures that need to be in place. How many departments whose information needs to be put out to other agencies? Should we be bombing, should we be restricting access to areas for other people? How many people need to be involved in that to safely um and efficiently, so we have to…commercially we obviously want to know whether we will complete the task. So there is a bit of a driving force there too. So how many people are we going to need to get in to take care of business so we can actually be earning for the day otherwise it wouldn't be worth it. So its um feasibility I guess just to see if it took more people than we could get or that we can afford to actually open. SIW 10

The account above supports a hierarchical way of organising, by first portraying a scope of knowledge as almost complete and organized, and then by suggesting a procedural rationality with respect to adaptation strategies. Moreover, hierarchy is apparent from the notion of high group and nested-bounded groups, in terms of communications between departments and the number of people needed for success and efficiency, as well as high grid with regards to restricting access. Interestingly, the participant also shifts discursively toward individualism, conveyed through a shift to a cultural bias of pragmatic materialism, supporting the business earning, but then retreating to hierarchy, implying a delicate balance to ensure they can function.

A description of an avalanche incident at a commercial ski area also depicts the hierarchical solidarity of commercial ski areas, and yet again the participant constructs a border between the respondent's personal world view and the 'they' (e.g., paid staff, ski patrol, managers, and responders):

> Generally it's just the patrol will just close that part of the mountain off. I think they were very quick in responding …, they had an avalanche dog up there as well. They had that in there and there was just – the field was just shut down straight away. Everyone was gotten off the field then just ropes were set up. Everyone that was capable of being pulled in was pulled in. Then it was seeing - then they with the process of seeing – because they scan all your tickets and stuff – they've got everyone's name on the register, who's on the field. Just making everyone accounted for. They had everyone down at base building just checking their names off sort of thing. You know, they were pretty much 80 per cent sure, because a few people saw it and everyone was sort of like 'I'm pretty sure everyone got washed out'[29]. But it all happened so quickly, you know. You're not able to say for sure everyone got washed out the bottom of it. So yes, it was responded to pretty well – as well as it could have been I thought. SIW 15

The participant's account presented above justifies a hierarchical response given the speed at which avalanches can happen, and the ensuing uncertainty associated with their consequences. Similarly to the account of the club field incident, people were not certain everyone escaped. In such instances, the consequences of being uncertain are so high that a precautionary approach (egalitarian solidarity) overrides the hierarchical response. Finally, the participant justifies the response, showing a hierarchical style of information rejection, namely, paradigm protection. A manager also conveyed the notion of paradigm protection in the following account:

> Well, I know from experience that as an example many years ago we had an avalanche through the base building of one of our ski areas, with a significant amount of damage. We had the ski area back up and running in two days, and this particular building here burned

[29] Getting washed out the bottom of an avalanche means that luckily there were no people buried in the avalanche, as the energy from the avalanche extracted them from the bottom.

> down in 1986 and we had a temporary building and stuff up and running within three days. SAM 5

Thus, through their experiences and protocols they are able to adapt quickly to keep the operation running.

Another common theme with respect to recovering from avalanches highlights a notion of reflexivity among all three of the participant groups. First, two ASR describe the event from different perspectives:

> I just carried on skiing. It didn't really affect me, just apart from making me more aware sort of thing. It was pretty cool. ASR 12

The account above indicates some degree of reflexivity on the part of the individual. Whereas the other ASR drew more than just heightened awareness:

> Yeah, definitely, that is, just think more, it's like don't get – how you get to use extreme tunnel vision, and so use my brain. I don't make calls that aren't – make calls that still maximise skiing but also maximise safety, perhaps don't be reckless. But like – doing skiing you're always like allowing for certain amount of risk. So there's always going to be that bit of risk of jumping off a cliff or going too fast, like it's a risky sport and that's why I don't think people like it. So it's a question of having a certain amount of risk and being comfortable with it without making bad decisions and so forth, so avoiding dangerous conditions, yeah. ASR 14

The above ASR account shows reflexive elements that are more indicative of hierarchy; yet, in the first ASR account, the participant was more individualistic.

For the SIW, the reflexivity ranged from informal to formal. For example, an SIW with limited experience notes,

> Well, take a first step reflect on the extent of the damage and the experience. Learn from, like, take the learning points out of it, and make the required changes. And, yeah. SIW1

An SIW with a considerable level of experience explains it differently:

> Um so we usually have debriefs on how things have gone daily, on those control days, those avalanche control days and um and certainly, as we review the documents at least annually, to see whether protocols and any incidences were um either down to somebody not following protocols or um in case of failure of equipment or something like that. SIW 15

This account highlights how debriefing exercises are very much part of the culture, and how they occur at different time scales (i.e., daily and yearly) to assess whether or not protocols were followed, or whether incidents result from equipment failure.

The notion of debriefs was also a common concept in the managers accounts. First, consider this example:

> We closed the mountain for the day, we debriefed. There wasn't much more we could do but we started from that day moving forward on how we can prevent this from ever happening again. So it's all about prevention. SAM 4

In addition, the following is a more detailed example that highlights the components and information garnered through the exercise of reflexivity:

> We certainly debriefed the situation that happened the night before or the day before, and just reviewed anything we may have done differently or any opportunities to be better prepared. But at the same time we started the next morning as another day of operation. So we carried on. Well, an assessment obviously. Any avalanche will give you information as well about the snowpack. We also do digging pits to check what snow stability and layered snow consists of, out and beyond where you know avalanche hazards exist. There is always a debrief after an avalanche control rout has been completed, just sitting down and documenting everything that's occurred which includes all your snow stability information as well, and a verbal debrief with the team to get everyone's input as to what they thought was going on around about. Opportunities, I mean those sorts of things are pretty much down pat as far as what you do and why you do it. So it's more or less just everyone being on the same page at the end of a debrief with what the snow conditions are like, and what we're expecting to see, whether it's developing over the next few days or certainly what we have got historically in the way of information to realise what's happening at the time. SAM 2

The notion of debriefing and the mix of approaches in how participants express their experiences with slope hazards indicate that the autonomous solidarity is present in the context, but it is a way of organising that is difficult to capture. I will try to convey how the autonomous solidarity is implicit within this situated risk by summarizing the accounts about slope hazards.

3.4.4.2.1 Summary of Slope Hazards & Social Solidarities

Over time, as the participants confirmed, experience in mountain communities has improved their ability to adapt to slope hazards. However, the participants said that the hazards, in various forms, still present danger to ski fields and communities. Interviewees noted that managing these hazards depends on a multitude of approaches, or as I have attempted to highlight, a *requisite variety* (Chapter 2). The participants described mitigating dangers of the slope hazards through personal preparation and collective response, active control and procedural rationality, and hinted that on occasion an acceptance of one's fate is justifiable. There were differences between participants of different contextual preference, that is to say club fields or commercial fields.

In the club ski areas, the descriptions of perceptions and adjustments to slope hazards seemed to be most reliant on individualist and egalitarian worldviews, through carrying appropriate equipment (e.g., avalanche transceiver) and knowing their use. Thus, it was apparent that the salient risk of threats, (the potential for catastrophic, irreversible, and inequitable developments e.g., an avalanche ultimately resulting in death) support a transaction connecting individualist and egalitarian forms of preparation. This is also supported by a scope of knowledge where individualists are prepared to respond in a sufficient and timely manner, linked to an awareness that even though their knowledge is imperfect but holistic, they can handle the risks by acceptance and deflection (e.g., carrying and assuming that others carry transceivers) or rejection and deflection (e.g., the members of the club know how to respond so for the members (e.g. those inside their boarder) the risks are minimal. Lastly, these solidarities show both styles of latent strategies: the individualist preservation of the individual's freedom to contract (i.e. choosing to wear a transceiver), and the egalitarian's survival of the collective (i.e. assuming all people wear and know how to use a transceiver).

Responses to avalanches from club field participants, as described by participants, illustrate how two of the cultural theory's solidarities are interrelated; individualists and egalitarians, through their consideration as group members within a particular context (in this case, the ski field, post-slope hazard occurrence). The need to prepare for a slope hazard was related more often as an individualist task, but in doing so, the combined efforts of the stakeholders contribute to an improved safety culture among the community of snow riders at a particular (club) field. Since the club field culture is more apt for individual preparation, due to more challenging terrain, there is also quite often a feeling of membership or camaraderie, and a personal sense of responsibility for others as well as oneself. Hence, the risks are shared amongst users at club fields, fostering collective survival. This is interesting because while it might seem that transactions between individualists and hierarchists are more likely, both of these strategies also indicate positive grip, the third dimension of sociality (Thompson, 2008). Yet here, with respect to avalanches, there is a distinct synergy between individualized manipulation and collectivised survival, which is not characterised by either positive or negative grip, but lies rather somewhere in the indistinct middle ground.

In the commercial ski areas, participants' accounts indicate a more pronounced preference for hierarchical forms of organization on the part of the management team, forcing the individual to the margin of organized patterns. The scale of risks in the commercial fields may be the driving force of hierarchy: more people, more infrastructure and thus more risk favours a scope of knowledge that is almost complete and organized and thereby favouring controllability through inherent orderliness as the desired system properties.

At commercial fields, the sentiment described by participants was that the responsibility for safety lay with the management and safety officers (ski patrol) at those fields. Transferring responsibility away from the individual might mean that the users were less likely to perform individual preparedness measures, forcing them into a position of negative grip. This may reduce hazard awareness, creating a higher degree of risk for the community of users at commercial fields, and transfer to an even higher level of responsibility for the ski area management; thus the managers are forcing themselves into a position of positive grip.

A persistent theme reinforced by some of the accounts above is the notion of speed at which the hazard event occurred, leading to uncertainties of whether people were affected. This is perhaps why the hierarchist worldview is selected as the predominant response in commercial ski areas. Elements of individualists' worldviews are also present, with the need for personal safety and appropriate equipment. Yet the possibility for uncertainty, perhaps from an awareness of avalanches through direct experience, caused some participants to transfer responsibility of "controlling" the hazards to the ski area management and staff. As well, egalitarian ways of life are present in mitigating avalanches, when individuals band together in an organic response to assist victims of those avalanches. This type of approach was not overtly present in commercial field participants' accounts.

In general, participants perceive avalanches as one of Nature's complex and uncertain phenomena where exercising adaptability is essential for a viable way of life. Hence, participants' overall report that mitigation of slope hazards (mostly avalanches) is viable with hierarchists, individualists and egalitarians in constant transaction and transformation. However, when avalanches are large enough (e.g., class VI avalanche), their catastrophic potential invokes fatalism; in the case of major avalanches, there is not much one can do if they are in harm's way. Perhaps when major natural hazard events have high levels of complexity and uncertainty, the potential for disastrous or even catastrophic consequences pushes solidarities toward fatalism. Looking into participants' perceptions of earthquakes might help us understand if this is actually the case.

Overall, the variety of strategies for mitigating slope hazards highlights transactions from each of the four viable ways of life described in Chapter 2. The hermit solidarity was not overt, but was present in participants' views of the constantly changing conditions in the mountains. The notion of change and the uncertainty associated with dynamic environments force people to adapt. Moreover, ski field stakeholders' ability to adapt to avalanches seems to embody cultural theory's requisite variety condition. Elements of preparation for, response, to, and recovery from avalanches highlight how participants have evolved transactions between the different active ways of life, leading to resilience as the desired system properties (i.e., being able to adapt, respond and recover) in the face of these common hazards. Are social solidarities resolved similarly when considering less common hazards such as earthquakes?; this is the subject of the next section.

3.4.5 Earthquakes and Alpine Ski Areas

This section presents participants' response to questions regarding their preparation for, response to, and recovery from earthquakes that could affect alpine ski areas. It begins by highlighting the few participants who had direct experiences with moderate earthquakes. It then highlights how most participants had never considered the possibility of an earthquake affecting them while they were at the ski field. Finally, it highlights some of the socio-cultural viabilities that emerged from participants' response to questions about their perceptions of earthquakes affecting the ski areas.

3.4.5.1 Direct Experiences with Earthquakes in the Ski Fields:

During the interview process, it was discovered that a few of the participants had experienced an earthquake and shared what their experiences were like:

> Would have been work party summertime, early 80s. And ah, we were putting posts into the inclinator, on those quite steep parts. Cause we would have to let ourselves down with ropes, digging holes, and pissing around. And we went up to the huts for lunch. And ah…sitting in the huts and the whole place just shook you know, like someone outside the place took the whole place and gave it a good shake. It was really sharp. It wasn't a gentle rocking it was sharp and you could hear rocks all around the hills just thundering down and falling around. Yeah so that would have been the early 80s. When they were building the gondola, ah the goods lift up there, first putting the posts in. ASR 15

One of the few ski industry workers who had experienced an earthquake described their experiences as follows:

> I only experienced one on the ski field and that was on [Ski Area Name Removed] in 1994 and that was the first time I'd ever experienced an earthquake in the mountains and I thought there'd be more avalanches than what had actually happened. There was more rock fall – was coming off rocky outcrops off the very tops of loam that was flying down the hill and massive boulders. But the actual snow didn't sort of, so there must not have been enough and so a weak layer there for the snow to get a shake and leave, it was mostly loose rocks that got a good shake off and tumbled down the hill. SIW 20

Thus two participants confirmed rock falls occurring in relation to the earthquake. The first account took place in the summer time, hence there being no snow for snow avalanches. Yet the second account highlights an expectation of avalanches, but ultimately shows that rock fall was actually more common. In addition, another participant who experienced an earthquake also describes an unexpected result of an earthquake:

> Um, while on a heli-ski operation we had an earthquake about 100k's away, and it was early in the morning, and immediately after we did feel it, I think it was between a or 7 magnitude, and um. We felt it at our guide's room, and weren't sure where the epicentre was, or anything. So we immediately jumped in the helicopter and flew around our range, our skiable terrain, just to have a look if it had affected anything. And it in fact did not to the eye affect anything. We walked on the grounds later and in the coming days, we didn't see any cracks or anything, but I would think there would have been significant settlement. SIW 4

The comments above on earthquakes confirmed that participants were aware that earthquakes could cause physical consequence, yet that the nature of the consequences can be uncertain, fickle, and even counter-intuitive.

Another participant describes an earthquake and its effects confirming similar experiences to those above but also introduces something different:

> The earthquake was um certainly unpleasant, the one I experienced.
> (Nod) Very unpleasant, twenty seconds seemed like forever. And it was yeah really noisy, loud, beds were rocking, power was gone.
> Yeah um, well um, there was all the books in the living room came off the shelves. A lot of them, there was um, a couple of cracks in the ceiling came from that particular episode. Um, yeah there were, and there were various other reports of you know things in other people's houses smashing. It was more the noise I think the rumble that was so loud. …SAM 11

The participant confirms the noise, the effects of shaking on physical items, disruption of lifelines, some damage, and again reiterates the intense noise. The difference between this account and those above is the description of time slowing down.

3.4.5.2 Earthquakes: A Novel Hazard

Earthquakes were viewed as a novel hazard in this study; that is, prior to the interviews, most participants had not considered the consequences of an earthquake occurring while they were at a ski area. With respect to earthquakes and their consequences, participants consistently responded that these events were not a substantial part of their horizons. For example, three ASR responses are provided below:

> No not an earthquake, I have never considered that here in New Zealand, very little. ASR 2

To be honest, not really no. ASR 4

No, I never have. None; I don't think about it at all. ASR 6

Ski area workers, particularly those concerned with snow safety (e.g., safety services, avalanche control, and first aid) also highlighted how earthquakes are not a key consideration in their day to day work. Moreover, some described how they and others had not concerned themselves with the hazard either:

> I think an earthquake would be a bit of a shock, because nobody has thought of it. As far as I know there is no formal plan so it would be a matter of just having the fact that there are people on the staff who are ski patrollers and are kind of trained to deal with emergencies. SIW 2

Interestingly, managers share a similar perception, as two managers explain:

> It hasn't been something that really has caused an issue in any ski area that I know in New Zealand, that we have a record of, you know. So it hasn't been one that has been at the forefront of my mind for sure. SAM 6

> No…I hadn't until you turned up. SAM 11

Thus, a consistent message from the stakeholders was that earthquakes were not something with which they concerned themselves. A few, on the other hand, had given it some thought. First, a response from an alpine snow rider:

> I'm not currently sure what kind of preparation you can have for an earthquake while you're on the slopes apart from a receiver if it does trigger a slide or something like that. I've never really given it much thought. ASR 3

Consider as well an account from a ski industry worker:

> Yeah, not a lot. You know, Once or twice I found myself kind of well I wonder if, are we…are we missing that hazard out of our overall planning. And um…how would it affect me? Hmmm… SIW 5

Next, a ski area manager stated:

> Um, well we have um, when people arrive we ask them to be equipped for any event. Um, it's a difficult one, cause we really, it's sort of, it's one of those things we don't really plan for. Because its um, hum? SAM 9

Thus, the three accounts above are all similar in that they convey a lack of consideration about earthquakes; yet, they are different in their suggestions for adaptation. The alpine snow rider suggests the earthquake-avalanche relationship and having a receiver[30] as a coping mechanism. The ski area worker notes that earthquakes are a missing hazard in their planning and wondered that they could be personally affected if one occurs. The manager is markedly different in suggesting that there is an expectation at the particular club ski area that people are equipped for any event. The first two accounts of the rider and worker therefore seem to accept the risk, while the manager in this instance transfers the risk. That is to say, the manager actually transfers the risk of earthquakes onto individuals, perhaps because he/she had never actually considered it in detail and thus had not planned for it.

Another manager also implies that it is a hazard that has received little consideration:

> Thought about it but not, well I guess we – and not throughout New Zealand but certainly in this location earthquakes are rare. Earthquakes of any size are even rarer. So my perception is that there isn't a major inference on earthquakes. At the end of the day we have an emergency response plan that, like any disaster that happens in a ski area, there is the same principal issues that are identified and there is a path to go down, in a general sense. I mean we have, without going through the actual emergency plan, I couldn't off the top of my head tell you the specifics. SAM 2

This last account is interesting because it highlights a rejection of information that holds earthquakes are rare and large earthquakes are even rarer. It is not a direct rejection of information being provided about the occurrence of earthquakes; rather it is an implicit rejection of the notion that they ought to worry about earthquakes, given that they already have an emergency response plan in place. This is distinctly an information rejection strategy characterised by paradigm protection, which is characteristic of the hierarchical solidarity.

Thus, the accounts pertaining to earthquakes demonstrate that there is little consideration for earthquakes, and that there are differences in perspective regarding who is responsible for their management. The next section delves deeper into this issue, by presenting accounts of participants' preparation strategies for earthquakes.

[30] Receiver is a one-way device that receives a transmitted signal so that rescuers can locate people in the event they are buried in an avalanche. These are part of a technology call Recco, which is more common in commercial ski areas. Some apparel (e.g., jackets) are fitted with one way transmitters that send a signal to a receiving station at a centralized location on the ski area. This is different to a transceiver with both sends and receives a signal.

3.4.5.3 Preparations for Earthquakes

Some respondents' accounts imply that others were responsible for mitigating the risk of earthquakes at ski areas. Consider the following elements of preparation from Alpine snow riders:

> Procedures, emergency procedures. ASR 4
>
> Okay, you'd want to have a good supply of water and food…. A backup generator for power. Maybe some sort of radio or something just in case the main lines are down….Communication, yes. …A plan, yes… Like a certain procedure that was well known… Maybe do drills, maybe? ASR 3
>
> Okay. You'd need to have an emergency plan… Okay. Employee training, that's all I can…Their emergency response…. I don't know what they call it – ski patrol, should I say… Evacuation. A buddy system…. Accessibility to a hospital for location. ASR 6
>
> Sort of what you should do if caught in an avalanche, so sort of tuition on, Yeah, avalanche education…. Probably a warning system on like how likely it is that an avalanche would occur. ASR 9

Thus, the ASR participants believe that there should be key things in place to mitigate earthquakes, such as emergency procedures and emergency personnel (i.e., ski patrol), evacuation considerations, avalanche education and a warning system. Therefore, the mitigation considerations from riders imply sharing of responsibility between management, workers and riders.

Managers included similar considerations in their accounts. For example:

> In the event of an earthquake?... Sure, shelter. Access, first aid, communications, water or water and food. Primarily 'water' I thinks' more important. SAM 2
>
> An evacuation, an initial plan, road equipment, medical staff… A lot of that's covered in the evacuation plan so food and water and you'd want communications. Yes, that would be some of the key ones. SAM 6
>
> Well, certainly the facilities that we have where the people are likely to be, buildings, lifts, primarily, are designed to comply with NZ Earthquake Codes so that we have a reasonable expectation that there will be no building or lift collapse. SAM 7
>
> In preparation wise I think it would be just our straight evacuation schemes… In an earthquake, the only other, the other one again is, you know, you're evacuating people out of the buildings, and the other one would be evacuating people off lifts so I'd imagine that would be the primary. SAM 8

Ski area workers also noted similar considerations, but a few were more specific about required steps for mitigation and adaptations. Consider the following examples:

Um, practice with that emergency plan, practice with the implementation of it I guess, would be a good variable, um, yeah – a good exit. SIW 4

Ah my spelling is going to be shocking. Emergency procedures, preparation, that's about it really. Oh, training, you have to excuse my spelling it's terrible… Prep work, so you want – is it – what's happening in real life or what should be happening? Assessment reports done by experts. Am I doing it for the ski field or my job? {INTERVIEWER RESPONSE} *From your perspective, so for your job… at the ski field.* Okay. So like meeting building codes is not part of my responsibility. SIW 11

…The most important variables – so for a start I think having an emergency plan. But I think within that plan there would need to be for an earthquake on the ski field, there would need to be an analysis of what the likely sort of outcome would be, or the effects on the land in that particular area. So I don't know quite how to summarise that. And then on buildings and other infrastructure as well. Yes. So for a ski field I imagine there is quite a lot of different buildings as well as ski lifts. … I think if that's been the question then it is understanding what is likely to happen to that infrastructure, and perhaps if you have that understanding then you could look at reinforcing or earthquake proofing buildings and that type of thing. So I think understanding sort of like the first step and once that has been done, coming up with some cautionary measures if earthquake risk is a real risk in that particular area. …Also for preparation I guess, which is normally in place on ski fields anyway, but having good emergency like medical people and supplies to hand. SIW2

Yeah, mostly, initially we need to have the…its gotta be that first initial reflex task and what, what whats gonna, what actually happens straight away. And how do we respond to that as a ski area. Um…so you need emergency planning, you need to make sure your staff know everyone, everyone knows what their role is to play in that emergency response. And they need to trained regularly to respond appropriately. And then we need to test it and check it and re-do it, keep improving. SIW 5

The workers included notions of emergency plans, lifts, and training, but also focused attention on other tasks such as analysis and reports, building codes, and trial runs.

Interestingly, despite the above considerations about what participants thought ought to be done about earthquakes, given that most had never even considered what to do about an earthquake *in situ*, it is not surprising that these hazards are generally not included in risk mitigation material. Consider the following responses from managers and workers:

I'd say zip. None, the only preparation, I'd say if anything happened to the lift alignment, the safety system on the lift would take care of that automatically. i.e., a derail would trigger emergency stops on both lifts. SAM 13

I don't think anyone's really put much thought into it if a big earthquake happened…. Yeah I've come up with a hazard evaluation for the whole area right from the road to top of the mountain and thinking about that; that actually doesn't mention anything about earthquakes as a hazard. But there was a hazard

> evaluation, a list of all of the different things and how you eliminate, mitigate or deal with the problem and I've read, and again not one mention of anything if an earthquake happens. SIW 20
>
> Ah, I've never thought about—well, the only avalanche/earthquake relationship that I've thought about was in, ah, when it occurred in [Ski Area Name] area….I am not aware of any ski area in the country or, in fact, the world, in fact, that I've been to where earthquake has ever been mentioned in any material that I've come across. SIW 9

The above comments were quite consistent in all but two interviews where ski patrollers explain that they developed a plan because of earthquake activity:

> Um, we do have, um, its real basic preparation, but earthquake is in the emergency response plan and that is due to the fact that there's a correlation between an avalanche that killed a snow-cat driver and that snow cat driver where he was driving and when this happened there was an earthquake, and I forget how far away it was from here, but the epicentre was near here so we've brought that into our plan. And it's nothing really specific it's just, it's just a heading in a book you know. SIW 5

This account is interesting because even though the participant is aware that the consequences from an earthquake have led to a death in the ski area, the earthquake portion of their emergency response plan was referred to as "…just a heading in the book…". This is an indication that the social solidarity with respect to earthquakes is somewhat fatalistic rationality.

3.4.5.3.1 Summary of preparations to earthquakes

The above comments outline how earthquakes and their consequences are a novel hazard for stakeholders of alpine ski areas. The first comment from the manager demonstrates a hierarchical perspective based on an engineering aesthetic of high tech-virtuosity, while the workers and manager convey a different message that earthquakes are not really on anyone's horizon. This might lead one to believe that they are fatalistic when it comes to earthquakes, but this may be partly a reaction to a rare and not well known catastrophic event. What is more likely is that the hazard posed by earthquakes is so novel to most participants that preferences for particular social solidarities pertaining to that situated risk have not stabilized in participants perceptions, thus perhaps fatalism is selected as a first impulse.

3.4.5.4 Responses to Earthquakes

Once we moved deeper into responses to earthquakes, participants did highlight the variety of social solidarities, but also were overtly fatalistic about the capacity to respond to an earthquake. For instance:

> I think ah, if you asked an avalanche expert, you know, what would do in an earthquake they would just throw their hands up in the air and go look you know. You just better get lucky say your prayers (chuckle). I don't know maybe they are trained up on sort of the stuff like that as well. SIW 8

This is a clear account of a fatalistic rationality and learning style based on luck with respect to earthquake response. There was also some notion of solidarities changing within the accounts of earthquake response. For example:

> Oh yeah, for the ski field we have um: set avalanche atlas; first response plans; everything basically; I mean it's written down. You know when those things do happen, it's all a shit fight and you really, it's all chaos. But we do have, we are trained and we do um run over the scenarios several times a year. But yeah, our main event is just an avalanche. It's all we really, and fire, for the lodge. Mitigation through you know control, basically that's it. You know for the rest of it, you just sit back and watch. You know. SAM 9

This account above starts by indicating hierarchy through a scope of knowledge that is almost complete and organized by referring to avalanche atlas and first response plans, but then shifts to describing the system properties as chaotic. It then transfers from fatalism back to hierarchy, suggesting consistent training for avalanches and fire; namely, desired system properties of controllability (through inherent orderliness). Last, the participant changes again to fatalism, a risk handling style of acceptance and absorption.

Thus, many participants did have an apparently fatalistic approach to the risks of earthquakes that can have consequences for ski areas. They believed they could not, on the whole, prepare for them; that earthquakes just happened unpredictably, and the participants were 'along for the ride'. Moreover, several of the people who did not wish to participate in the study leaned toward fatalism when considering this hazard. Their lack of participation is not what makes me view them as fatalists. Rather, it was the comments they made while declining participation. For example, in declining an interview, one participant declared, "oh you can't do much about earthquakes up here…if your number's up, it's up… or down, I guess. At least you'd be doing something you loved". But again it should be stressed that they have not spared the earthquake hazard much thought; fatalism might be just an impulsive response.

The majority of the participants perceived that there would be adverse physical effects from an earthquake affecting a ski area, including avalanches, rock fall, and damage to buildings, as well as aftershocks that could pose major challenges to the response efforts. When I further prompted the participants to imagine what the ski field would be like after an earthquake, many were able to detail their ideas of flow-on effects. The accounts of the effects were different among the targeted stakeholder groups.

Some participants did note that the ability to respond was conditional on a variety of factors. Consider the following account:

> I've thought about how it would affect the people and how it would affect probably more our facility at base, what that would do to our business and that's where I think about the relocation of the actual business being at the base and I've thought about how we extract the people from the slop like if we've got an issue with the road which is more than likely considering the stability of our road. SAM 4

The above manager also noted that it would be a challenge to cater to their clientele, but believed they could manage for a brief period.

> For a very short time though. Because we know, we're prepared for a minimum of two days. A minimum of two days, probably a maximum of seven to be able to cater for people. SAM 4

A different manager outlines some of the challenges that an earthquake might pose:

> Well, apart from the typical building collapse, and then what you would end up with is, then you may end up with probably lift failure of some description, maybe a cable would come off. If a cable comes off then you've got lots of hurt people. So again it would be just like any emergency situation, you start prioritising, what the, …the people lying broken on the ground will dictate where your resources end up going to. SAM 8

This is an example of how the physical consequences of the earthquake could lead toward fatalism. The participant describes some of the possible physical consequences for infrastructure, and outlines how it would be approached similarly to any emergency situation prioritising hierarchically, but then seems to shift solidarities toward fatalism, saying the "people lying broken on the ground will dictate where your resources end up going to".

Several participants also described that the fickle nature of earthquakes (that is, the inability to precisely locate where, when and at what magnitude they are likely to happen) presented a dilemma to the participants, making it difficult to detail whether they would be able to manage the effects of an earthquake. A ski area manager noted how the weather and number of people could alter the priorities of response:

> If it was a nice sunny day like today, you know, the priority that happens today might not be the same priority on a day that it's snowing in exactly the same event and the weather conditions are a bit different, or if we had an earthquake today and you know there's only 300 people on the ski area or 1,000 it might be quite different to how you treat it if there were 3,000 or 4,000 on there. SAM 2

A worker explains that they believe the smaller areas would be more resilient because of the perceptions that the smaller fields are less at risk:

> Yes, I think the smaller areas would be a lot more resilient. There is less to manage. Yes, there's less at risk. The nature of a larger number of people in one area would mean that there would be a lot more risks. SIW 6

The last two accounts highlighted a theme that emerged where participants were aware that the number of people would make a significant difference to the level of risk.

Several participants also highlighted how the size (e.g., intensity or magnitude) of the earthquake would have an influence on their response capability. For example, a manager notes:

> It would depend on the size of the earthquake; I mean we might all go down the crap (laughing). I wonder what happens to the fat fryers if we have a nine on the Richter scale. Yeah the fat fryers, the Chippies'll blow for sure (laughing). It's actually quite a hazardous area in an earthquake when you think. Like the shop for instance all those gas bottles. SAM 11

Interestingly, the thought of large earthquake (e.g., a 9 on the Richter scale) causes the participant to trivialize the notion, and draw instead upon their sense of humour ("we might all go down the crap...the chippies'll[31] blow for sure"). But then the manager seems to realize that the ski area is a hazardous one when it comes to earthquakes, as demonstrated by the subsequent change of tone. A ski industry worker also noted how the damage caused by an earthquake is an important consideration:

> I think it depends on the amount of damage the earthquake causes really and what type of damage, it's very hard to say. If it was centred right there and it was huge then maybe not. SIW 2

The account above outlines how if the location of the earthquake was in close proximity to the ski area, then a response might not be possible; this is yet another indication of fatalism.

Several participants also noted that the novel hazard and high number of variables lead to uncertainty about what they ought to do. Nevertheless, some did provide some anecdotes about possible responses. For example:

> Well there is (sic) a lot of variables. So I guess, I don't know exactly, but try to make contact with somebody who seemed like they were in a more stable situation. And yeah I guess there is some reliability. I don't know exactly what would happen so it is hard for me to imagine how I would recover from the situation that I haven't experienced. So it is kind of a difficult question. ASR 2

[31] By chippies the participant is referring to French Fries.

Others had some consideration for an assortment of possible consequences. Here is a prime example of the high level of detail provided:

> Yes – just I mean a lot of snow can affect you like in blocked roads, so I mean snow something like generally only lasted – I mean you could wait a day or two and you would probably be fine, but like an earthquake I mean the road is out. I mean there is very little – on a ski field, there is such minimal amounts of supplies. I mean you would probably run out of food. The club fields and staff and cafeterias – if you have got hundreds of people up there – yes, there is just going to be - maybe the club fields would be better because they have catering facilities. So they probably have quite a lot of food, but when they have people up there I would say, but if all those people are up there, then they are going to use all the food.
>
> So, people like – there is going to be people on day trips that are going to be in trouble because they have just come up for the day and brought their sandwiches and they are going to be without food. They are going to be without a combination to a degree depending on how badly damaged structures are, they are going to be yes – …. Depending on the magnitude obviously, if it is meaning that you are not going anywhere – if it means that there is no way to get down the main areas that I see, it would be a question of finding somewhere warm to sleep and wait and finding enough supplies to make you comfortable to survive.
>
> I do not think that you would starve to death or anything but you definitely would get pretty hungry – if you are like having to go a couple of – I mean New Zealand has not got that many people and the majority of them are in the cities, so once cities are kind of recovered, then I reckon that getting people out of those tricky situations would not take you know too long. So, I would not see that you would be stuck up there for longer than maybe five days. ASR 14

Most of the participants concentrated on trying to describe the physical consequences of earthquakes, but rarely were other types of consequences (i.e., psychological, behavioural, access to emergency services) described. A few of the participant responses highlighted the concept of emotional or social damage that the experience could bring, including the stress to rescuers and ski field owners/operators themselves, or that there could be a vast scale of disaster.

> As a response I think having either trained or just skilled people at dealing with people, dealing with distraught people and latching onto people in the chaos **…** going not going on the sort of different sectors that will have to recover, like there will be all the people who have been injured or affected personally by it. So I think to help those people or the families or the community recover is probably going to take a lot of community support-type stuff. SIW 2

Some of the managers explained that they would approach an earthquake like any other hazard but there was still some uncertainty about this novel hazard. For example:

> Well an earthquake, I think would be similar to what we already encounter with a

number of things like you know, wind and snow causing an issue. So I think we've got good plans in place where we've got you know all our stocks of water and food; and we'll have equipment and you know, we've got medical staff, we've got safety guys, we've got good communication, we've got radio. So that sort of disaster would be similar to a number of the sort of events that happen anyway. So I think we'd be well prepared for that really. I think the only issue would be the, probably buildings. But the buildings in snow areas are built reasonably strong anyway to withstand a lot of snow and weight. So I think that the buildings would be in reasonably good order from that point of view. SAM 5

The account above captures the perception that an earthquake would be like any other hazard. The participant highlights several coping mechanisms in place, pauses for thought about buildings being a concern, but then reasons that buildings have been built to withstand the weight of snow. This is another indication of discursive response: initially the participant reasons that their coping mechanisms are sound (e.g., paradigm protection), but drifts to worry about their buildings, then reverts to the hierarchical solidarity reasoning that the buildings are sound.

Another manager notes they would respond in the same way to an earthquake:
In the same way that we would with any other event. Certainly once that the situation has been either isolated or eliminated we would sit down and review everything that we went through during the course of that incident and look at ways to improve. I don't doubt that there would be opportunities there. I would be a fool to think that there wouldn't be opportunities. But at the same time I'd like to think that again the general processes that we go through – certainly we are in recovery mode from the time the incident happens, right from that point on we are in recovery mode. SAM 12

This account highlights how they believe there would be a great deal to learn from the earthquake, to improve their future responses. But in general, there is a belief that ski fields' processes for managing hazards are sound. Yet again, a different manager highlights a perception that they have a plan in places for managing an earthquake, in this case for evacuation:

Just simple evacuation plans, just,… um,… just the ah….I mean the standard evacuation for any event. And um, with communication we've got basic plans. But if power goes then basically someone has to walk off. SAM 1

This is interesting, because at first the evacuation plans are described as simple, then standard, but if power is lost then evacuation on foot is required. Other participants from workers stakeholder group saw the matter quite differently:

Could be evacuation, trying to get people out of here if the roads still there or not. It's probably the only main one. If we had to get people out of here, how are they going to get out? SIW 20

Obviously they have got some heavy equipment up there that, yeah, once the

> bridge is out; the bridge is out sort of thing. There is a helicopter service sort of at the bottom of the road just up the valley a little bit. So in that situation there is enough helicopter operating companies around I guess to get people in and out. But if there was a lot of people up round by the vehicles. It's quite a drastic one I guess. SIW 10

> I guess my main thoughts, are how we? Or at least the main should be, particularly how would we get from the ski field back. Back into like our community. Like how would we get from there to there? The roads would be, you couldn't get off the roads. Um, in the event of a big earthquake, it would be chaos. And probably the car parking and the vehicles would be wiped out and things like that. So the main issue would be um, how would we get back to our community? In the event that we couldn't get back to our community. Well simply, how long would we last up there with the gear that we had? So it would be the food that we had. With our gear that we had. And I guess I also thought about how ready or how experienced are lift operators and people in the ski field, um in travelling in a situation like that. ASR 12

Thus, some of the non-managerial participants believe that evacuating the ski area would actually be quite an undertaking. These participants also recognized that external assistance might be required to respond. For instance:

> The aspect would be based on all that information that you are going to get in really. How good the information is um, and what really the scale of things. If we can handle…, like most disasters not necessarily just earthquakes, but if we can handle something in house if we had the resources, personnel and equipment to respond and take care of something um than that's fine. But if something is bigger in scale, either geographic scale or intensity, or um or in duration. Something is lasting a lot longer that we can't sustain our work in responding to that. Then we need to look for outside help. So co-coordinating with police essentially is our main um avenue of gaining more resources. Which is more just, more personnel trained or equipped personnel. SIW 15

The account above outlines recognition by an experienced ski patroller that there are limits as to what they can manage. Another participant from the same group recognizes that they are responsible for preparation, but that they are a part of a network:

> Yep, for sure yes its interesting being in this situation you know um, I guess where we are responsible for the company being prepared. We're not the end of the road we are part of the team that is part of working up here. We need to all be part of that process. And um, going up to the avalanche, or up to the [geographical feature removed] last year to pick pieces of the guys that were in [geographical feature removed] when it [natural hazard event 2007]. That was quite a um,eye opening experience to go out into that really recently erupted volcano crater area. And um, yeah I think we underestimate or we don't actually acknowledge, without actually having to have some experience like that it's really hard to acknowledge or even anticipate what it's actually like to be around something that's got, that's that powerful. And I think, I haven't never,…I've never experience a big earthquake but even small ones that sort of carry on you start to get a feel for what the actual, How powerless you are so you know so, that

> volcanic stuff gave me a new um, that going up last year, gave me a new sort of motivation to be involved with, to further our preparation, to further our planning in that stuff. The more we talk about this stuff the more I realize we're um, um you know we do need to look at not just how our current plans, how good our current plans are, but what are we not planning for. So um yes it's triggering some good thought processes in my mind. SIW 5

This account was exceptional in that it highlights several key elements of hazard mitigation. First, that although the responsibility for preparation does lie with particular entities (e.g., the individual, the ski patrol, and the business), there is also a team of people working who make up that entity. Also, drawing from direct experience with an expected event (i.e., Lahar), the participant realized that they may underestimate the hazards. It took the experiences of a hazard to recognize this. Moreover, an experience with a hazard that exceeded expectation instilled motivation for further preparation. Finally, the interview process itself did help to highlight some potential gaps in planning.

3.4.5.5 Summary of Response Capacity to earthquakes

In the section dealing with what participants thought should be done to prepare for earthquakes, participants highlighted some excellent considerations. Yet in accounts of their actual response capacity, participants highlighted fatalistic tendencies, but show indications of other solidarities at work including hierarchy, individualism and slight undertones of egalitarian forms of organising.

3.4.6 Recovery from Earthquakes

Accounts of recovery considerations will now be presented to illustrate participants' perceptions of recovery considerations. First, consider these two accounts from riders:

> Well, first of all you've got to make sure the area is safe and do checks on all the equipment and stuff like that – the lifts. Make sure everything is up to standard safety wise… Assess the procedure that's gone before and find any faults that went wrong and maybe try to improve on what's happened. ASR 3

> That's a tough one, you would just have to, I imagine a huge, a lot of debriefings including staff and you know. Insurance policies and all the those type of sensible situations would have to be evaluated and before re-cert or anything like that…ASR 4

The two accounts above highlight two different perspectives. The first suggests recovery is straightforward and implies hierarchy in terms of standards, adjustment to procedures, identifying faults, and improvements going forward. The second implies that recovery is a more daunting task and its hinting at egalitarian organization suggests comprehensive debriefs and assessments to certify safety. Both imply that safety, debriefing, and assessments need to complete prior to opening the area.

Workers described how recovery would be contingent on a variety of factors, including debriefing and assessments as well more detailed considerations. There were some differing views among the workers. First, consider the following accounts from three club field workers:

> Just go back to normal I'd say. It just depends how much damage there is to the infrastructure and that and how long that would take really to get things back up and going. If they've not covered by insurance? SIW 20

> I think time is the biggest healer really and I don't think you can put a time on it; it just depends on the scenario. With my business, with [Business Name Removed] we have a number of ski areas so the other ski areas would continue if it was in one area and perhaps that ski area would hold and it wouldn't go any further. It's really up to the discretion of the skier really as to what they do next. Could be a number of elements, safety would be the first one, financial abilities and so forth as well. SIW 6

> Well obviously, a big volunteer— in a place like this there'll be a big volunteer response from— so the club needs to help rebuild any structures and that, that may have been destroyed. So yeah, the cleanup process and, yeah, they'll have to get that underway. SIW 1

The accounts above highlight different myths of nature as perverse and tolerant. The first account notes that the amount of damage would need to be assessed, and the amount of damage would correlate with the time required to get field up and running again. The second account notes that although a ski area may close as a result, there are other areas that would continue at the discretion of the skiers. The third account reiterates the notion of the discretion/influence of the skiers (the club members) as they make the decisions and allocate human resources to rebuild. The next account reinforces the situational considerations associated with recovery, and provides more details about specific elements of recovery:

> So to recover from Damaged Infrastructure and so on I guess. It is just a matter of if it is viable to rebuild and to rebuild in a way that the same thing won't happen. But hopefully the preparation would have, you know, you would not get to that stage, but I think for recovery, if you are talking about recovering a ski area to the state it was in before, then exactly. You have to rebuild. Yeah. Yes. So I think all the infrastructure, anything that has been damaged really. So it might be roads, it might be buildings that have collapsed. It could be terrain that has changed its shape. And as far as economic recovery, it is not really my specialty. I think probably things like a good message in the media and that type of thing would perhaps come into the feature at some point. You know,

managing the media. Convince some people that it is safe to go back. It can get quite tough. SIW 2

Another worker notes the fundamentals that need to be repaired, mentioning "similar" themes as above, but in relation to response instead of recovery:

> Um well it would be the access road, would need to be repaired. So, that they can get vehicles and whatever else in there and out of there. um. Accommodation, um you know I'm just picturing if there was a situation like this and the club fields are such a unique example because there are so small and...and dinky and I'm sure that a lot of the buildings there would, would handle a very major earthquake because they are only single story and they're very you know wooden structures. I'm sure they could handle a lot of abuse. But I would say um, I would say the access road um power and um they get their water from the mountain off springs and things like that I'm sure that would always be flowing, perhaps not; its' hard to say. And obviously the accommodation, being a winter environment you need to get shelter out of there so um, but I would probably have to say it would be the road followed closely by the accommodation. SIW 8

The above account notes again that the access road, power (electricity), and accommodation need to be dealt with. When referring to accommodation, there is a belief that small is good and the timber frame buildings could be resistant to earthquakes. Thus, the account is implying that the club fields could be resilient to earthquakes contingent upon roads and accommodation.

Interestingly, the workers note that the club members could be useful in helping with recovery. A manager from a club field reinforces the notion of situational constraints, but also provides some scepticism given the constraints:

> Ah, oh it would be massive. You know we are in a situation as a club that does all the maintenance on its facilities for example. Where we don't have a lot of membership anymore, don't have a lot of money. Therefore, the situation would be I think irrecoverable. If it was major event. Of course we are insured for that, but we are talking a massive amount of down time between event and recovery. Of course depending on what time of the year it happens, that um would make a big difference, but um… you know um it's just a simple where we are, and I suppose where most ski fields are, the logistic of actually rebuilding or actually building anything is a massive one, and especially with no access road. You know that increases costs massively. SAM 9

There were similarities in the accounts from the ski area workers at the commercial fields. The first similarity was the implicit notion of situational constraints:

> If we can handle…, like most disasters not necessarily just earthquakes, but if we can handle something in house if we had the resources, personnel and equipment to respond and take care of something um than that's fine, but if something is bigger in scale either geographic scale or intensity, or um or in duration, something is lasting a lot longer that we can't sustain our work is responding to that…. Which is more just more personnel trained or equipped personnel. SIW 15

The notion of outside resources was also apparent in one account from a club field worker's account.

> The sort of different sectors that will have to recover, like there will be all the people who have been injured or affected personally by it. So I think to help those people or the families or the community recover is probably going to take a lot of community support-type stuff. And I think that is where the outside resources would probably provide that, perhaps a little bit beyond what happens at the ski field. SIW 2

Participants from the managers group also highlighted considerations that the riders and workers had in both the club and commercial fields. First, a manager points out the following:

> I guess the…relates to…recovery, well it's all about, I guess, it's about initially how it's managed…how we manage that recovery, how we…yeah, timeframes I guess, timeframes for… I guess for repairs…or media work…SAM 5

Another manager backs up the situational nature of recovery, while detailing similar themes to the accounts presented above:

> Well that would depend on the damage but we would be doing control work. We'd certainly do avalanche control work, we would be doing road clearing to make sure it was clear and safe and the key thing would be making sure that the lifts are safe, and that may take a little bit of time. If we felt that it was severe enough to cause any alignment problems on the lift and that could cause us some issues, cause alignment problems. SAM 6

Thus, the manager above points the transition from response (avalanche control work) to recovery (road clearing, making sure lifts are safe, etc.), and the possibility of lost time to deal with the possibility of lift alignments. In fact, lift alignments was a common concern among the members in the managers group. The next account from a manager provides considerable detail regarding the key considerations for recovering from an earthquake:

> It would be a huge job because you've actually got to - I mean you've got a sewage issue, which you know there's so many variables. We're like a small community here so we would have to look at the whole infrastructure of the business. We would have to get lifts up and running, we would have to get the facility up and running, we'd have to get the sewage up and running. We generate our own electricity on the hill so that could mean a long period of getting that up and running again, which isn't just a quick fix because we don't have mains power.... We get 300 kilowatts of mains but to run our business we're generated – two 500-kilowatt generators. So there are lots of different aspects that would need to be monitored to see that they're a 100 percent operational…. I wouldn't be rushing it. I wouldn't be wearing a commercial hat that was thinking I needed to be generating some revenue. I would be taking it step by step and ensuring that everything was back in order…. And that would happen even if was a small-scale earthquake but a larger scale I think you always treat a little more gently… Depends on the season you know. To be honest if it happened in September I

> wouldn't even attempt to get up and running. If it happened in the second week of September I'd look at it commercially and go it's not - the effort that's going to go in and the pressure that it's put people under it's not actually commercially worthwhile. But if it happened at the very start of the season you'd have to look at that quite differently and you'd have to chunk it down and look at the areas that are important and it may mean that you operate the season where you don't run certain parts of the business – you may run it with a very small café and turn your business into a bring your own lunch. We've got skiing; we've got a ticket booth at the bottom of the road and operate out of Portacoms. SAM 4

3.4.7 Summary of Considerations for Recovery from Earthquakes

Participants' accounts stressed several key considerations regarding recovery from earthquakes. First, a common theme present in their accounts is the situational nature of their ability to recover, which was contingent on damage and the availability of resources, thereby suggesting a hierarchical solidarity based on the myth of nature as perverse and tolerant. Second, the items that were viewed as crucial for successful recovery included assessing and repairing the roads, buildings, power, lifts and water, which all hint at individualism based on a substantive rationality. In addition, implicit in the accounts of recovery is the need to conduct assessments to ensure the ability to operate safely after an earthquake, highlighted through accounts of direct consent (e.g., a desire to know that the area is safe). Moreover, a few accounts noted that working with the media would be an important tool for communicating with stakeholders. Some participants described recovery in a fatalistic light (i.e.., recovery might not be possible); others implied hierarchy, suggesting recovery would be possible (i.e., detailing specific tasks), though it could take considerable time to open, depending upon the nature of the consequences from the earthquake, thus demonstrating a balanced distinction between short and long term.

3.4.8 Summary and Integration: Perceptions of earthquakes

It is evident that across the three stakeholder groups, the idea of an earthquake affecting the ski industry and their particular ski fields is a novel one. Furthermore, the idea of personal preparation for an earthquake is new. A few stakeholders did give evidence of consideration being given to 'what might happen if there were an earthquake', but most pointed out that the thought never manifested in any further preparatory action or planning. Some respondents indicated that they thought it was the responsibility of the operators to plan and manage such an event, while others suggested that it is up to individuals to have the wherewithal to be prepared for *any* event.

In the participants' considerations regarding response to earthquakes, there is a mix of different social solidarities. Some participants highlighted fatalism, in a belief that there is little one could do in the face of nature's capriciousness (e.g., "we might all go down the crap"). Several highlighted hierarchy, appropriate procedures and controls that could hold the ball in the basin of attraction. A few accounts portrayed individualism as the way of organizing in the face of earthquakes, detailing personal equipment, knowledge that is sufficient and timely, and being able to adapt to changing conditions as they arise.

Some critical questions arise from the above perceptions: (1) whose responsibility is it to be prepared for an earthquake in or near ski fields? (2) What elements need to be discussed by stakeholders to begin the process of developing policy and practice to prepare for, respond to, and recover from earthquakes when they directly affect the ski areas? (3) Do the suggested elements embody one particular solidarity (i.e., elegant solution)? Or does the collection of elements embody the five ways of organising (i.e., clumsy solution)? These questions highlight that there is the opportunity for much more research in the context, or relating to earthquakes in general. However, in this study, I have attempted to answer these questions using fuzzy cognitive maps. Now a discussion will help re-orient the reader prior to presenting the results from fuzzy cognitive maps.

3.5 Discussion: Participant's perceptions of natural hazards

The horizons captured in participants' accounts of three different natural hazards, in this interpretation, do show four of the viable ways of life as described in cultural theory. Participants' accounts showed how social solidarities actually changed throughout the individual interviews as they considered different questions and even within particular responses. Some participants' accounts may have impulsively selected certain solidarities (in the case of earthquakes, for example, fatalism appeared to be common), but some participants also relied on ways of organising that were applied to common hazards such as hierarchy, individualism, or egalitarian. The selection of solidarities may be dependent on the social context, the risks, or their experience - that is, people may favour particular solidarities circumstantially.

The accounts indicate how people do mix the solidarities depending on the specific event they are dealing with. This reflects a finding known to cultural theorists, which stresses that preference for a given solidarity over another is often contingent upon the situation (Adams, 1995, Thompson, 2010, pers.comm). Moreover, it is difficult to interview a form of solidarity; as Douglas (n.d. in Thompson, 2008) insisted, you have to be sensitive to the transactional context.

> You do not want your individual to be hopping about from one solidarity to another while you are trying to understand one of those solidarities by talking to him or her (Thompson, 2008, p.142).

I had hoped to use participants' accounts to categorize them into social groups based on preferences for one or more solidarities; however, this was not possible. Although the collective accounts from particular social groups regarding situated risks inferred preferences for specific social solidarities, the individual participants' accounts also implied changes in selection of solidarities; some, in fact, changed throughout the interviews in several accounts. In any event, some general conclusions can be drawn from participants' accounts of the three different hazards.

Severe weather was an alpine hazard familiar to the participants. Their accounts show some commonalities as well as differences. One common message from all three stakeholder groups was the notion of the swiftness of weather changes, as well as the possibility for conditions where humans cannot survive. Sometimes, these sudden weather changes can happen so quickly that people are 'caught out', causing people to shift solidarities to fatalism - 'survival of the individual'. The differences among the social groups may be role driven; for instance, the managers and workers seem to view severe weather from a hierarchical perspective, based on a scope of knowledge that is almost complete and organized (through accurate weather forecasting). Furthermore, practising and refining procedures for dealing with severe weather implies desired system properties of controllability (through inherent orderliness). The alpine snow riders, on the other hand, selected individualist strategies, using equipment knowledge and mental toughness to get oneself to safety. Implicit in most of the participants' responses is an interest in the safety of all, a latent strategy of survival of the collective, which is characterized as egalitarian, where humans are fragile in the face of severe weather. This view provides justification for the procedures and practices to provide shelter from the elements. Hence, managing severe weather appears to be a mostly hierarchical endeavour.

Similarly, in coping with avalanche hazards, participants described a mix of solidarities. Avalanches, more than severe weather, show distinct transactions between two or more ways of life that are contextually-based on situated risks. In the club fields, there are overt transactions between individualist and egalitarian ways of organising based on the tit-for-tat use of transceivers. In the commercial fields, where avalanche control is more centralized and is driven by staff and managers, the snow riders who reported a transferring of risk to the operators (i.e., individualist acceptance and deflection) are pushed to the margins of organized patterns, thus holding them in a fatalist position. Regardless of the context, participants also report that some avalanches are so large that if one is caught in harm's way, a fatalistic rationality is justifiable.

In general, participants had difficulty in answering what they perceived could happen if an earthquake affected a ski field because, as they said, they had not thought about it before then. What this general lack of consideration might suggest is that, overall, given the potential consequences outlined in the introduction and highlighted by the geomorphic assessments, there may be a need to consider the consequences of an earthquake (including secondary, tertiary, and flow-on effects) that could occur in close proximity to a ski area (or any recreational area) while they are operating.

More poignantly, there may be a requirement for education about the earthquake hazards in general that ski areas face. An earthquake on a ski field is the type of problem that could elicit the various solidarities given by the cultural theory, but without prior experience in this realm, social functions are not predisposed to clear preferences. However, as noted, some participants did draw from perspectives on other hazardous avalanches and severe weather to describe their views on earthquakes.

Individuals had not considered the risks from earthquakes that can affect ski areas; hence, 'proper' conduct is not established. Participants likely select their preferences for individual self-sufficiency, hierarchical social order, or collective social action, or simply giving up based on experiences with other hazards in a particular context (e.g., club or commercial ski areas), because of limited experience with earthquakes. The groups characterized by an earthquake affecting the ski area have not determined the consideration of the environment as robust, fragile, capricious, and so forth. Experiences with severe weather and slope hazards helped to provide a familiar benchmark. After eliciting lived action-coping strategies for common hazards, participants were able to suggest adaptations for earthquakes. The interview process thus helped participants identify gaps in their own knowledge, and it may have been a starting point for expanding the existing culture of safety.

The participants provided detailed accounts of their experiences with and perceptions of natural disasters and natural hazards that are particular to the mountainous environments. Participants' accounts highlight selection of various social solidarities according to cultural theory. The ability to adapt to the myriad of risks and hazards that are present in the context of alpine ski areas appears to rest on interactions and transactions from the four viable ways of life. What is more, each of the viable ways of life is wholly rational to individuals' and possibly the collective's horizons in conditions of situated risk. Overall, it appears that managing natural hazards is contingent on the *requisite variety condition,* using strategies from the five different viable ways of life.

The qualitative interviews provided useful information about the status of hazards awareness with respect to severe weather, avalanches, and earthquakes. In particular, participants' perceptions highlight a variety of ways of organising with respect to given hazards, but how can we extend this qualitative information to model potential strategies for improving mitigation of an earthquake hazard, which seems to have received little consideration from the participants? In the next section, I will attempt to extract further insights about hazard mitigation specifically dealing with preparation for, response to, and recovery from earthquakes that can affect ski areas. This may also highlight particular social solidarities that are implicit in how the participants perceived earthquake hazards.

3.6 Results – Fuzzy Cognitive Maps

> The contemplation in natural science of a wider domain than the actual leads to a far better understanding of the actual. (Edlington, n.d.)

This section of the results seeks to provide a deeper understanding of how stakeholders perceived preparation for, response to, and recovery from an earthquake that affects an alpine ski area. Using fuzzy cognitive maps was a useful extension of qualitative information with quantitative tools. The FCMs generated an understanding that could not be afforded through geomorphic assessments and qualitative interviews.

Cognitive mapping (a form of wider contemplation of people's thoughts and perceptions) has been useful for studying political systems, environmental management and other expert knowledge systems, but has yet to be applied to help identify opportunities for mitigating natural hazards. Therefore, I have developed and applied an approach designed to examine the perceptions of three stakeholder groups that is an initial step toward participatory policy development for hazard mitigation concerning earthquakes and their consequences for alpine ski areas.

The development of policies and implementation of strategies for managing natural hazards would benefit from models based on stakeholders' knowledge. I have applied a modified version of Ozesmi and Ozesmi's (2004) multi-step fuzzy cognitive mapping approach in an attempt to study people's considerations for the management of a high consequence, low probability event. The FCM approach can be applied to almost any system or problem.

First, a brief review of processing the FCMs (condensation and aggregation) into social group fuzzy cognitive maps (SGFCMs) for AANN (Autoassociative Neural Networks) simulations is provided. Then, results from graph theoretical indices are provided, based on the individual FCMs. In addition, a stepwise comparison using graph theory indices from the original FCM to the condensed and aggregated SGFCMs of the three targeted social groups is presented. Some general inferences from the indices are drawn.

Second, prior to presenting simulations, the meanings of upper level themes extracted from the condensation of concepts are presented to help the reader understand the inferences drawn from policy scenarios. Then, the results of five policy simulations for three stakeholder groups are presented. Finally, a discussion of the results is presented that highlights apparent social solidarities based on the results.

3.6.1 Review of Processing FCM: Qualitative Condensation

The condensation began by placing all of the distinct concepts from participants' FCMs into a spreadsheet. The similar concepts were then grouped into upper level themes. This reduced the overall number of concepts. In this study however, one level of condensation was not sufficient for gaining much interpretive insight, as there were still over one hundred qualitatively distinct variables, and over one thousand connections. Therefore, qualitative condensation continued, relying on the researcher's ability to understand the participants' maps and interview data together. The condensation was conducted on the individual maps to bring the condensed variables close to their original concepts from the participants FCMs, while including all the active variables in participants' FCMs in the upper level themes.

The upper level categories and exemplars of the critical considerations in them (i.e. concepts of key considerations regarding preparation for, response to, and recovery from earthquakes) are presented in Appendix 3.D The section that follows provides concise qualitative descriptors of the condensed themes to familiarise the reader with the content to make the inferences drawn from policy scenarios more intuitive.

3.6.1.1 Condensed Themes

The key concepts in FCM were condensed into a total of 23 upper level themes and this sections presents their name and interpretation.

The theme *Access* means simply access in and out of the ski area via the road. This was described as an important consideration to facilitate evacuation of the ski area.

Adverse Effects pertains to the physical consequences of an earthquake on the landscape such as rock fall and avalanche, lack of land stability, and isolation.

Analysis and Reports relates to understanding the risks and hazards to mitigate earthquakes through investigative analysis and reports from previous hazard events.

Avalanche Considerations pertain to awareness of the avalanche hazards through avalanche education as well as avalanche control.

Bad timing refers to how a variety of time frames can increase the risk of exposure to hazards by virtue of the time that an earthquake occurs. For example, if an earthquake occurred during winter, early season, and or in the middle of the day on a weekend, more people are at risk to the initial consequences and business recovery would be difficult. Whereas an earthquake in the summer would result in few people being on the mountain, thus lowering the risks, and recovery may be possible prior to opening the business the following season.

Good Buildings describes the ability of buildings to resist earthquakes by virtue of good building codes, or standards that depict appropriate designs for structural integrity.

Good Communication ranges from the general need to communicate with staff, clientele and external agencies, but also includes notions of communication tools such as cell phone or radios, and the need for alternatives, such as mountain radios or satellite phones. Overall, communications considerations highlight the need and facilities to communicate effectively in emergency situations.

Community Assistance is a recognition that help from the immediate community (e.g., clientele or club members) aids the response and recovery efforts after an earthquake.

Damaged Infrastructure is the negative consequences for infrastructure, such as loss of critical lifelines (e.g., power, water and communication), which could hinder response efforts. In addition, Damaged Infrastructure pertains to longer-term recovery issues such as lift re-alignments, re-certifying infrastructure, and rebuilding.

Emergency Personnel refer to trained and skilled people such as ski patrol, medical staff, and other key people to respond to hazard events.

Emergency Plan and Procedures reflects the need to have an emergency plan and emergency procedures in place prior to an earthquake event. There were also references to warning systems, international or national standards, and the difficulty of predicting hazards, which is a key reason for having emergency plans and procedures.

Equipment considerations include equipment such as ski equipment (e.g., ski or snowboard, warm clothing), as well as rescue equipment (e.g., pack, shovel, probe and transceiver) and safety equipment, such as a first aid kit. Other equipment includes group equipment such as snow equipment (e.g., snowmobile) and equipment checklists.

Evacuation Consideration depicts the need for plans to evacuate lifts, buildings and eventually the ski area.

External Assistance is a recognition that in an earthquake, there is a requirement for external support in the form of medical support, resources, or other emergency services beyond the ski area.

First Response is associated with locating people quickly, assessing injuries and treatment of injuries through first aid.

Hazard Awareness relates to education, experience, and awareness of hazard's consequences (e.g., aftershocks).

High Intensity only includes three concepts, yet it was treated as distinct because it was frequently mentioned in the qualitative interviews. The concepts which were depicted in the maps were 'Large Scope and Scale', 'High Intensity *of* Magnitude', and 'Severe Shaking'. For simulation purposes, High Intensity means the experience of an earthquake as major, intense, and severe.[32]

Managing People relates to how managing a large number of people who may experience emotional reactions to an earthquake (e.g., panic) and therefore, require good leadership.

Recovery of the Ski Area pertains to longer-term issues of getting the ski areas operational. Critical to recovery is the idea of debriefing to enable updating of emergency plans. Another common element of Recovery was managing contact with the media. Recovery also entails repairing infrastructure, which requires money possibly from insurance claims to enable businesses to move forward. Hence, overall, *Recovery of the ski Area* means updating emergency procedures, effectively communicating with the media to remarket the ski area as a safe destination, and repair infrastructure to enable business operations.

[32] See Appendix 3.H Modified Mercalli Intensity Scale

Resources Considerations includes the need for adequate resources inventory, with additional resources if needed. They do not include specific descriptions of what these resources are, but they could be, for instance, human resources, physical resources, and technological resources critical to preparation, response and recovery.

Safety Considerations means Safe Zone(s), as in a safe area(s) to gather that are not at risk to hazards and are easy to identify and access. Other concepts were safety in general and the safety of specific groups of staff, public, or inclusively safety of all. Hence, *Safety Considerations* mean that safety has been provided to all people in the ski area, by having a safe area to gather in the event of an earthquake.

Survival Considerations include elements of basic survival (e.g., water, food and shelter). Water and food was the most common survival consideration. Other critical survival considerations include shelter from the elements (e.g., safe accommodation). Therefore, survival considerations mean being able to survive because water, food and shelter have been afforded.

Training Considerations refer generally to good training, but there are also elements of scenarios, drills, and trial runs that are implicit in the ability of all staff to deal with emergencies.

3.6.2 Aggregation to form Social Group Fuzzy Cognitive Maps (SGFCMs)

> Respecting the fact that a social cognitive map must be encoded in symbolic human language replete with moral terms, we can give the following definition: a *societal cognitive map* is the set of shared symbols describing a collective environment and prescribing the organized behaviours appropriate to preserving social stability in that environment. In its descriptions a societal cognitive map locates the principle physical aspects of the environment… These descriptions are rarely in terms that moderns recognize as 'scientifically valid, but they are usually amazingly perceptive…' (Lazlo *et al.,* p.61, 1996).

Participants FCM can be aggregated into social group fuzzy cognitive maps (SGFCMs) (Kosko, 1987, Kosko 1992a; Kosko 1992b). The SGFCMs show different results in simulation from what the individual maps would show because the connections with opposite signs cancel each other out, whereas, agreement reinforces causal relationships in the aggregated maps (Ozesmi, 1999). The result is a "lossy consensus" which results from "loss" as members leave or join a community (Carely, 1997; Ozesmi, 1999). "Social cognitive maps take on a life of their own through social processes" (Ozesmi, 1999, p. 153), that is, they affect individuals who act based on their own maps but also embody shared social knowledge (Carley, 1988). The shared social knowledge may not be overt in cognitive maps, but it is assumed to be obvious. It is, therefore, important that the interviewer has a rudimentary understanding of the study groups' assumptions and beliefs to elicit social knowledge.

In an attempt to elicit shared social knowledge using a novel methodology, the condensed individual maps were analysed quantitatively using Self Organising Maps (SOM) method to investigate natural clustering patterns of stakeholders based on their individual condensed FCMs.

3.6.2.1 A Novel Clustering Tool: Self-Organising Feature Maps (SOM)

"Unsupervised networks are used to find structures in complex data". (Samarasinghe, 2007)

This section provides information on how the third step of data processing works. SOM are unsupervised networks that can project high-dimensional input data onto one-or two-dimensional spaces to represent it in a compact form, so that the inherent structure and patterns in the data can be interpreted meaningfully and validated visually (Kohonen, 2001). The benefit of SOM is that they can be used to find structures (unknown clusters) in complex data without *a priori* knowledge of the clusters (Samarasinghe, 2007). For a detailed explanation with examples, see Samarasinghe (2007). This is particularly useful in this study where an FCM is characterised by a large number of concepts (dimensions) and clustering of similar concepts into high-level themes can simplify the subsequent map analysis and scenario simulations. Furthermore, SOM can cluster all participant FCMs across the three stakeholder groups into similar groups based on their perceptions and reveal potential solidarities existing in the whole sample.

The first step of SOM is preparing input vectors. For example, in clustering of concepts, it can be applied to individual fuzzy cognitive maps, social group fuzzy cognitive maps (SGFCM) or total social group map (TSGFCM). In any case, each concept in terms of its relationship to other concepts in a map constitutes an input vector; specifically, the strength of connection between a particular concept and all the other concepts makes the input vector for that concept. For an m node map, there are m^2 connections for each node; thus, there are m input vectors with m^2 elements in each input vector. The second step is defining the SOM structure. An SOM consists of a number of neurons organised in a two-dimensional grid that can be square, rectangular, or hexagonal in shape. Each neuron is represented by a weight vector of the same dimension as the input vectors and the neuron weight vectors are initialized with random values, such as those drawn from a [0,1] uniform distribution. Then, an input vector is presented to the network and the distances between the input vector and all neuron weight vectors are calculated based on a distance measure, such as Euclidean distance, to find the neuron closest to the input. This neuron is declared the winner and its weight vector is brought closer to the input vector by a fraction of the distance between the two. Simultaneously, a predefined number of neurons that are in the neighbourhood of the winner also adjust their weight vectors by a smaller fraction to bring them also closer to the input. This process is repeated for all inputs and the cycle is repeated a number of iterations until weight adjustments become negligible.

This process is called learning or training of an SOM. Suppose that for a random n-dimensional input vector x with components $\{x_1, x_2, \ldots, x_n\}$, the winner neuron is identified and the position of the winning neuron is indexed as $\{i_{win}, j_{win}\}$ on the map. Then all the weight vectors w_j of the winner and neighbours are adjusted to w_j^l according to

$$w^l_j = w_j + ß\ NS\ [x - w_j],$$

where NS is the neighbour strength function that diminishes with the distance from the winning neuron to the other neurons in its neighbourhood and it defines the strength of weight adjust of the neighbours with respect to that of the winner; the NS is always equal to 1.0 for the winner. The form of NS is a linear or nonlinear decay function of which Gaussian and exponential decay functions are the most common. ß is the learning rate that determines how much the weights of the winner and its neighbours move towards the input, i.e., it indicates the fraction of the distance between the input vector and the winner or neighbourhood neuron vectors (x-w_j in the above equation) used in weight adjustment .

A trained SOM is a compact representation of input vectors in that each neuron represents a cluster of inputs vectors and adjacent neurons represent input vectors that are close to each other in the input space (i.e., more similar to each other in reality). This latter feature is called topology preservation and is useful for finding spatial organisation of input vectors (i.e., concepts) with respect to one another. A powerful feature of SOM is that the spatial organisation of the input vectors can be seen on the 2-dimensional grid using a colour coded map that shows the distance between the neurons; larger distances between neurons indicate distinct clusters and cluster boundaries. In cases where clusters are quite distinct, colours indicate the potential number of clusters. In many cases, the exact number of clusters are not self-evident on the SOM due to complexity of the data.

The function of SOM is to reveal the spatial organisation of data and provide a glimpse of the nature of potential clusters; it does not determine the exact number of clusters in the data; therefore, an additional step is usually required to quantify the number of clusters on the map. In this step, trained neuron weight vectors are used as inputs to a clustering algorithm to determine the number of neuron clusters. There is a variety of approaches to clustering unsupervised networks. Generally, the two main approaches used are hierarchical and partitive (Samarasinghe, 2007). For example, clustering trees known as dendograms are produced in a hierarchical fashion. It is also possible to divide this latter approach into agglomerative and divisive algorithms, depending on whether top-down or bottom-up approaches are used to build the hierarchical clustering tree (Samarasinghe, 2007). Agglomerative methods are more common than divisive methods. The basic mechanism behind agglomerative methods is as follows. First, each input vector forms its own cluster. Second, the distance between all clusters is computed based on a distance measure, such as Euclidean distance, and the two clusters that are closest to each other are merged. This process is repeated until there is one cluster left that is made up of the total data set. Thus, the data points are successively merged together to build a cluster tree that consists of one cluster, consisting of the whole dataset. This tree can be used to interpret data structure and determine the number of clusters.

Once the tree is formed, the next step is to identify the unique clusters in the tree based on the distance between the clusters that were successively merged in the formation of the tree. Though there are several methods that can be used, in this case study, we used the Ward method (Samarasinghe, 2007). The Ward method is an agglomerative clustering method that is efficient when the dataset is not too large. Furthermore, Ward clustering can be remarkably accurate in performing classifications when class labels are not known *a priori* which is the case in many complex problems (Samarasinghe, 2007).

The Ward method computes the likelihood of various numbers of clusters from which the most appropriate number of clusters can be obtained based on a likelihood index, defined as,

$$\text{Ward Index} = \frac{1}{\text{NC}}\left(\frac{d_t - d_{t-1}}{d_{t-1} - d_{t-2}}\right) = \frac{1}{\text{NC}}\left(\frac{\Delta d_t}{\Delta d_{t-1}}\right)$$

Where d_t is the distance between the centers of the two clusters to be merged in the current step, and d_{t-1} and d_{t-2} are the distance between the merged clusters in the last step and the step prior to the last. NC is the number of clusters left. Thus, the Ward likelihood index is a measure of the difference in distance between the two clusters to be merged at the current step (d_t) and the two clusters merged at the last step (d_{t-1}) relative to the difference in distance in the last two merging steps (d_{t-1}- d_{t-2}) normalized by the number of clusters left. The clusters that are far apart have a higher numerator and therefore a higher Ward index; when applied to trained neuron weights, this can be used as an indication of the separability and the number of potential clusters of neurons on the SOM. The benefit of SOM for aggregation of concepts is that it captures linear or nonlinear relationships existing between concepts and allows clustering of highly correlated variables into groups. Thus it enables one to know and aggregate the highly correlated variables into high level themes for simplifying the simulation of targeted policy scenarios.

The other useful function of SOM in this study is in the investigation of the formation of clusters of participants based on their perceptions. When participants' FCM are aggregated into social group fuzzy cognitive maps (SGFCMs) (Kosko, 1987, Kosko 1992a; Kosko 1992b), the SGFCMs show different results in simulation from what the individual maps would show because the connections with opposite signs cancel each other out, whereas, agreement reinforces causal relationships in the aggregated maps (Ozesmi, 1999). The result is a "lossy consensus" which results from "loss" as members leave or join a community (Carely, 1997; Ozesmi, 1999). "Social cognitive maps take on a life of their own through social processes" (Ozesmi, 1999, p. 153), that is, they affect individuals who act based on their own maps but also embody shared social knowledge (Carley, 1988). The shared social knowledge may not be overt in cognitive maps, but it is assumed to be obvious. It is, therefore, important that the interviewer has a rudimentary understanding of the study groups' assumptions and beliefs to elicit social knowledge.

In an attempt to elicit shared social knowledge using a novel methodology, the condensed individual maps were analysed quantitatively using Self Organising Maps (SOM) method to investigate natural clustering patterns of stakeholders based on their individual FCMs. This was first done by training an SOM where each input vector represents an individual FCM. The elements of an input vector are the connection strengths for all connections among the twenty-three concepts in an individual FCM. SOM spatially organises similar input vectors in close proximity based on a distance measure such as Euclidian distance or correlation distance. This enables qualitative visualisation of possible clusters of input vectors (i.e., FCMs) on the trained SOM, as well as making it possible to apply a clustering method to quantify the clusters. The next section presents results from the SOM clustering of stakeholders. The SOM based clustering of concepts is deferred until after the analysis based on the condensed maps with 23 themes where further condensation of concepts is attempted.

3.6.2.2 Comparing participants condensed FCMs with SOM

Specifically, once the individual maps were condensed into the twenty-three themes described above, it was possible to see if participants would cluster together into emergent social groups using the SOM method. This was first done by training an SOM where each input vector represents an individual FCM. The elements of an input vector are the connection strengths for all connections among the twenty-three concepts in an individual FCM. SOM spatially organises similar input vectors in close proximity based on a distance measure such as Euclidian distance and correlation distance. This enables qualitative visualisation of possible clusters of input vectors (i.e., FCMs) on the trained SOM, as well as making it possible to apply a clustering method to quantify the clusters. In this study, SOM with 100 neurons (10x10 hexagonal map) was trained using correlation distance measure which brings stakeholders with similar trends in perceptions together. The SOM was trained very quickly, and after training, Ward clustering method was used to find the clusters. The most likely number of clusters of individual FCMs are 12, 2, and 7 according to the Ward likelihood index (Figure 3.3).

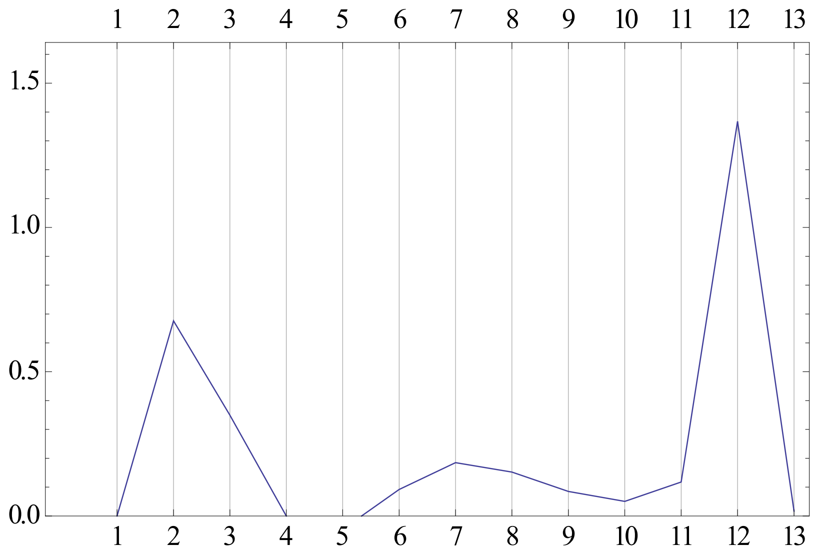


Figure 3.3 Ward likelihood index for numbers of clusters for grouping participants.

The strongest likelihood index is for 12 possible clusters of participants followed by 2 and 7 clusters. The lattice in Figure 3.4 is the SOM showing the cluster structure for the two clusters of participants. In this figure, small circles are neurons coloured according to the cluster and grey lines depict connections between adjacent neurons. The SOM also shows the position of the each stakeholder allowing one to discern the relative positioning of stakeholders (FCMs) with respect to one another based on their perceptions as represented in a condensed FCM. The configuration of two clusters is interesting because in one cluster, there is only one participant SIW 2, and the rest of the participants were in the other cluster.

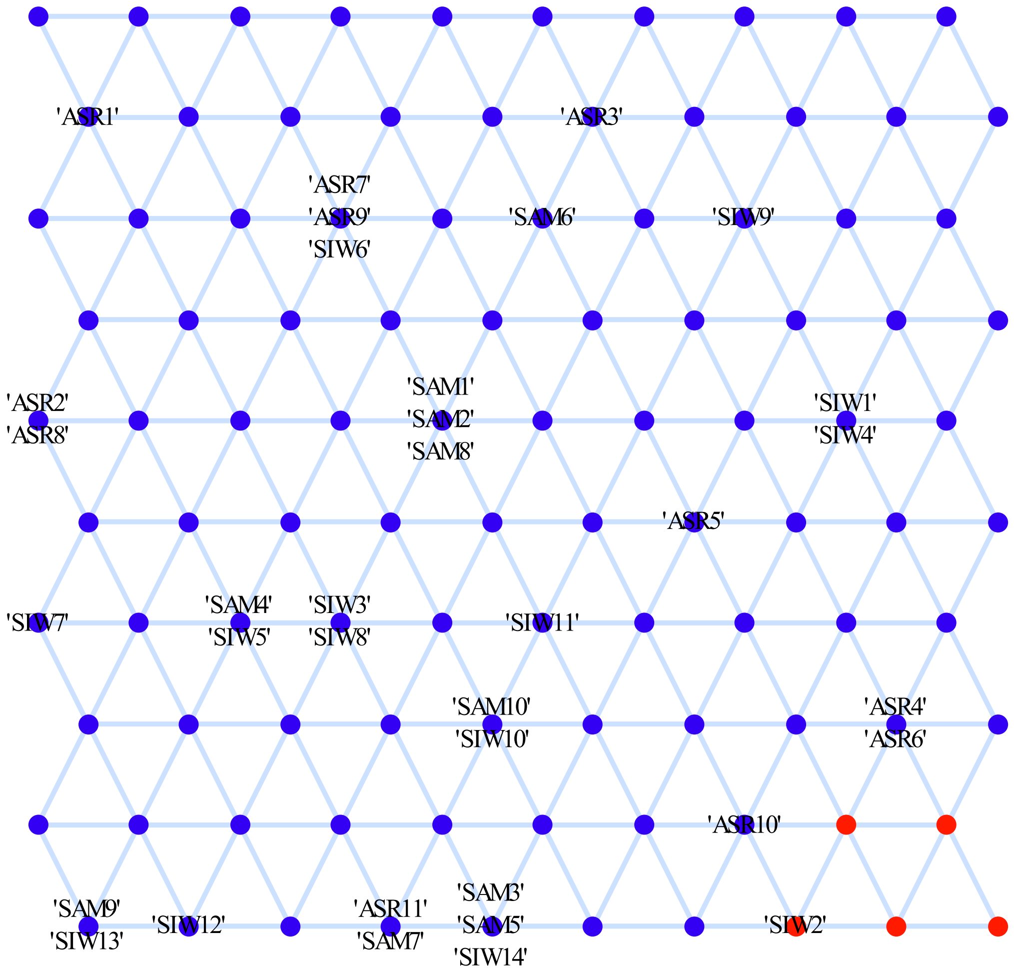


Figure 3.4 Clustering of Participants based on two clusters.

This result begs the question, how is SIW 2's condensed FCM so different than the other participants' condensed FCMs? The main difference is that SIW 2's condensed FCM was highly complex with a much higher number of connections (94) when compared to the other maps, which ranged between 4 and 70 with an average of 25.6 connections. This gives us a starting point for comparison. When examining a less likely 7-cluster configuration, a different cluster merits attention.

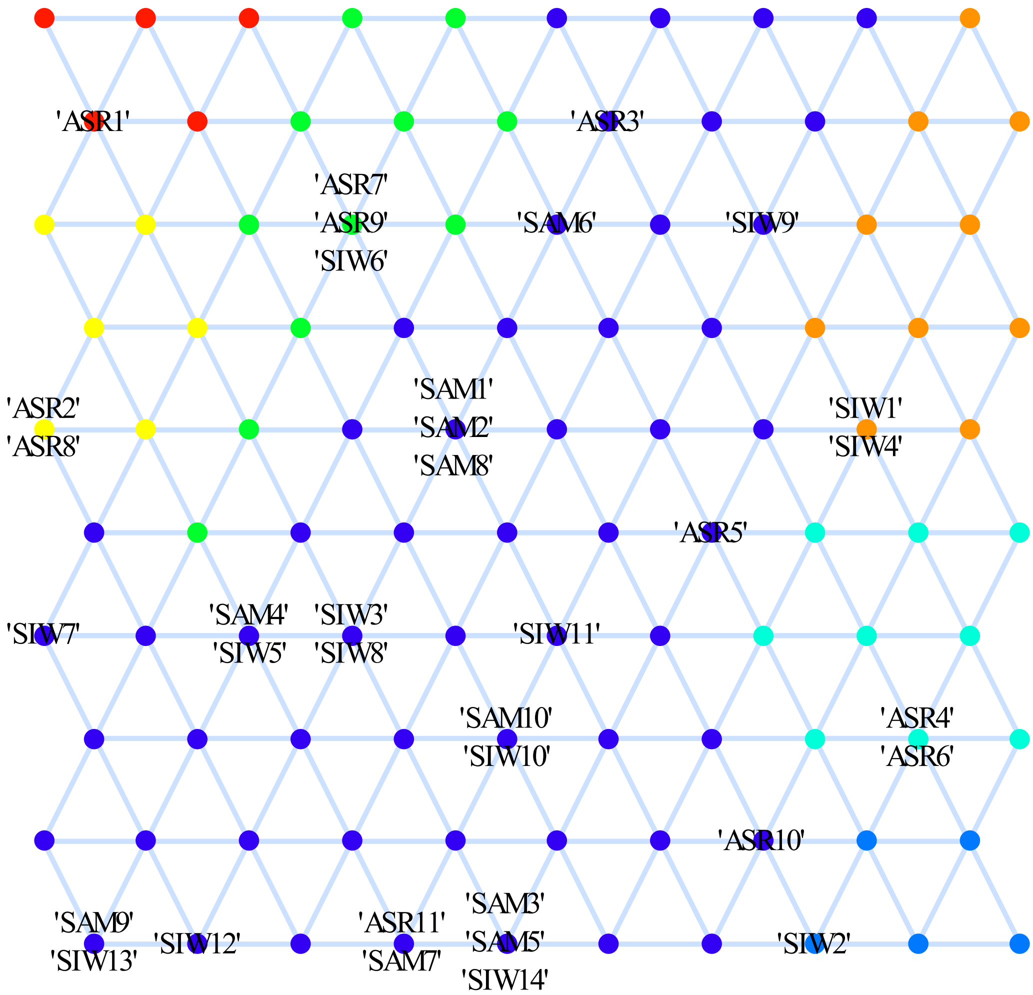


Figure 3.5 Clustering of Participants based on 7 clusters.

In Figure 3.5 the largest cluster contains 24 maps (3 ASR, 9 SAM, and 11 SIW). What are the commonalities between these participants as expressed in their condensed maps? One way to answer this question is to take two maps that represent the cluster and compare their vectors. SAM 10 and SIW 10 are close to the center of the cluster and thus provide a good demonstration. These two participants clustered together because in their condensed maps they had connections between variables that were similar. Specifically, the condensed FCM for SAM 10 and SIW 10 included negative influences from *Damaged Infrastructure* to *Emergency Plan and Procedures*. Additionally, both participants also share a similar view of *Emergency Plan and* Procedures having a positive influence on itself. The cluster is so large that, with 24 maps, providing an exhaustive comparison is not useful. Moreover, this 7 cluster configuration was not the cluster with the strongest likelihood. More insights can be gained by looking at the configuration with strongest likelihood (Figure 3.6).

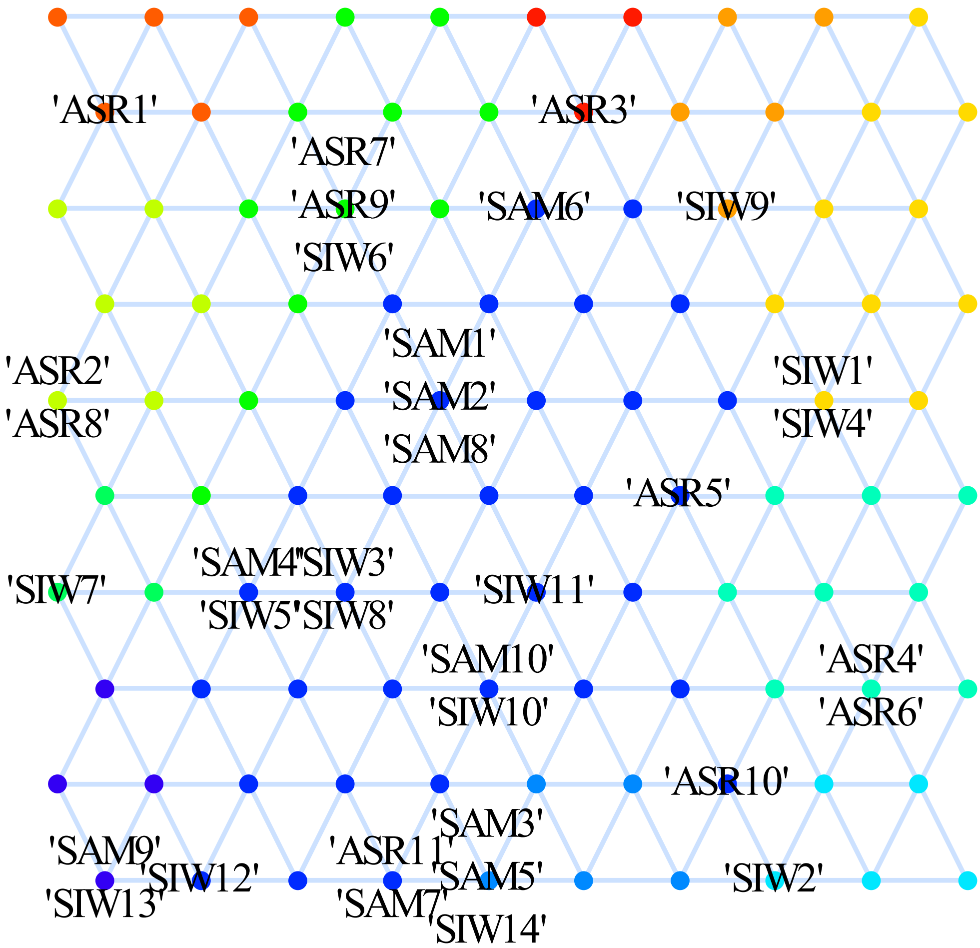


Figure 3.6 Clustering of Participants based on twelve clusters

The twelve clusters for the participants did not yield enough meaningful information for the purpose of aggregating participants into social groups; however, there is an indication that the SOM in general does capture the existence of shared social knowledge. First the green cluster which contains ASR 7, ASR 9 and SIW 6; these three stakeholders' maps indicated similar connections between several variables, but notably strong positive influences between *Communication* and positive influences to *Hazard Awareness.*

Second, the dark blue cluster captures interesting similarities between participants with respect to their roles. First, SAM and SIW participants are clustered together tightly. What is more significant is that all of the SIW in this case are in positions of responsibility, such as ski patrol manager (SIW 3), safety services (SIW 5), ski maker and builder (SIW 8), snow safety officer (SIW 11), alpine guide (SIW 12), general operations and maintenance (SIW 13), and avalanche control team manager (SIW 14). What appears to be happening is that these middle managers and top-level management (i.e., those with a high level of experience) have similar horizons. This shows that roles (managers, workers or riders) may define preferences for and selections of particular strategies for adaptation, and the interactions between those strategies. Overall, though the use of SOM to cluster participants does indicate that there is shared social knowledge.

Despite the possibility of forming new social groups based on the self-organising map clusters of participant groups, further research was needed to closely examine the character of individual maps and condensed maps in order to shed more light into this aspect. Furthermore, understanding the relations between the original and condensed maps enhances the interpretation of policy simulations through transparent links of final condensed maps to qualitative interviews and makes it possible to approach the target social groups for further consultations for refining the policies. I therefore decided to conduct an in-depth quantitative analysis of the targeted social groups of Alpine Snow Riders, Ski Industry Workers, and Ski Area Managers. All condensed participant maps were treated as equally valid by assigning a weight of one to each map before they were additively superimposed to create SGFCMs of the targeted social groups, and a TSGFCM of the entire collection of 35 maps. The main reason for doing so is to improve the understanding of the results from policy simulation scenarios with the aid of reference to qualitative interview results, thereby providing an ability to triangulate the apparent social solidarities. Thus, this approach improves the recommendations for future policy discussions with these particular social groups.

The results that follow represent fuzzy perceptions based on participants' social group fuzzy cognitive maps (SGFCMs); that is, they are a product of condensation of concepts and aggregation of FCMs. The next section analyses FCM with three tools: 1) graph theory indices to understand their structure, 2) Self-Organising Maps to further aggregate the 23 themes into a smaller number of more highly condensed themes, and 3) neural network (i.e., auto-associative ANN) based analysis of the system response for policy simulations based on SGFCMs. First, comparisons between original FCMs and SGFCMs using graph theory indices are presented commenting on the structure of static SGFCMs. As well, the centrality of each of the SGFCMs will be presented in an illustrative manner using figures and summarizing results. Second, a novel use of Self-Organising Maps is presented to condense the 23 themes into broader high-level themes that facilitate complex policy scenario simulations. Third, results from five what-if policy simulations based on AANN are presented to compare and contrast the SGFCMs social group maps. Additionally, illustrative descriptions are provided to make the results accessible and to link them to the five sociocultural viabilities.

3.7 Comparing FCMs and SGFCMs

Graph theoretical indices can provide some understanding about the structural properties of cognitive maps. The indices used include *number of concepts, number of connections, density, in-degree and out-degree and the resulting variable types, centrality,* and *hierarchy.*

3.7.1.1 Tools for Analysing FCM: Graph Theoretical Indices

Graph theory indices are used to examine the structure of the FCMs and commonly include *density, indegree*, *outdegree,* and *centrality,* as well as *complexity* and *hierarchy.* Density (D) is a useful index of the entire map outlining the connectivity of a cognitive map and is represented by $D = C/N^2$, where C is the number of connections that exists in a map, and N^2 is the maximum number of connections possible for that map (N is the number of nodes) (Hage and Harary, 1983, in Ozesmi 1999). The overall structure of the FCM is illustrated "by finding *transmitter variables* (forcing functions, givens, heads), *receiver variables* (utility variables, ends, tails) and *immediate domains"* (Bougon *et al.,* 1997; Eden *et al.,* 1992; Harary *et al.,* 1965; as cited in Ozesmi, 1999, p.151). These variables are defined by their *outdegree* [$od(v_i)$] (i.e., the sum of absolute values of connections going out from node i to node k denoted a_{ik}):

$$od(v_{\mathrm{i}}) = \sum_{k=1}^{N} a_{\mathrm{ik}}$$

And *indegree* (i.e., the sum of absolute values of connections coming into a node i from node k [$id(v_i)$]):

$$id(v_{\mathrm{i}}) = \sum_{k=1}^{N} a_{\mathrm{ik}}$$

Transmitter variables have positive outdegree and zero indegree, whereas receiver variables have positive indegree and zero outdegree. Ordinary variables have both non-zero indegree and outdegree. Another way to distinguish between transmitter and receiver variables in a general sense is to use the ratio of outdegree to indegree, and decide what threshold boundary delimits transmitter, neutral (rather than ordinary), and receiver variables. Transmitter, receiver and ordinary (herein referred to as Neutral) variables were identified using the ratio of outdegree to indegree. The ratio for Transmitter variables was set at greater than or equal to 1.15, receiver variables at less than or equal to 0.85, and Neutral variables between 0.85 – 1.15. The ratio for variable types was changed to better capture a variety of general variable types.

The overall contribution of a single variable i in an FCM is understood by calculating its centrality (ci):

$$ci = od(v_i) + id(v_i)$$

The centrality (a.k.a., total degree or immediate domain) is the summation of *outdegree* and *indegree*, and is an indication of the "importance" of a single variable in a cognitive map.

The complexity index of the map is the ratio of receiver to transmitter variables (R/T). Many receiver variables indicate a high degree of complexity as they consider many outcomes that result from the system, whereas, many transmitter variables indicate a "formal hierarchical system" (Eden *et al.,* 1992, in Ozesmi, 2003). Complex maps have large complexity ratios because they define more utility outcomes and less controlling (i.e., forcing functions) (Ozesmi and Ozesmi, 2003). Another structural measure for cognitive maps is the hierarchy (h) index (MacDonald, 1983; in Ozesmi and Ozesmi, 2003):

$$h = \frac{12}{(N-1)N(N+1)} \Sigma_i \left[od(v_i) - \Sigma od(v_i)/N\right]^2$$

When h = 1, the map is fully hierarchical, and when h = 0, the system is fully democratic. (N is the number of nodes)

In summary, the greater the *number of concepts* in a map, the greater the complexity; yet, *the number of connections* and their respective weights results in a computational behaviour that is different than merely adding up the units. The *density* of a map is an indication of connectivity in the maps; that is, how connected or sparse the maps are. It is possible to ascertain the *type of variables* (transmitter, receiver, and neutral variables) by using in-degree and out-degree. By comparing the ratio of receiver to transmitter variables, it is possible to gauge the *complexity* of the maps where large ratios define more utility outcomes and less controlling functions. Finally, the *hierarchy index* provides an indication of whether the maps are dominating (hierarchical) or adaptive (democratic).

3.7.2 Results of Graph Theoretical Indices

From the 52 participants in the study, 35 fuzzy cognitive maps (FCMs) were gathered. In total, the 35 FCMs contained 300 variables (i.e., concepts that represent key considerations regarding preparation for, response to, and recovery from earthquakes that can affect alpine ski areas). The total number of causal connections in all of the original maps was 1353, a large number from which to extract meaning. Analysis commenced with the determination of graph theoretic indices for each individual FCM containing original variables as well as those for the condensed FCM and corresponding social groups. The results for social groups were used to calculate the indices for the total social group (TSG). The results for the social groups and the TSG are shown in Table 4.1 and individual FCM results are in Appendix 3.F.

According to Table 4.1, the average number of concepts in the participants original FCMs was 8.57 ± 2.3 SD. The average transmitter variables were 3.06 ± SD, average receiver variables, 3.37 ± 1.36 SD, and the average neutral variables was 2.13 ± 1.77 SD. The maps overall had an average complexity index of 1.36 ± 0.64 SD, and an average of 38.66 ± 24.54 SD connections that resulted in an average density of 0.51 ± 0.21 SD. The average hierarchy[33] index was 0.36 ± 0.19 highlighting that overall the original maps are slightly adaptable to changing inputs.[34] The riders original maps had more variables and connections than the managers and workers, but the managers and workers in particular had higher complexity indices and slightly higher densities. Thus, the managers and workers maps are arguably a more complete representation of the system.

Table 3.1 Average Graph Theoretical Indices for targeted and total social groups.

	ASR	**SAM**	**SIW**	**TSG**
Maps (N)	**11.00**	**10.00**	**14.00**	**35.00**
Num Vars	10.09 *±1.55*	7.40 *±2.36*	8.21 *±2.10*	**8.57 *±2.30***
Connections	54.18 *±30.05*	21.50 *±9.20*	38.71 *±26.53*	**38.66 *±24.54***
Density	0.49 *±0.13*	0.51 *±0.23*	0.53 *±0.26*	**0.51 *±0.21***
Receiver	4.27 *±1.57*	2.90 *±0.92*	3.00 *±1.43*	**3.37 *±1.36***
Transmitter	4.09 *±0.88*	3.10 *±1.74*	2.21 *±1.13*	**3.06 *±1.39***
Neutral	1.73 *±1.16*	1.40 *±1.64*	3.00 *±1.57*	**2.14 *±1.77***
Complexity	1.15 *±0.43*	1.18 *±0.47*	1.66 *±0.91*	**1.37 *±0.64***
Hierarchy	0.34 *±0.16*	0.34 *±0.20*	0.39 *±0.22*	**0.36 *±0.19***

[33] Hierarchy is a more complex indicator of the adaptability of a map to changing conditions. Values closer to one indicate more hierarchical maps and are less adaptable than maps with hierarchy closer to zero that is viewed as more democratic.
[34] Democratic maps are more resilient/adaptable to changing conditions.

Alpine snow riders had an average of 10.09 variables in their map, which is slightly more than SIW and SAM. The differences do not mean that participants have respectively more or less understanding of the system, as the quality of decisions do not necessarily correlate with the number of variables. In might appear, for example, that ASRs have more complex maps based on having more concepts; however, the average complexity index tells us more about the complexity than the number of concepts. The receiver to transmitter ratios, a better indication of structure, shows that on average each of the participant groups indicates a system that is complex, with more utility outcomes than forcing functions. Furthermore, the hierarchy index being closer to zero than one indicates that the three social groups see the system as more adaptable rather than controlled by external factors.

The purpose of the above analysis was to demonstrate an approach that compares stakeholder groups (e.g., similarities and differences) to address gaps in policies and practices for coping with earthquakes in mountainous environments. As illustrated, the averages from graph theory indices can give some insights as to how the targeted social groups viewed the system under consideration during the FCM exercise (Table 3.1).

Comparisons can also be made between original FCMs and the condensed FCMs (with 23 previously discussed upper level themes) based on graph theory indices. The comparative results for the Number of Variables, Connections, and Density are provided in Table 3.2 for target social groups (e.g. Managers, Workers, and Riders) and the total social group.

Table 3.2 Averages and Standard Deviation for attributes of the original FCMs and condensed FCMs: Number of Variables (NumVars, NVa-Cond); number of connections (Connections, Cns-Cond); Density (Density, D-Cond).

	ASR	**SAM**	**SIW***	**TSG**
NumMaps	**11.00**	**10.00**	**14.00**	**35.00**
NumVars	**10.09 *±1.55***	**7.40 *±2.36***	**8.21 *±2.10***	**8.57 *±2.30***
NVa-Cond	7.55 *±1.40*	6.10 *±2.12*	6.43 *±2.04*	**6.69 *±2.00***
Connections	**54.18 *±30.05***	**21.50 *±9.20***	**38.71 *±26.53***	**38.66 *±24.54***
Cns-Cond	32.09 *±13.22*	19.10 *±9.74*	30.07 *±19.51*	**27.57 *±15.83***
Density	**0.49 *±0.13***	**0.51 *±0.23***	**0.53 *±0.26***	**0.51 *±0.21***
D-Cond	0.06 *±0.02*	0.04 *±0.02*	0.06 *±0.04*	**0.05 *±0.03***

Note: Number of Maps (NumMaps) is the actual number of maps for the three targeted social groups. Values for the original FCM and the total social group are shown in bold and standard deviations from the means are in italics.

Comparing the averages from the social groups demonstrates that ASR considered more variables than SAM and SIW in the original FCM. In the condensed maps, the number of active variables (i.e., variables that were present in the condensed maps) was also slightly higher in the ASR maps. Correspondingly, ASRs had the highest connections in the original FCMs, followed by SIW and SAM. However, in the condensed maps, the ASR and SIW had a similar number of connections, much higher than SAM. The density of the FCMs was similar among the social groups for both original and condensed map versions. However, owing to the reduced number of variables and connections, density of the condensed maps is remarkably smaller.

The types of variables and complexity ratios also change as maps are condensed. This can give a vague indication of whether or not the maps are a fair representation of the original FCMs provided by participants (Table 3.3).

Table 3.3 Averages and Standard Deviation for types of variables and complexity.

Participant Group	ASR	SAM	SIW	TSG
Receiver	**4.27 *±1.57***	**2.90 *±0.92***	**3.00 ±1.43**	**3.37 ±1.36**
R-Cond	2.82 *±1.07*	2.80 *±1.08*	2.36 ±1.03	**2.63 ±1.10**
Transmitter	**4.09 *±0.88***	**3.10 *±1.74***	**2.21 ±1.13**	**3.06 ±1.39**
T-Cond	2.91 *±1.02*	2.60 *±1.52*	*2.29 ±0.84	**2.57 ±1.17**
Neutral	**1.73 *±1.16***	**1.40 *±1.64***	**3.00 ±1.57**	**2.14 ±1.77**
N-Cond	*1.82 *±0.60*	0.70 *±0.84*	1.79 ±1.21	**1.49 ±1.07**
Complexity	**1.15 *±0.43***	**1.18 *±0.47***	**1.66 ±0.91**	**1.37 ±0.64**
Cmp-Cond	1.10 *±0.34*	*1.40 *±0.66*	1.08 ±0.33	**1.18 ±0.44**

Note: Values for the original FCM and the total social group are shown in bold and standard deviations from the means are in Italics.

Most of the variable types decreased as the maps were condensed. The reason for this is that the maps that had less than 12 variables were increased to 23 variables in the condensed maps to include a variety of concepts. Thus, most of the variable types have decreased. What is interesting is that in three cases, the variable types actually increased; these are indicated by (*). The increases are small and are within the standard deviations from the means, but they do highlight how condensing of FCMs had a framing effect, making the maps sparser than the original to enable the upper level themes to be included. In addition, the complexity index from the SAM group also increased, meaning that the structural complexity of the SAM SGFCM may yield slightly more utility outcomes than we would see from the individual maps that make up the social group. The general characteristics of the four SGFCMs that were used in the policy scenario simulations are now presented.

3.7.3 Characteristics of SGFCMs

The total social group FCM (TGFCM) was obtained by additively superimposing the three individual condensed social group FCMs (SGFCM); the latter maps were obtained by additively superimposing the corresponding individual FCMs. The TSGFCM thus includes 35 FCMs and it has 23 active variables linked by 380 connections. It includes 7 transmitters, 6 receivers, and 10 neutral variables with a complexity index of 0.857. A complexity index of more than 1 is more complex than those that are less than one. A graph of the centrality of variables according to the TSGFCM is shown in Figure 3.5.

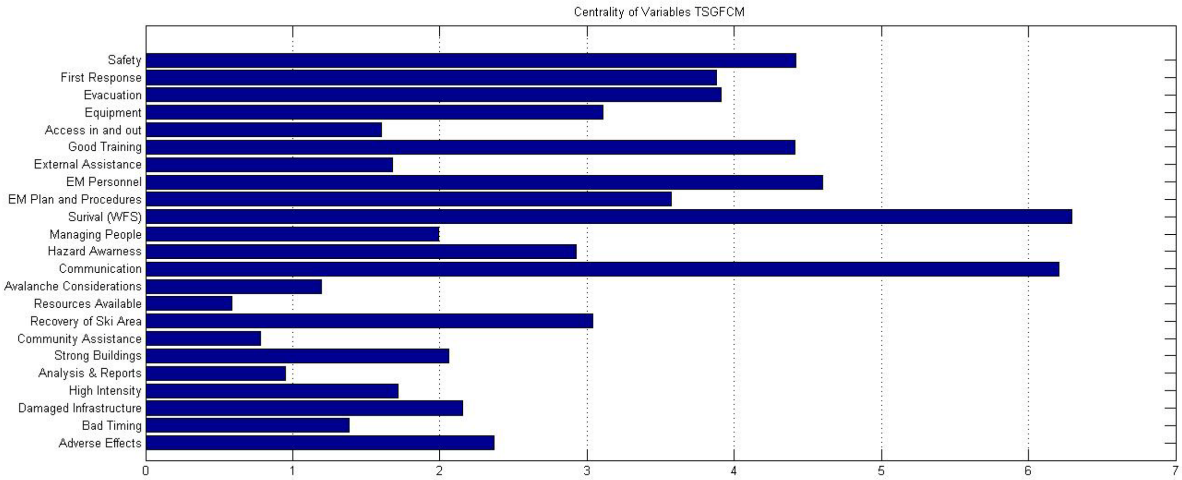


Figure 3.5 Centrality of variables in TSGFCM.

The top five most central variables in the TSGFCM are Survival (Food, Water, and Shelter), Communication, Emergency Personnel, Good Training, and Safety.

The ASRFCM includes eleven FCMs with 22 active variables linked by 215 connections. It includes 7 transmitters, 8 receivers, and 7 neutral variables with a complexity index of 1.143. A graph of the centrality of the most important variables in the ASRFCM is shown in Figure 3.6. The top five most central variables in the ASRFCM are Survival (WFS), Equipment, EM Personnel, Communication, and Good Training. Note that Analysis and Reports is an inactive variable for the ASRFCM.

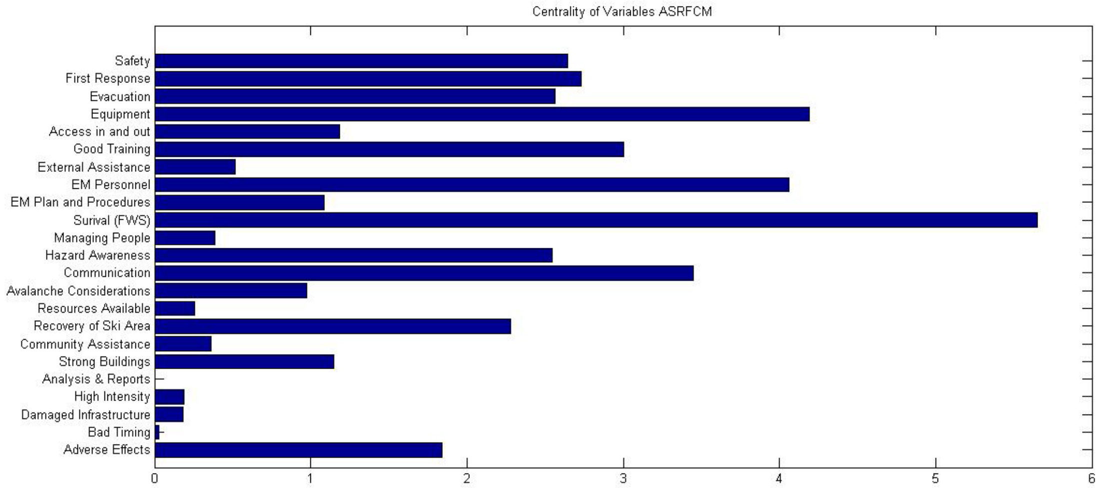


Figure 3.6 Centrality of variables in ASRFCM

The SAMFCM includes 10 FCMs with 20 active variables linked by 140 connections. It includes 7 transmitters, 10 receivers, and 3 neutral variables with a complexity index of 1.486. A graph of the centrality of variables for the SAMFCM is show in Figure 3.7. The top five most central variables for SAMFCM are: Communication, Survival, High Intensity, EM Plan and Procedures, and Bad Timing. Note as well that there are three variables inactive including: Analysis and Reports, Managing People, and Equipment.

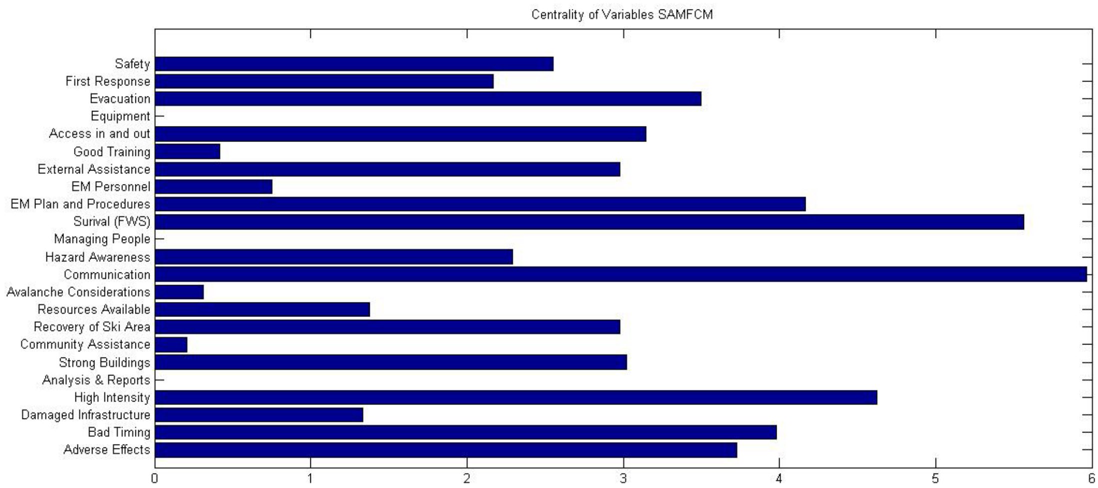


Figure 3.7 Centrality of variables in SAMFCM

The SIWFCM includes 14 FCMs with 23 active variables linked by 215 connections. It includes 10 transmitters, 9 receivers, and 4 neutral variables with a complexity index of 0.9. A graph of the centrality of variables for SIWFCM is shown in Figure 3.8. The top five most central variables in the SIWFCM include: Communication, Good Training, Safety, Damaged Infrastructure, and EM Plan and Procedures. Note that all of the variables are active in the SIWFCM.

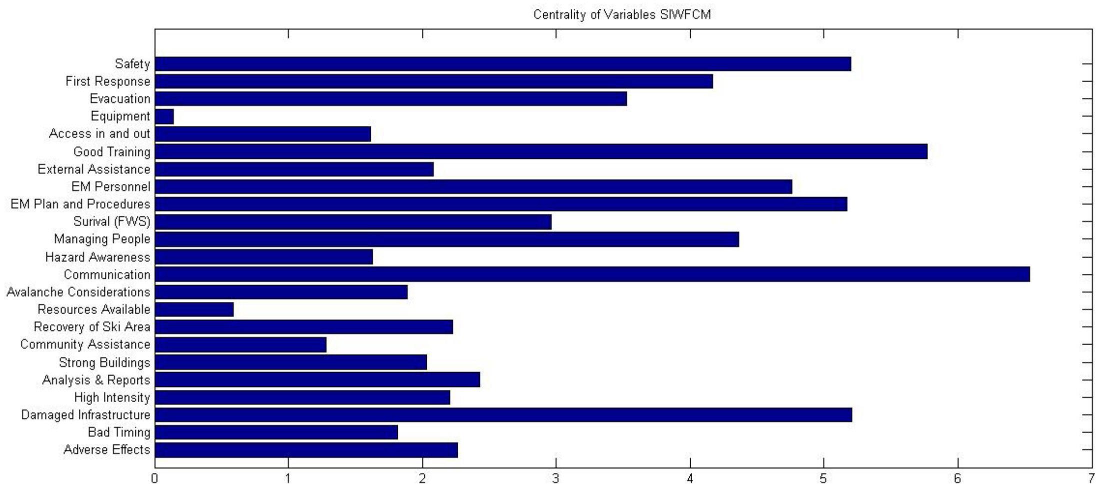


Figure 3.8 Centrality of variables in SIWFCM

3.7.4 Similarities and Differences between SGFCMs:

The ASR and SAM map complexity indices showed more utility outcomes and therefore less control from external factors. The SIW group demonstrated more controlling forcing functions and less utility outcomes, which means the map captures a perception that some things are beyond their control. It is interesting to note that the TSGFCM also captured this perception, that is, when all participants' maps are aggregated, there are more receiver variables than transmitters, but only just, thus implying a perception of slightly more influence from external factors. The external factors that came to light in the SGFCMs can be better understood by considering the most central variables in the maps.

The SGFCMs show agreements and differences in how influential particular variables were perceived according to the aggregated groups. These might provide opportunities to use synergies between social groups, and stress the need for further dialogue in areas of differences. First the participants' SGFCMs show consistency in placing *Communication* as a key consideration based on their centrality. The result that communication is the second most central concept in the TSGFCM lends support to such an emphasis. The most important variable in the TSG map was *Survival (Food, Water, and Shelter),* which was in the top five for ASR and SAM, whereas it was ranked tenth in order of centrality for SIW. A different agreement was apparent where both ASR and SIW placed *Good Training* as highly central (i.e., in the top five), while SAM placed it as seventeenth overall in rank of centrality. The agreement between ASR and SIW caused it to remain the fourth overall in the TSGFCM. The SAM and SIW placed *EM Plan and Procedures* in their top five most central variables while in the ASR SGFCM, it is fourteenth. We could also note how the ASR map held *Emergency Personnel* as the third most central variable which forced it to the third most influential concept in the TSGFCM. Similarly, the SIW map assigned a high centrality on *Safety* considerations which was instrumental in it being in the top five for TSGFCM, despite it being seventh for SAM and twelfth for SAM.

The agreements and disagreements between stakeholder groups demonstrate how power is an emergent property of this self-organising system. Some of the differences can help to identify gaps in knowledge between stakeholder groups and may help identify focal points of discussions for improving policy and practice. The centrality of variables also provides an indication of role based perceptions that may help to further bridge gaps. At this point however, I will digress to more novel modes of organising perceptions to generate better understanding of similarities and differences between stakeholder groups, by running policy scenario simulations based on the SGFCMs.

3.8 Organising and Disorganising variables in SGFCMs

The results of policy scenario simulations from condensed social group fuzzy cognitive maps (SGFCMs) are now presented. However, prior to this, SGFCMs were simplified using Self-Organising Maps. This is a novel attempt to simulate complex policy scenarios by simplifying SGFCM that have a high number of variables and potentially non-linear relationships between variables, while maintaining a high level of detail. With twenty-three condensed upper level concepts, it could still be quite difficult to interpret the results, as maps with many variables (e.g., 20-30) are counterproductive for gaining insights (Ozesmi and Ozesmi, 2004; Buede and Ferrel, 1993). In an attempt to overcome this challenge, SOM was used to compress the data while preserving the topological (spatial proximity) features of the condensed and aggregated SGFCMs. This is a *new methodological contribution to* *processing FCMs* that overcomes subjectivity in re-combination of concepts and is superior to ordinary cluster analysis by its inclusion of non-linear and indirect influences drawn into the FCMs.

The 23 variables in the SGFCMs were treated as a separate input data set where the values for each variable across the maps represented an input vector. An SOM with 25 neurons was trained based on correlation distance measure which brings variables that are similar (highly correlated) together so that they can be formed into clusters. The training occurred quickly and the input vectors were projected onto the SOM for visual evaluation of their spatial organisation. The SOM results were then subjected to clustering based on the Ward likelihood index for finding the optimum number of possible clusters for grouping the variables as shown in Figure 3.9 which indicates that 3 or 5 clusters is the optimum, meaning that the 23 concepts from the 35 FCMs organized into three or five clusters. The results for the case of 3 clusters formed on the SOM are shown in Figure 3.10.

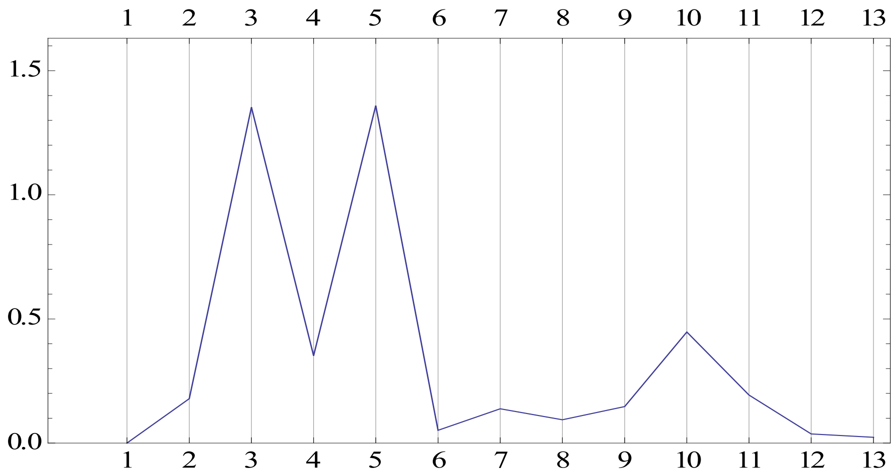


Figure 3.9 Ward Likelihood Index for Condensing Variables

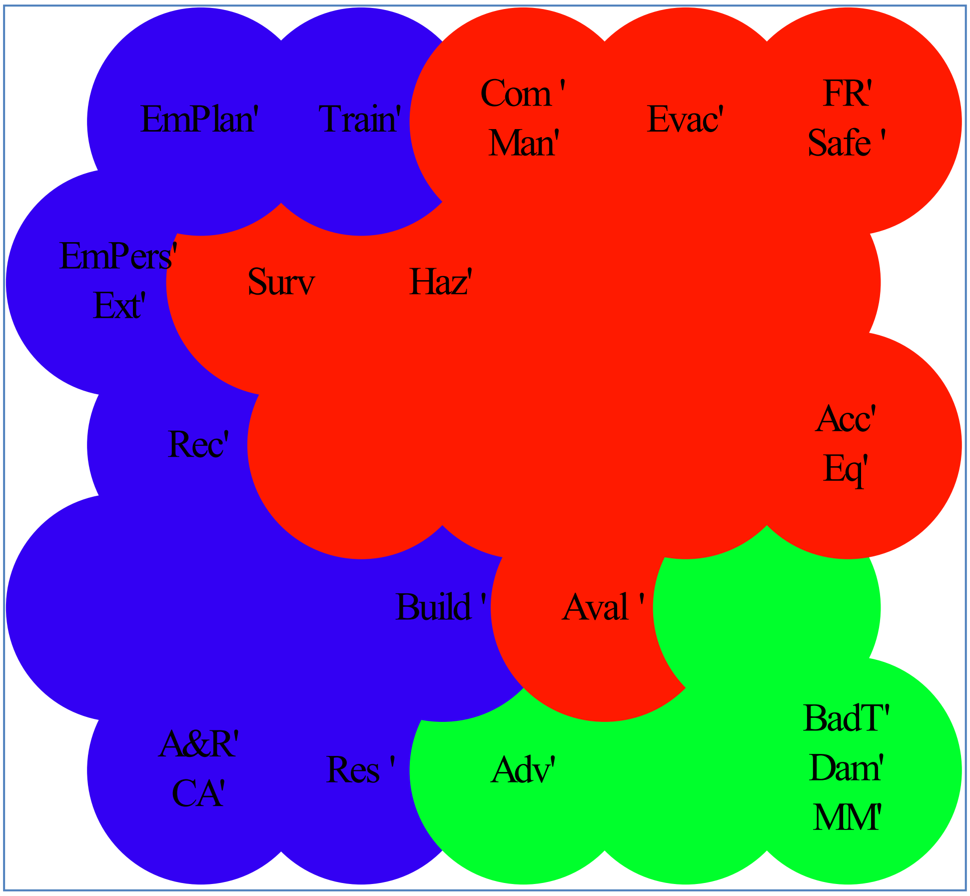
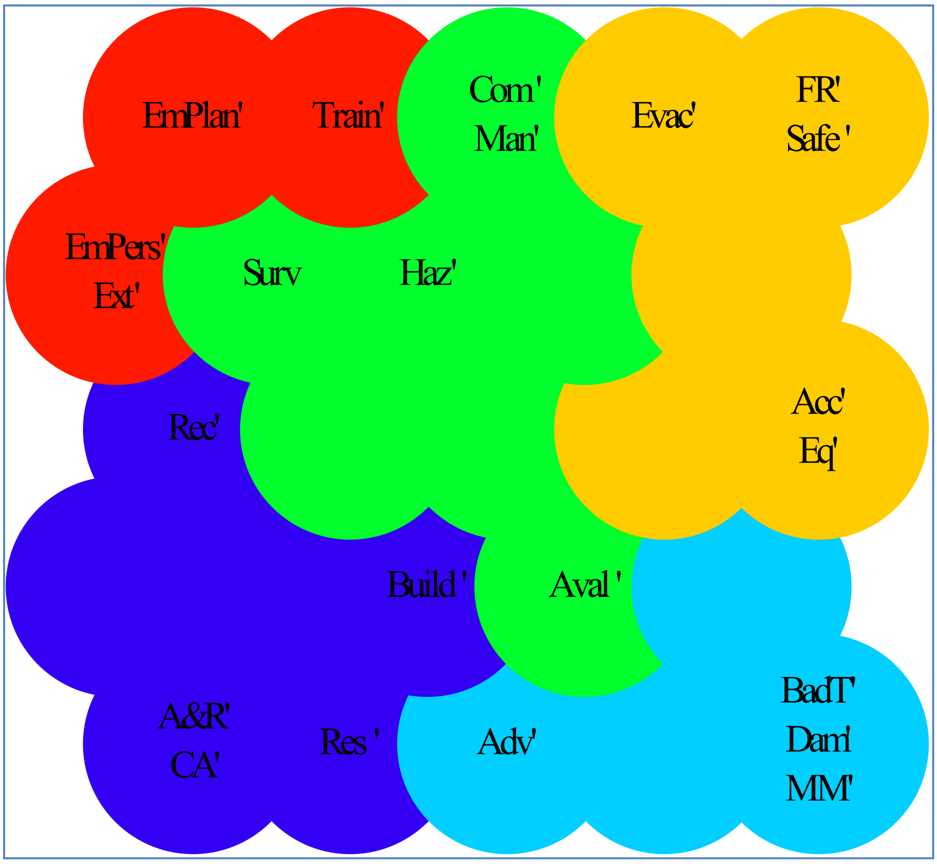


Figure 3.10 SOM depicting three clusters of the original 23 variables

Showing the clusters of the vectors in groups or spaces provides an emergent representation of how the total social group represent the perceived earthquake hazards in Alpine Ski Areas. On examination, I discerned that the blue cluster incorporates variables that depend on high level of coordination**,** namely mitigation and preparation variables, but also the recovery phase. The concepts in the blue cluster are instrumental response considerations that depend on preparation. The red cluster represents key considerations that must be in place to enable immediate response. The concepts in the red cluster are instrumental in mitigating the influence of the variables in the green cluster, specifically, the variables that are perceived as negative consequences of an earthquake.

The five cluster formation of variables was also investigated as shown in Figure 3.11. There were some persistent clusters, but the results illustrated some interesting differences from the 3 cluster structure.

Figure 3.11 SOM depicting five clusters of the original 23 variables



First, there is a separation between the variables that depend on a high level of coordination, namely: *EM Plan, EM Personnel, External Assistance* and *Training* were separated from *Recovery, Building Considerations, Analysis and Reports, Community Assistance* and *Resources.* Another separation occurs between key considerations that must be in place to enable response. The considerations, *First Response, Safety, Evacuation, Access*, and *Equipment* were separated from *Communication, Managing People, Survival, Hazard Awareness*, and *Avalanche Considerations.* Onc cluster that was persistent in both 5- and 3-cluster organization was that containing negative consequences including *Bad Timing, Damaged Infrastructure, High Intensity or Magnitude,* and *Adverse Effects*.

The new configuration shows more diversity than the three-cluster one. Therefore, further insight can be generated by condensing the 23 variables into this five-cluster configuration depicting even higher upper level themes (Table 3.4) than was possible from the qualitative condensation used previously in this study.

Table 3.4 High level themes based on clustering condensed variables using SOM

SOM	Description for High Level Themes	Condensation Level Three
A	Negative Consequences	Adverse Secondary Effects (Landscape)
		Bad Timing (Winter, Early Season, During the day)
		Damaged Infrastructure
		High Intensity or Magnitude
B	High Coordination (Long Term)	Analysis and Reports
		Strong Buildings
		Community Assistance
		Recovery of Ski Area
		Resources in place
C	Response Requirements (Long Term)	Avalanche Considerations
		Good Communication
		Hazard Awareness
		Managing People
		Survival (Water, Food, & Shelter)
D	Culture of Safety (Preparation and Response)	Emergency Plan and Procedures
		Emergency Personnel
		External Assistance
		Good Training
E	Response Requirements (Immediate)	Access (in and out)
		Personal Equipment
		Evacuation Plan
		First Response
		Safety Considerations

By re-organising the twenty-three upper-level themes based on self-organisation of the concepts in the condensed FCMs, some general insights can be drawn about the overall perceptions of the participants. The most notable differences between the three and five cluster configuration is the separation of concepts in the blue and red clusters in the 3-cluster map. The blue cluster now represents elements of *High Coordination* including: Good Buildings via implementing building codes, *Analysis and Reports* about the risks of natural hazards, *Community Assistance* in response and recovery, *Resources* available to support preparation for response to an earthquake, and the *Recovery* of the ski area. These can be characterized as elements that are linked to immediate actions that support a balanced distinction between short term and long-term recovery.

The variables in the red cluster (Figure 3.11) centered on preparation considerations that are embedded in ski fields' *Culture of Safety,* including Emergency Plan and Procedures, Emergency Personnel, External Assistance and Good Training. Culture of Safety is associated with a rationality that is sufficient and timely where, in their activation, the short term dominates long term by virtue of Emergency Personnel and External Assistance afforded, while Emergency Plan and Procedures and Good Training is a balanced distinction between short and long.

The green cluster now represents a blend of preparation and response considerations in that each of the concepts would need to be considered pre- and, in the short-term post-event horizons, hence these *Response Requirements* include: Avalanche Considerations, Good Communication, Hazard Awareness, Managing People, and Survival. These concepts seem to favour a balanced distinction between short and long term.

The yellow cluster represents concepts that are required immediately after an earthquake, called *Immediate Response* considerations, Access, Personal Equipment, Evacuation Plan, First Response, and Safety Considerations. The concepts seem to hold the view that the short term dominates the long term, favouring a rationality that is sufficient and timely.

The light blue cluster contains all of the consequences of the earthquake that had negative influences on the other considerations, including Adverse effects, Bad Timing, Damaged Infrastructure, and High Intensity and Magnitude. These concepts seem to view the natural environment of an earthquake scenario as capricious, and also construct temporally as an involuntary myopia.

Though the five new upper level themes give the appearance that participants' perceptions have given rise to grouping of variables that characterise hierarchy, individualism and fatalist manners of organising, if we consider the concepts that make up the high level clusters, or even examine the original themes, there are other mixes of solidarities nested within them. Take, for example, the *Immediate Response* considerations (cluster E in Table 3.4): here, the *First Response* and *Evacuation* might infer hierarchical forms of organising while *Safety* and *Access* might be characterised as more egalitarian, and *Equipment*, given the dominance of personal safety equipment (as described by participants) may be characterized as individualistic. It is conceivable that the different solidarities are actually manifesting within the upper level themes; this is most unexpected and welcome. This will be revisited later but presently, I will move into the simulation results to generate better understanding of the social solidarities that manifest in the outcomes of simulations using the SGFCMs. First, however, some contextualising may be needed to make the results of the simulations more accessible.

3.8.1.1 Negative Consequences:

The high-level theme **Negative Consequences** in Table 3.4 captures the perceived consequences of earthquakes in the participants' maps, including *Adverse Effects, Bad Timing, Damaged Infrastructure,* and *High Intensity and Magnitude*. *Adverse Effects* pertains to the physical consequences of an earthquake on the landscape such as rock fall and avalanche, lack of land stability, and isolation. *Bad Timing* is an important recognition, which refers to how a variety of time frames can increase the risk of exposure to hazards by virtue of the time that an earthquake occurred (such as day or night, summer or winter). *Damaged Infrastructure* represents the negative consequences for infrastructure, such as loss of critical lifelines (e.g. power, water and communication), which could hinder response efforts. In addition, *Damaged Infrastructure* pertains to longer-term recovery issues such as lift re-alignments, re-certifying infrastructure, and re-building. *High Intensity* means the experience of an earthquake is major, intense, and severe (> MM VII).[35] Thus, *Negative Consequences* pertains to a high intensity earthquake that causes rock falls and avalanches, damage to buildings, lifts, and critical lifelines at a particularly bad time, such as in the middle of the day of a busy weekend.

3.8.1.2 High Coordination:

The theme **High Coordination** encompasses long-term considerations for earthquake mitigation, including *Analysis and Reports, Good Buildings, Community Assistance, Recovery of the Ski Area,* and *Resources*. *Analysis and Reports* relates to investigations that can help stakeholders understand risks and hazards to aid mitigation efforts. *Good Buildings* is the ability of buildings to resist damage from shaking caused earthquakes, by virtue of adhering to building codes or standards that depict appropriate designs for structural integrity. *Community Assistance* is a recognition that assistance from the immediate community (e.g., clientele or club members) advances the response and recovery efforts after an earthquake. *Recovery of the Ski Area* means updating emergency procedures, effectively communicating with the media to remarket the ski area, and repair of infrastructure to enable business operations. *Resources Considerations* include the need for adequate resource inventory, with additional resources if needed. Participants did not include specific descriptions of what these resources are, but they could be, for instance, human resources, physical resources, and technological resources. Thus, overall **High Coordination** means having a solid

[35] See Appendix 3.E Modified Mercalli Intensity Scale

understanding of the risks posed by hazards to aid mitigation, making sure that buildings are resistant, the community is ready to respond, recovery plans are in place and an adequate resource inventory is available.

3.8.1.3 Response Requirements (Long Term):

The theme **Response Requirements** (Long Term) encompasses the need for contemplation to have occurred prior to an earthquake to enable response, including *Avalanche Considerations, Good Communication, Hazard Awareness, Managing People,* and *Survival Considerations. Avalanche considerations* pertain to awareness of the avalanche hazards through avalanche education as well as active and passive avalanche control. *Good Communication* is the general need to communicate with staff, clientele and external agencies, but also includes notions of communication tools such as cell phones or radios, and the need for alternatives, for instance, mountain radios or satellite phones. *Hazard Awareness* relates to education, experience, and awareness of hazards consequences (e.g. aftershocks, rock fall, and avalanches). *Managing People* relates to how managing a high number of potentially distraught people will require good leadership. *Survival Considerations* includes elements of basic survival (e.g., Water, Food and Shelter). Thus, **Response Requirements (Long Term)** entails being aware of, and being able to control, avalanches, communicating effectively with staff and clientele, being well aware of hazards such as rock falls, avalanches and aftershocks, being able to manage distraught people, and having access to basic survival items such as water, food and shelter.

3.8.1.4 Culture of Safety:

The theme **Culture of Safety** refers to the existing practices of ski areas with respect to managing risks including: *Emergency Plan and Procedures, Emergency Personnel, Evacuations Strategy, and Training Considerations. Emergency Plan and Procedures* means having an emergency plan and emergency procedures in place prior to an earthquake event. There were also references to warning systems, international or national standards, and the difficulty of predicting hazards, which is a key reason for having emergency plans and procedures. *Emergency personnel* include trained and skilled people such as ski patrol, medical staff, and other key people to respond to hazard events. *Evacuation Consideration* depicts the need for plans to evacuate lifts, buildings and eventually the ski area. *Training Considerations* refer generally to good training, but there are also elements of scenarios, drills, and trial runs that enable the staff to deal with emergencies. Thus, **Culture of Safety** necessitates having well trained emergency personnel who have practiced and can carry out the emergency plan and procedures, and evacuate people from lifts and buildings and eventually evacuate the ski area.

3.8.1.5 Response Requirements (Immediate)

The theme **Response Requirements (Immediate)** deals specifically with considerations that need to happen right away when an earthquake has occurred. The theme *Access* means simply access in and out of the ski area via the road. *Equipment considerations* include personal (e.g., pack, shovel, probe and transceiver) and group equipment (e.g., rescue, first aid, vehicles) that is needed to facilitate a response. *Evacuation Consideration* depicts the need for plans that are in place and have been practised to quickly evacuate lifts, buildings and eventually the ski area. *External Assistance* is a recognition that in an earthquake there is a requirement for external support in the form of medical support, resources, or other emergency services. *First Response* is associated with locating people quickly, assessing injuries and treatment of injuries through first aid. *Safety Considerations* mean that safety has been provided to all people in the ski area, by having a safe area to gather in the event of an earthquake. Thus, **Response Requirements (Immediate)** means that there is access in and out of the ski area, enabling emergency services to support response, such as locating people, assessing and treating injuries, and gathering people to a safe area so that strategies for evacuating lifts, buildings, and eventually the ski area can occur.

3.8.2 Scenario Orientation

In order to facilitate simulation of policy scenarios, three social group FCMs and a total social group FCM (TSGFCM) with 5 variables that correspond to the 5 SOM clusters containing high level themes were first developed by map condensation and aggregation. Thus, each variable in these maps is made up of the concepts in the corresponding SOM cluster. For simulation purposes, the maps were treated as AANN where neurons are the map variables from the participant's condensed maps. The Logistic function was used to process the weighted inputs into each neuron. The weights were obtained in the process of map condensation and aggregation through additive superposition.

Five policy simulation scenarios were created where each scenario clamped one out of the five variables in a map meaning that the state (input) of that variable was set to 1.0 (meaning high level) throughout the simulation. This also means that all the concepts making up that variable are all set at the level of 1.0 for the simulation. The simulations in this section were conducted using a Matlab m-file script (Appendix 3.F).

3.8.2.1 Policy Simulations: Fuzzy Cognitive Map Inferences

Once FCM are processed, realistic policy options can be simulated where the SGFCM provides the structure for using the neural computational method known as auto-associative artificial neural networks (AANN) framework (Kosko, 1992; Reinman, 1998; Ozesmi, 1999, 2003; and Strickert *et al.,* 2009). These networks do not learn in the same way as traditional neural network architectures (e.g. Hebbian or Back-propogation); rather the researcher becomes the interpretive tool of the network in a 'steady state', or, more aptly, a 'desirable configuration'. The structure of FCMs with nodes and forward and feedback connections make them directly transferable to the format of AANN where a number of neurons form a network with forward and feedback loops. Nodes in FCM become neurons in AANN and connection strengths or weights between neurons in AANN are the same as those between nodes in the FCM. Thus an FCM is an AANN where each node (neuron) in the AANN represents a key consideration in the FCM and the connection strengths between the neurons are the same as those provided by the participants for the strength of relationship between the corresponding key considerations in the FCM. For example, each neuron in the network can be depicted as shown in Figure 2.4 to demonstrate its operation.

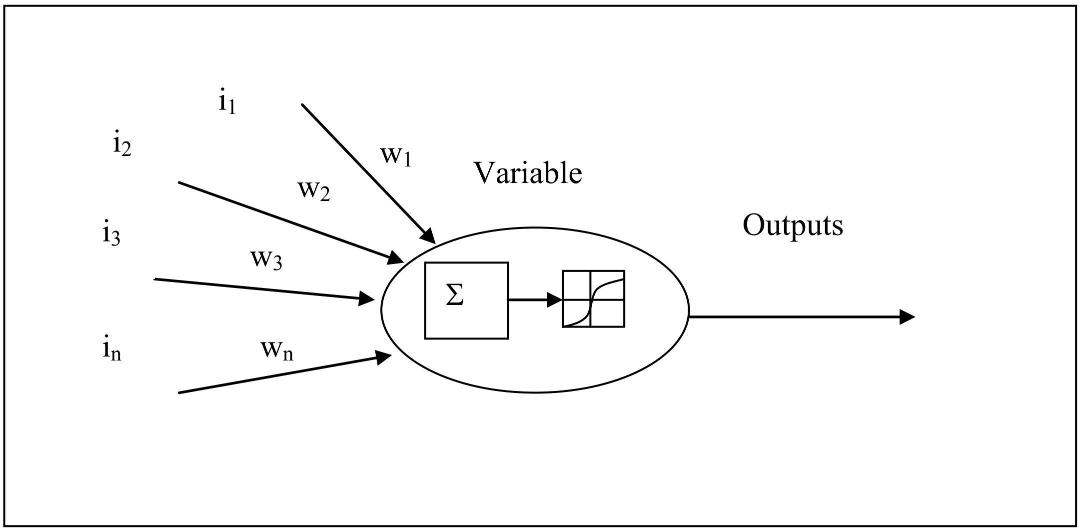


Figure 2.4 Single activated neuron in an AANN.

A neuron as shown in Figure 2.4 represents a variable (i.e. key consideration). Each neuron receives inputs (i_n) from other neurons and itself. Inputs are the state of each of the key considerations, i.e., the importance given to each of the key considerations, in the range of **[0 to 1];** 0 meaning no importance whatsoever is given to that consideration and 1 means a high importance is given to it. Each input is weighted by the strength of the connection (w_n) between the neuron sending the input and the neuron receiving it and this connection strength is the strength of relationship between the corresponding key considerations provided by the participants. Thus all inputs received by a neuron are multiplied by the weights of the connections and then summed. The neuron can produce this as its output, but a better approach is to standardize or normalize it so that the output always stays within the bounds of 0 and 1. This is achieved by processing the net sum by a function such as logistic function that performs a nonlinear transformation of data between 0 and 1. This output is then sent to all other neurons and itself as an input and the process repeats until there is no change to the outputs, meaning that a steady state or equilibrium has been reached (usually within 20-30 iterations or loops). The steady state reflects the effect of initial inputs (level of importance given to the key considerations) on the net outcome of the whole system. The steady states determine where the system will end up based on participants' views. The system could theoretically settle into a fixed point, limit cycle or chaotic attractor (Dickerson and Kosko, 1994).

Once the steady state solution is ascertained, the neural computational method can be used to simulate the effect of changing the status quo to a desired policy setting with respect to the level of importance given to the key considerations (inputs) in the network. For example, "clamping" (i.e., fixing) a predetermined number of variables at a high level (i.e. setting their input to 1 and holding them at this level through each iteration) depicts a policy scenario where these variables are considered very important for decision making. The change in the outcome (variable state) with respect to that of the status quo gives an indication of the effect of the "what-if" scenario on the system. By "clamping" inputs at various levels between 0 and 1, a variety of policy options and their effects can be simulated.

For instance, consider the following policy scenario: Negative Consequences (adverse effects) are clamped at a high level (1) and held for every iteration. Then the outcomes (i.e., difference between the steady state of the initial activation and the outcomes of the clamped scenario) result in increases to High Coordination, Response Requirements Immediate, Culture of Safety and Response Requirements Long Term (See Section 3.8 for detailed descriptions of these high level themes); thus the scenario would infer that these high level concepts need to be enhanced to enable adaptation to a high level of adverse effects.

As discussed above AANN simulation involves first running the system until it reaches equilibrium with the present state (status quo) of the variables. The present state of the variables basically is their inputs. These were ascertained from participants' accounts in the qualitative interviews and range from 0 to 1 where 0 means the variable has no influence or importance. The second step of the simulation is to clamp the state of a selected neuron at the predetermined fixed value and run the simulation again while keeping this node at the fixed value until convergence or there is no change to the system response. Then the effect of the clamped variable is ascertained by assessing the shift in the output of the remaining nodes from their reference or equilibrium value.

The results of the five scenarios for the TSGFCM and the respective changes to the remaining variables are presented in the next section. These scenarios were also run for each of the participant groups SGFCMs (Appendix 3.H, 3.I, 3.J) in order to compare how social group scenario simulations are qualitatively different from those of the TSGFCM. This can provide insights into overall perceptions of particular social groups, highlighting similarities and differences in perceptions, and which groups were driving particular views. The analysis can be used to identify targets for engaging in multi-way risk communication with participants. The inferences drawn from the results can identify starting points for policy discussion. The simulations also provide insights into how the five social solidarities of cultural theory surface, and how these are important for the policy development process. In particular, this might help to highlight adaptive strategies that can be enhanced by highlighting potential synergies, contradictory certainties, and slight differences to help generate clumsy solutions.

3.9 Complex Scenarios Clamping Multiple Nodes

In this section, the results of policy scenario simulations are presented. They are designed to study the influence of the five high-level themes represented by AANN nodes on each other. These themes, identified by SOM clustering and presented in Table 3.4, are Negative Consequences (A), High Coordination (B), Response Requirements (Long Term) (C), Culture of Safety (D) and Response Requirement (Immediate) (E). Themes B-E are in fact four management options and the theme A represents external effects. First, we can compare the results of all five simulation scenarios to see which scenarios cause the most significant changes. This is shown below in Figure 3.12 illustrating the scenarios A, B, C, D, and E from TSGFCM. For greater detail, the results for all 23 concepts embedded in the 5 nodes are presented in the figure.

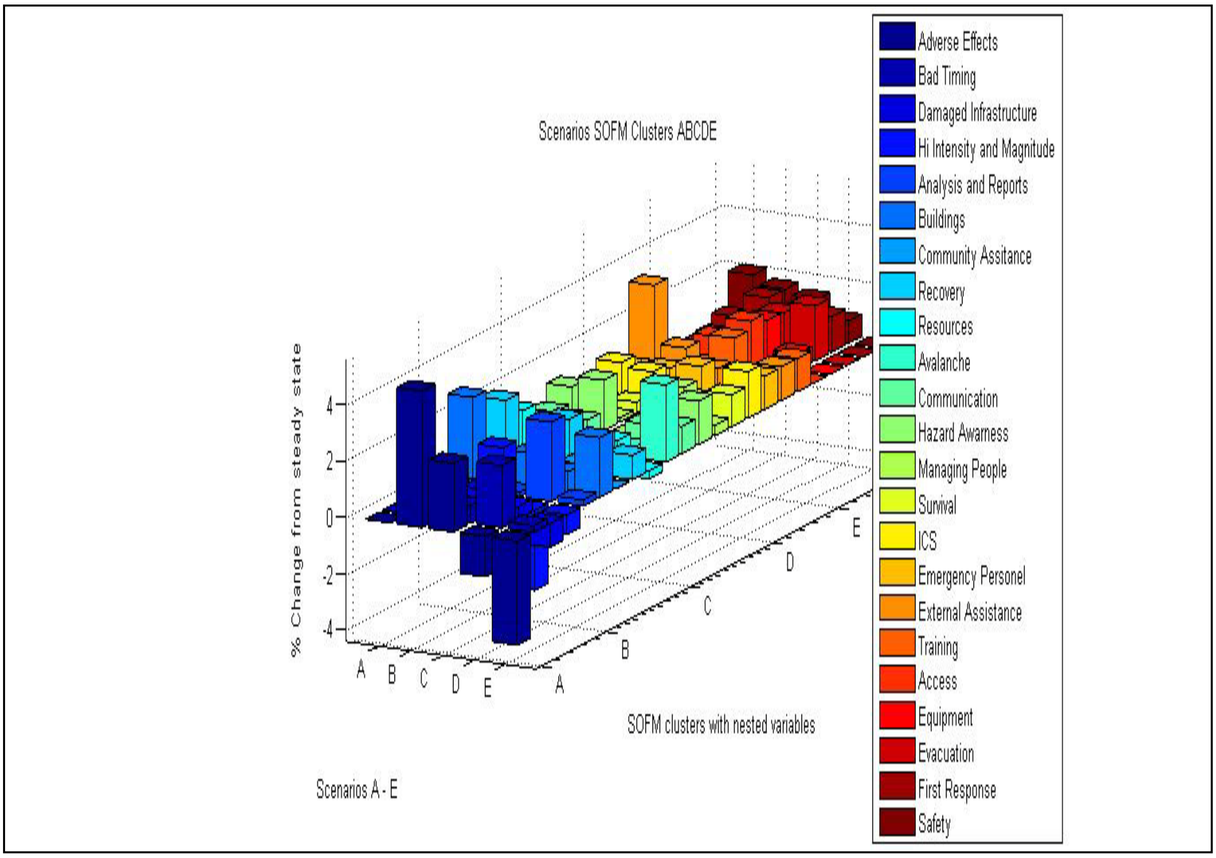


Figure 3.12 Comparison of scenarios A, B, C, D, and E from TSGFCM based on the % change in the value of the corresponding variables from their steady-state values

***Note:** The dependent (clamped) variables for each scenario were removed to better represent their influence on other dependent (non-clamped) variables. The changes are represented as the percent change (i.e., difference between the variable-state with no variables clamped and the variable-state of the policy scenario when a group of variables was clamped. Those above zero are described as an increase (meaning enhanced) while those below zero are described as a decrease (i.e., meaning a lessening of impact) under the conditions of the given scenario (i.e., dependent on the particular variables which are clamped). Significant changes are those above 2%. Moderate changes are those between 1% and 2%. Slight changes are those between 0.5% and 1%. Very slight changes are less than 0.5 %. It is also important to remember that the results of the simulations are a direct result of condensation, aggregation as well as the emergent configuration supported by the SOM. Attempts are made in the text to let the voices of participants come through by providing exemplars using the concepts from participants' FCMs and insights garnered from qualitative interviews.

The results of the multi-node scenario simulations provide insights into participants' (i.e., social groups) collective perceptions or horizons as represented by their condensed and aggregated SGFCM regarding earthquakes affecting a ski area and potential management options. This is achieved by treating each scenario as a new set of conditions that dictate independent variables (i.e., the variables that are clamped at 1 meaning a high level of importance, or effect) and dependent variables (i.e., those that were not clamped and allowed to stabilize). The chart shows the difference between the original steady-states and those of the scenario conditions. It is quite difficult to follow the three dimensional bar charts when there are many concepts; therefore, Figure 3.12 can be simplified by unpacking the individual scenarios to illustrate more clearly the response of the dependent variables (see the **Note** above). In addition, it is possible to identify which stakeholder groups supported particular perceptions of interest that are present in the TSGFCM by comparing them to the same scenarios run for each of the targeted social groups (Appendix 3.H, 3.I, 3.J).

The interpretations deal with the following questions: 1) What do the overall results of each of the TSGFCM scenario simulations mean?, 2) How can these results be interpreted using the themes from the original FCMs?, 3) What are the differences in perspectives between the social groups?, 4) Which solidarities of cultural theory are evident based on key elements of the four political cultures?. These simulations speak directly to the objectives of the project by taking a holistic approach to the of study natural hazards using a transdisciplinary approach; the triangulated mixed methodology demonstrates how different policy options enhance the viability of human systems in the face of compounding natural hazards.

The detailed outcomes of five scenarios are presented in the next section. The first is a worst-case scenario where all the negative consequences are set at a high level. It examines the changes (i.e., outcomes) from the steady-states of the variables that make up the other four different management strategies: High Coordination (B), Response Requirements (Long Term) (C), Culture of Safety (D) and Response Requirement (Immediate) (E). The rest of the four scenarios are run by clamping the relevant high-level themes in each of the options of B –High Coordination, C –Response Requirements (Long Term), D –Culture of Safety, and E – Response Requirement (Immediate) to examine their influences on the rest of the management options or Negative Consequences. All five simulations are in effect 'nice' or 'good' scenarios comparing four different management options in the relation to potential Negative Consequences. Subsequently, lessons from the four management scenarios are discussed by relating them to key elements of social solidarities and the overall social constructions of nature using the metaphor of a ball on a landscape.

3.9.1 Scenario A: Negative Consequences at a high level

In Scenario A, the concepts that make up the **Negative Elements** node (e.g., *Adverse Effects, Bad Timing, Damaged Infrastructure, and High Intensity*) were clamped at a high level. As an illustration, Scenario A is where an earthquake affects a ski area, causing a number of consequences. Primary effects include severe shaking and immediate damage to buildings. Secondary effects could include avalanches, rock fall, and landslides. Tertiary effects such as ski lifts being knocked out of alignment or collapsing, loss of critical lifelines, and the outbreak of a fire at an inconvenient time of the day or early in the ski season were also included. This scenario examines what could happen to the collective horizon (i.e., TSGFCM) in terms of which variables are increased (i.e., impacted greatly) or decreased (i.e., lessening of impact) when the N**egative Consequences** of an earthquake are set at a high level (Figure 3.13).

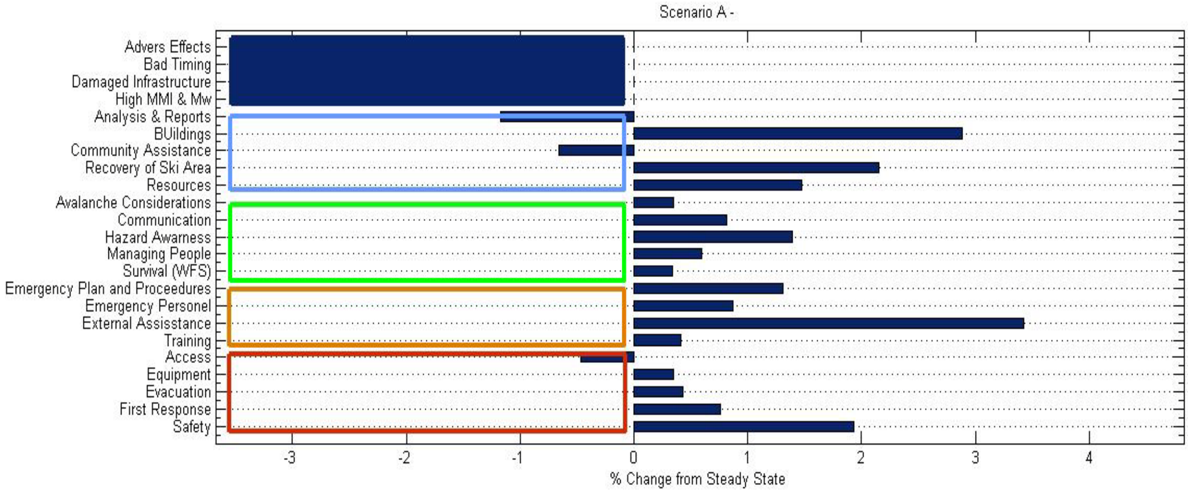


Figure 3.13 TSG Scenario A –**Negative Consequences** clamped at 1. The % change in values of variables making up the high-level themes from their steady-state values are shown.

The most significant changes in Scenario A are increases to *External Assistance*, *Building Considerations*, *Recovery*, and *Safety*. The increase to External Assistance means that it is important to enhance *External Assistance*, such as the need for ‘External Emergency Services’ when **Negative Consequences** are high. The increase to *Building Considerations,* such as ‘buildings adhering to building codes’, for example, means that the need for building codes is enhanced (e.g., more important) when **Negative Consequences** are high. The increase to *Recovery*, for instance, the need or requirement for a ‘Follow up debrief’ after the event is higher when **Negative Consequences** are high.

Other notable changes, in Scenario A – **Negative Consequences** set at a high level are decreases in *Analysis and Reports, Community Assistance*, and *Access*. The decrease in *Analysis and Reports*, for example, the need to ‘Identify High Risk Areas’ means that during a worst-case scenario earthquake the effectiveness of *Analysis and Reports* will have little impact. The same is true for the decrease to *Community Assistance,* when the **Negative Consequences** of an earthquake are high, indicating that Identifying High-Risk Areas and having community members involved in the response will have limited impact. The decrease in *Access* (e.g., “no access road”) highlights a horizon that *Access* to and from the field after an earthquake may be disrupted, an obvious cause and effect relationship. The increase to *Safety* means that when the **Negative Consequences** are high, there is additional need for a 'well marked safety zone' or to enhance 'Safety of All'.

3.9.1.1 Differences in perceptions from SGFCM Scenario A

The increased need for *Building Considerations* was significant and shared by all three social groups, but was more influential in SAM and ASR, than SIW horizons (Appendix 3.H, 3.I, 3.J). The increased importance for *External Assistance*, in particular, was predominately a concern of the SAM, as ASR and SIW did not perceive the positive influences on this to be nearly as high. The SIW group mostly drove the increase to Safety, such as the need for a 'well-marked Safety Zone', as ASR and SAM did not perceive the same degree of increase. The decreases in *Analysis and Reports*, for example, the need to 'Identify High Risk Areas' only featured in the SIW group for this scenario. The decrease in *Access* (e.g., "no access road") came solely from the SAM group, which highlights a horizon that *Access* to and from the field after an earthquake may be disrupted, another distinct cause and effect relationship.

3.9.1.2 Social Solidarities Associated with Negative Elements

Scenario A indicates that the need for *External Assistance* in an earthquake is a critical consideration; it is interesting to note that this perception came mainly from the SAM group, who also believed that *Access* would decrease. This is evidence of the SAM's SGFMC showing some preference for a hierarchical form of organising based on a risk handling style of absorption and rejection. The latter is based on the notion of absorbing the risk understanding that '*Access'* will be compromised while at the same time rejecting the consequences of the risk through the need to enhance 'External Assistance', such as support from external agencies via helicopter. Thus, in a worst-case scenario, the ball can be kept safely in the basin between two humps through facilitating external support without depending on ground transport.

These results also highlight the selection of risks by two groups, possibly due to roles and positions of responsibility. The SAM are those who are responsible for coordinating *External Assistance* prior to and during an event, while the workers (i.e., ski patrol) would be on the front lines attempting to provide *Safety* for clientele and staff. Both of these groups' scenario simulations infer that resources are present to coordinate responses to *Adverse Effects*. *Communication* increased moderately in the scenario driven from the SAM whereas it increased to a lesser extent in ASR, which may highlight an opportunity for synergy of SAM communicating to ASR what they should do, an example of a transaction (i.e., opportunity for synergy) between hierarchist and individualists, respectively.

Another indication of where one's roles and responsibilities may define the perception is highlighted by the fact that SIW saw higher increases to *First Response* than ASR and SAM, which makes sense because many of the participants in the SIW group were ski patrollers who are expected to be on the front lines in emergency situations. This could be an indication of individualism insofar as the weight on *First Response* may be based on a substantive rationality, a scope of knowledge that is sufficient and timely, and driven by trial and error learning styles, which were common themes among this participant group in the qualitative interviews.

When looking at the entire social group, the scenario shows evidence of preferences for hierarchical, individualist, and small instance of egalitarian forms of organization. High **Negative Consequences** requires due consideration for *External Assistance*, *Building Considerations*, *Recovery*, and *Safety.* Another key point worth noting is that when using the additive method of aggregation into social groups to create the TSGFCM, some key differences of individual social groups can be preserved by looking at them separately from the TSGFCM. For example, consider how the decrease to *Analysis and Reports* and *Community Assistance* was driven solely by the SIW. This might infer that in a scenario where the **Negative Consequences** of an earthquake are high, *Analysis and Reports* might not be a helpful strategy, which could be construed as fatalism. However, if the SIW were indeed viewing the scenario from an individualist solidarity, as highlighted above, when their social construction of time is considered, the result becomes clearer. The *Analysis and Reports* will not be useful according to a perception of time where the short term dominates the long term, which is wholly rational if one is responsible for first response during an emergency, and from the perspective of a ski patroller, is probably more justifiable than involuntary myopia. Lastly, the increase to *Safety*, as in a 'well marked Safe Zone' or 'Safety of All' could be construed as a preference for an egalitarian manner of organising. However, in some of the following simulations, we see a rejection of egalitarian organising as it does not appear that the ball will fall off the mesa; rather, by enhancing various management options, the **Negative Consequences** may be reduced thus implying a collective view of nature as perverse and tolerant. The next four simulations will examine how the various management strategies affect each other and the variables that make up the subgroup of **Negative Consequences.**

3.9.1.3 Insights from Scenario A – Negative Elements

Scenario A was in effect a worst-case scenario which examined the perceived changes (i.e., adjustments to various management strategies) when all of the negative elements of an earthquake are at a high level. It highlights some useful insights that can aid the development of policies to enhance adaptive capacity in an earthquake. These insights become apparent by looking at the similarities and differences among stakeholder groups.

First, all three stakeholder groups FCMs indicate that *Building Considerations* need to be increased (e.g., implement building codes to ensure strong buildings). Second, there is a need for increasing *External Assistance* (e.g., allocating assets such as helicopters to aid in response), though this was driven mostly by SAM. Third, *Safety* (e.g., a well-marked safety zone) needs to be increased, though this was driven mostly by SIW. Fourth, SIW were sole drivers of a decrease to *Analysis and Reports* (e.g., identify high-risk areas), which might suggest that reports are inadequate or that they will be of limited effectiveness in responding to or recovering from an earthquake. Fifth, the decrease in Access (e.g., blocked access road) was a clear cause and effect relationship motivated only by the SAM, which also validates their view of the need for external assistance.

3.9.1.4 Transition from Worst-Case Scenario to Management Strategies

The results presented above included a high level of detail. The next simulations highlight the most insightful results from management strategies in simplified form, while including exemplars from original FCMs to provide illustrative examples. After the results from each scenario are presented, attention is given to differences between the stakeholder groups followed by attention to apparent social solidarities. The abbreviations of ASR, SIW, and SAM are changed to riders, workers and managers.

3.9.2 Scenario B: High Coordination

The next scenario (TSG Scenario B) investigates the outcome of clamping elements of **High Coordination** at a high level and the influence on the other variables. Scenario B shows outcomes of clamping *Analysis and Reports*, *Building Considerations*, *Community Assistance*, *Recovery*, and *Resources* at a high level (Figure 3.14). This means that the following elements are held at a high level: *Analysis and Reports* (e.g., the production and dissemination of detailed hazard reports, essentially an inventory of previous hazard events and the possible consequences of future events); *Building Considerations* (e.g., buildings are constructed to appropriate building codes for mitigation of natural hazards); *Community Assistance* (e.g., the ski field community is informed and prepared to assist in response to a natural hazard event); *Recovery* (e.g., plans for recovery such as consolidating and updating buildings during reconstruction, lift re-alignments, and reflexive deliberation via debriefing to enhance response capacity in the future); *Resources* (e.g.. human and physical resources are in place to support response and recovery operations). The results show cause and effect relationships, as well as some counter-intuitive results.

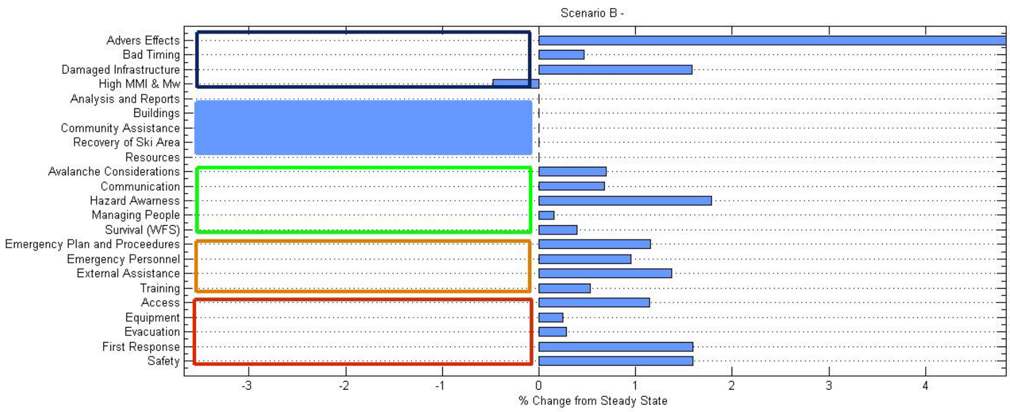


Figure 3.14 TSG Scenario B **High Coordination** clamped at 1.

The most significant changes in Scenario B (**High Coordination** is a high priority) are increases in *Adverse Physical Effects*, *Damaged Infrastructure*, *Hazard Awareness*, *First Response,* and *Safety*. The increases to *Hazard Awareness, First Response* and *Safety*, are quite straightforward; they are enhanced with **High Coordination.**

Conversely, the significant increase in *Adverse Physical Effects and Damaged Infrastructure* is counter-intuitive. The outcome supposes that despite **High Coordination,** there are enhancements to *Adverse Effects* and *Damaged Infrastructure*.

Other notable changes are decreases in *High Intensity*. The decrease in *High Intensity* such as 'Severity of Shaking', 'High Intensity of Magnitude', and 'Large Scope and Scale' means that **High Coordination** could lessen the intensity of the participants' experience with an earthquake, once again showing cause and effect.

3.9.2.1 Insights from Scenario B – High Coordination

Scenario B examined the changes (i.e., adjustments to both Negative Consequences and other management strategies) that occur when **High Coordination** is at a high level. This scenario highlighted two notable differences between stakeholders' group FCMs. First, workers perceived an increase to *Damaged Infrastructure,* while the managers perceived a decrease. Another difference was that managers and workers perceived a decrease in *High Intensity* (i.e., lessening intensity of the experience), while the riders perceived an increase (i.e., more intense).

Some similarities also existed between the stakeholder group FCMs in scenario B. First, all three groups' FCMs indicate perceived increases to *Hazard Awareness*. Second, all three groups perceived increases to *First Response*, though more by workers and managers than riders. Third, the increase to *Safety*, was present in all three groups' FCM, but mostly in managers group, then workers, and only to a small extent by riders. Finally, all three groups perceived that Scenario B increased *Adverse Physical Effects*. This appears counter-intuitive, yet it may not infer a direct cause and effect relationship such that placing those variables at a high level make the adverse effects worse; rather, it may mean they perceived that activating these elements of **High Coordination** highlight that the consequences of *Adverse Physical Effects* need due consideration. Therefore *more clarification is needed* regarding this concept through further discussions with the stakeholders.

3.9.2.2 Social Solidarities Associated with High Coordination

The outcomes of simulations may imply preferences for social solidarities that are based on participants' roles as managers, workers, or riders. To begin, comparisons are made between outcomes for variables that make up **Negative Elements**.

The concept *Damaged Infrastructure* showed differences in social solidarities between the managers and the workers. The managers indicate it would decrease, thus high coordination reduces the impact on *Damaged Infrastructure,* suggesting the system controllable. The workers, however, indicate that it would increase, thus suggesting the system is fragile. The outcome of the scenario also highlights differences with respect to High *Intensity and Magnitude.* The workers and managers perceive a decrease, the system is controllable, while the riders perceive an increase, the system is fragile or capricious.

All three groups' simulations indicate that *Adverse Effects* are enhanced significantly in a scenario of **High Coordination**. Assuming the relationship is one of cause and effect, this highlights a view of nature capricious, though as noted above, more clarification is needed. One might assume that **High Coordination** will decrease the consequences of *Adverse Physical Affects*, but it is possible that Scenario B is capturing a perception of vulnerability in that people are at the mercy of the environment in an earthquake. Drawing this inference appears to represent a view of nature ephemeral or capricious which is characteristic of egalitarian or fatalist solidarities. Another interpretation is that a high priority placed on the concepts of **High Coordination** stresses the need for adaptation rather than control of the physical environment in an earthquake. This inference indicates a view of nature as resilient, and would place humans as part of nature (i.e., changing the landscapes as it changes them), rather than being separate from it. The increase to adverse physical effects was shared by all three participant groups and may provide an indication that *the autonomous way of organising is present* when considering a situated risk of an earthquake in the context of a ski area.

Thus, in a scenario of **High Coordination,** overall, the participants did not perceive nature as benign. Instead, the ball seems to be rolling between the two humps, implying time perspectives that are either a balanced distinction between short term and long term, a preference for long-term vision needing radical change immediately, or, finally, a rationality of immediacy. Perhaps looking at the Response Requirements (Long Term) will shed more light on participants' social constructions of time.

3.9.3 Scenario C: Response Requirements (Long Term)

TSG Scenario C investigates the effect/influence of clamping **Response Requirements (Long Term);** therefore, *Avalanche Considerations*, *Communication, Hazard Awareness, Managing People*, and *Survival* are at a high level. This scenario means the following: Avalanche Considerations (e.g., avalanches have been controlled; *Communication* (e.g., communication is effective and messages regarding the hazards have been given to participants prior to and immediately after a hazard event outlining how to prepare and respond); *Hazard Awareness* (e.g., understanding of hazards is high, people have a solid understanding of the potential consequences of an earthquake in mountainous areas); Managing people (e.g., Plans have been developed to manage people after an event taking into consideration the possibility of an emotional reaction or panic caused by being thrust into an extreme and unusual environment); finally *Survival (*e.g*.,* the means for providing food, water, and shelter are all in place prior to an earthquake) (Figure 3.15).

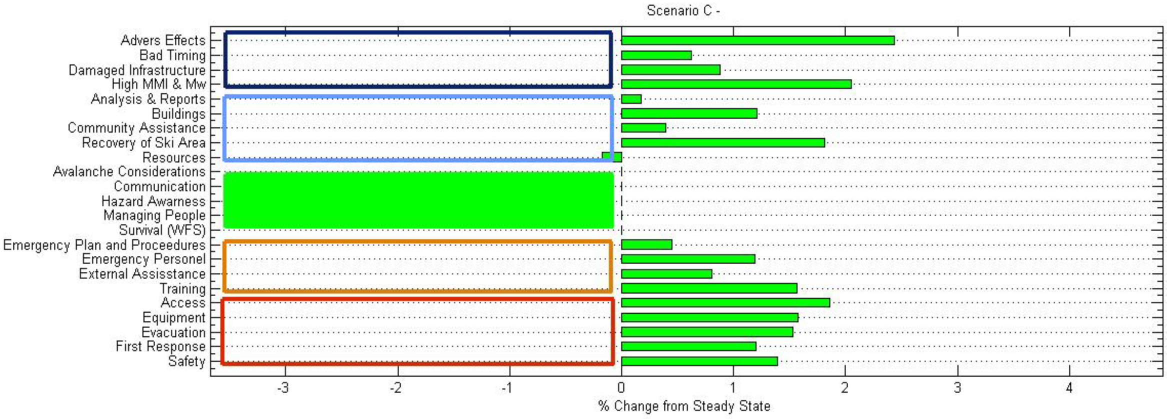


Figure 3.15TSG Scenario C Response Requirements (Long Term) clamped at 1.

The most significant changes in Scenario C are increases in *Adverse Secondary Effects, High Intensity, Recovery,* and *External Assistance,* as well as all the variables in cluster E – (i.e., Response Requirements (Immediate) containing *Access, Equipment, Evacuation, First Response, and Safety)*. This scenario shows another instance of counter intuitive results, namely, the increases to *Adverse Secondary Effects* and *High Intensity*. This may be another indication that deeper discussions with stakeholders are needed.

The increase in *Recovery Considerations* means that ‘Re-marketing post event’, and ‘follow up debrief’ will be enhanced if a long-term vision is in place. The increase to *External Assistance* (e.g., ‘outside resources’) means that if **Response Requirements (Long Term)** are at a high level, then external assistance is enhanced, perhaps by ensuring assets (e.g., helicopters) are available in nearby communities.

It is also interesting to note that a high level of **Response Requirements (Long Term)** enhance all of the Response Requirements (Immediate). It will be interesting to see if this works both ways and with the same level of enhancement.

3.9.3.1 Insights from Scenario C – Response Requirements (Long Term)

Scenario C- examined the changes that resulted from Response Requirements (Long Term) being set at a high level. There were differences between stakeholders in this scenario. First, managers and workers drove the increase in Adverse Effects, whereas the riders’ map indicated a miniscule decrease. The managers’ and worker’ maps both showed increases to *Bad Timing*, while the riders’ showed no change. Similarly, the managers and the workers again showed increases to damaged infrastructure, and the riders showed no change. There was also an area of agreement; all three groups perceived an increase to *High Intensity and Magnitude.*

The variables that make up the other management strategies also showed similarities and differences. First, all three groups noted increases to *External Assistance* and *Recovery Considerations.* Additionally, the three groups were in general agreement regarding the increases to the variables that make up the subgroup of Response Requirements (Immediate), including *Access, Equipment, Evacuation, First Response,* and *Safety.* There was one notable difference therein*:* riders' maps showed a significant increase to *Equipment Considerations,* while the workers and managers indicated no change.

There were other notable differences between participants' social group maps and the outcomes of the variables from the management strategies. First, the riders and workers maps indicated moderate increases to *Safety Considerations,* while the managers only indicated a very slight increase. Similarly, the increase in *Recovery Considerations* was driven more by riders and workers than managers. This is an interesting view from the perspective of the clientele and staff, which could highlight to ski area managers that debriefs and a media strategy are critical for effective recovery.

3.9.3.2 Social Solidarities Associated with Response Requirements (Long Term)

The outcomes of scenario C also indicate fatalism. The managers and workers believe that despite a high level of response requirements, *Adverse Effects* and *Bad Timing* are enhanced. The riders disagree, suggesting that adverse effects will decrease, thus the system is robust. Though the riders agreed with the managers and workers that *High Intensity* would increase, their solution is to enhance *Equipment Considerations*; this a change from their egalitarian organising of scenario A and B, suggesting fatalism based on individualised survival given that most equipment was personal equipment.

3.9.4 Scenario D: Culture of Safety

The next scenario explores how variables are affected by clamping the elements of **Culture of Safety** at a high level. In a real world scenario, this would mean that the following elements were given high priority: *Emergency Plan and Procedures*, (e.g., development of an emergency plan or incident command system); *Emergency Personnel*, (e.g., ski patrol and medical staff are in place and ready to respond); *External Assistance*, (e.g., police, fire, and EMS are reachable and understand the environmental conditions and the response requirements); *Training*, (e.g., training programs are present for all staff including simulation scenarios to test and refine systems) (Figure 3.16).

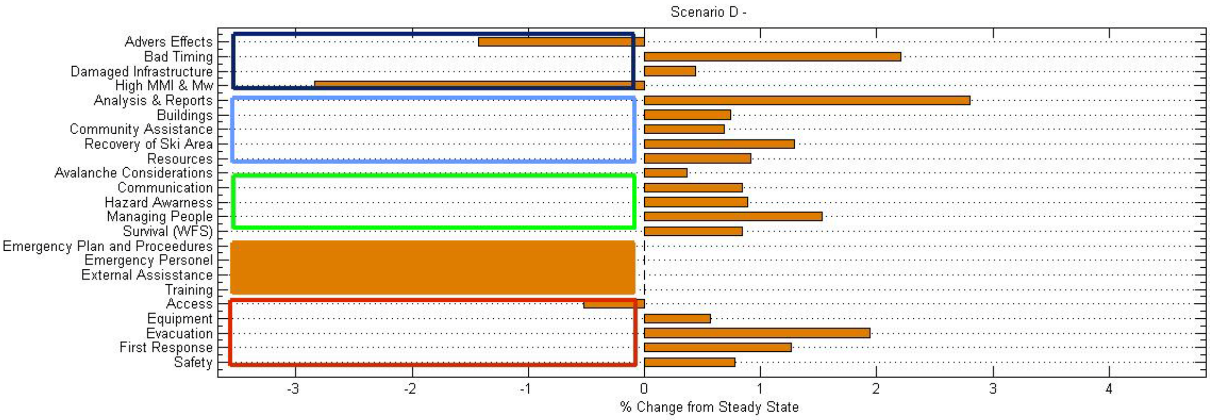


Figure 3.16 TSG Scenario D **Culture of Safety** clamped at 1.

The most significant effects of this scenario are an increase to *Analysis and Reports*, *Evacuation*, and *Bad Timing*. Thus, if **Culture of Safety** is high the efficacy of *Analysis and Reports* has been enhanced. The increase to *Bad Timing* highlights that in a high **Culture of Safety** all of the procedures, personnel, external assistance, and training, must take into consideration the winter environment, and how an earthquake would affect the business if it occurred early in the season, effectively planning for a worst-case scenario. There was also a significant decrease to *High Intensity*, and *Adverse Effects,* which means that a high **Culture of Safety** could curtail the consequences of an earthquake (i.e., cause and effect).

3.9.4.1 Insights from Scenario D- Culture of Safety

Scenario D examined the outcomes from **Culture of Safety** at a high level, and again there were similarities and differences among the social groups. First, a notable difference, the decrease in *Adverse Effects* was driven by riders and workers, as the SAM groups' SGFCM indicates an increases in *Adverse Effects.* Second, the increase to *Bad Timing* was only common in managers and workers. Third, stakeholder groups' FCMs showed disagreements regarding *High Intensity* - managers perceived a strong decrease, workers perceived a small decrease, and the riders actually perceived an increase. The differences between the total social group fuzzy cognitive map results and those of the three different social groups provide a key insight from the simulation that represented a high **Culture of Safety**. Overall, it demonstrates “power” as an emergent property of the system, where in this instance, managers’ and workers’ perceptions overpowered those of the riders.

3.9.4.2 Social Solidarities Associated with Culture of Safety

The social groups’ outcomes of Scenario D also lean toward fatalism; despite a **Culture of Safety**, *Damaged Infrastructure* increase. Managers and workers also noted that *Bad Timing* increases. Interestingly, this presumption of fatalism was countered by an alliance between managers and workers, who indicated that a high **Culture of Safety** could curtail *High Intensity*.

3.9.5 Scenario E: Response Requirements (Immediate)

The final scenario examines the **Immediate Response Requirements** of the mountain communities, and how the other considerations changed when these were set at a high level. Scenario E shows the effect of clamping: *Access, Equipment, Evacuation, First Response,* and *Safety* at a high level (Figure 3.17). An illustration of this scenario is having the following elements at a high level: *Access* (e.g., access has been enabled by clearing debris from access road, or because aerial assets such as helicopters are available); *Equipment* (e.g., warm clothing, pack, probe and shovel, safety equipment are present); *Evacuation* (e.g., an evacuation plan for both lifts and buildings and the coordination of a full evacuation from the ski area is in place); *First Response* (e.g., locating people, triage and treating injuries); *Safety (*e.g., safety zones are in place and are well marked so people know where to go in an earthquake).

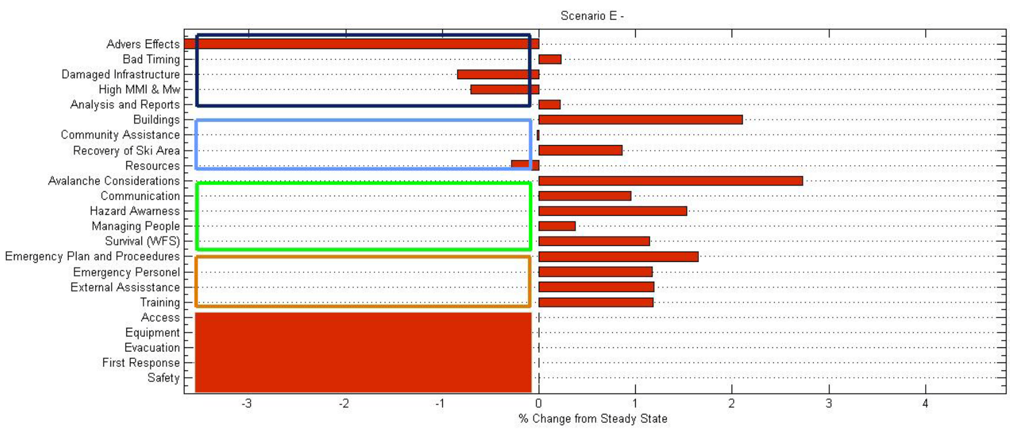


Figure 3.17 TSG Scenario E –Immediate Response Requirements Clamped at 1.

Interestingly, **Immediate Response Requirements** has the most significant decrease to *Adverse Effects*, as well as slight decreases to *Damaged Infrastructure*, *High Intensity, and Recovery*. This means that if *Access, Personal Equipment, Evacuation Strategy, First Response,* and *Safety* are at a high level, the negative physical consequences will be curtailed by a more significant margin than any of the other strategies. In addition, the impact of need for *Recovery* also decreases slightly when response requirements are high.

The decrease to *Adverse Effects* means that if, for example, *First Response* and *Safety* is at a high level, then the *Adverse Effects* (e.g., 'Avalanches Zones') will have less impact, as they will be able to respond by virtue of having access, equipment, evacuation and avalanche extraction through first response, in addition to a safe place to meet away from avalanche run-out zones.

There are also significant increases in *Buildings Considerations* and *Avalanche Considerations*. The increase to Building Considerations (e.g., 'Structural Integrity', 'Infrastructure Stability') means that, placing the buildings in a safe area has enabled the building to perform well in resisting the shaking from earthquakes, and secondary flow-on effects. By locating infrastructure in *Safe Zones*, the *Damaged Infrastructure* decreases, as does the experience of the earthquakes' intensity. The increase to *Avalanche Considerations* means that if, for example, 'Safety' is at a high level, then 'Snow Pack Stability' increases likely by virtue of avalanche control.

Moderate increases occur to *Recovery, Communication, Hazard Awareness, Survival, Emergency Plan and Procedures, Emergency Personnel, External Assistance, and Training*. The increase to *Communication* was consistent among all three groups, and highlights how communicating effectively will need to be enhanced to enable a high level of **Immediate Response Requirements**. The increase to *Hazard Awareness* means that if 'safety zones' are in place, then *Hazard Awareness* needs to be enhanced so that people know to move to these locations in the event of a hazard. The increase in *Survival Considerations*, for example, 'Food, Water, and Shelter' need to increase to conduct *Evacuation* and *First Response*. The increase to *Emergency Plan and Procedures* means that for a high level of safety, *Emergency Plan and Procedures* need to be enhanced. The increase to *Emergency Personnel* was consistent among the three groups, and means that setting **Immediate Response Requirements** at a high level requires enhancing *Emergency Personnel*. What is not clear is whether this is to improve the existing personnel, or add more, or perhaps both. The increase to *External Assistance* means that if there is a high level of **Immediate Response Requirements,** then *External Assistance* needs to be enhanced. Lastly, the increase to training means that if **Immediate Response Requirements** are at a high level, the level or amount of training needs to be enhanced.

3.9.5.1 Insights from Scenario E – Response Requirements (Immediate)

Scenario E examined the changes that resulted from *Response Requirements (Immediate)* at a high level, and again there were similarities and differences among the social groups. First, at the TSGFCM level, Scenario E had the most significant decreases to *Adverse Effects* and *Damaged Infrastructure*. Interestingly, different stakeholder groups drove these. The decrease to *Adverse Effects* was driven solely by the ASR; the managers showed a slight increase, and the workers a moderate increase. Similarly, the decrease to *Damaged Infrastructure* was driven by workers, as the managers and riders both indicate a miniscule decrease. Another notable difference of this scenario was that the workers drove the decrease to High Intensity and Magnitude, and this perception overpowered that of both the riders and the managers, who perceived slight increases; another indication of "power", though this time one stakeholders group view was strong enough to dominate two others. Likewise, increase to *Training* in the total social group map resulted from the riders and the workers again overpowering the managers whose map showed a decrease.

Despite evidence of power struggles, there were some areas of agreement with respect to the variables that make up the management strategies. First, all three groups agreed on the perceived increases to *Building Considerations, Hazard Awareness, Survival, Emergency Plan and Procedures, Emergency Personnel, and External Assistance.*

There were also some slight differences. First, the increase to *Avalanche Considerations* was driven by riders and workers, but not managers. Second, the increase to *Managing People* was once again driven only by riders and workers. Third, the increase to *Recovery Considerations* was driven by workers and riders, and marginally by managers. Fourth, only the managers' map showed a moderate decrease to *Resources Considerations*. Fifth, the increase to *Analysis and Reports* was only driven by the managers and workers, but not the riders.

3.9.5.2 Social Solidarities Associated with Response Requirements (Immediate)

Scenario E might be the only management scenario where fatalism is not selected. That is, the cumulative result of all three social groups was decreases to the negative elements. Still, there were some differences of note. The robustness of the system in the face of *Adverse Effects* was driven by riders only, yet was strong enough to overpower the managers and workers; thus, robustness prevails. In addition, the workers overrode the riders and the managers to cause an increase to *Damaged Infrastructure*.

3.9.5.3 Summary of Policy Scenarios

The policy scenario simulations show three meta-level insights, including role-based selection of risks, power as an emergent property, and the need for more discussion with stakeholders. The outcomes of the social group maps in the management scenarios did show some instances of fatalism, but overall it appears that the selection of adaptation strategies is based on respective roles that participants play in the context. First, the managers selected hierarchy, in line with a procedural rationality. Second, the workers appear to prefer individualism, in line with a substantive rationality. Third, the riders appear to have a partiality for egalitarian organising, based on a critical rationality. Despite these apparent preferences, there were indications of switches, swaps and alliances that seem to pull the rationalities toward fatalism (as was apparent in scenarios C, D, and E). Scenarios A and B on the other hand were dominated by hierarchy, where holding the respective strategies at a high level could keep the ball nestled between the two humps.

3.9.5.4 Transitions from Complex to Simple Policy Scenarios

The scenarios above involved diverse concepts configured into high-level themes, thus the meaning of each scenario was presented and attention was given to the most significant changes from the steady-state. The level of detail provided by twenty-three concepts is very high, but can be confusing; thus the next scenarios focus only on the effect the five high level-themes, this time without dwelling on the component details, in the simulation of the same worst-case scenario (i.e., Scenario A), and the four management scenarios (i.e., Scenario B-E).

3.9.6 Simplified Policy Scenario Simulations

Each simulation treats a ‘clamped’ group of variables as independent variables and leaves the unclamped dependent variables to stabilize. The simulations are simple and show the result of clamping each of the five high level categories. The results of the five simple scenarios are presented in Figure 3.18.

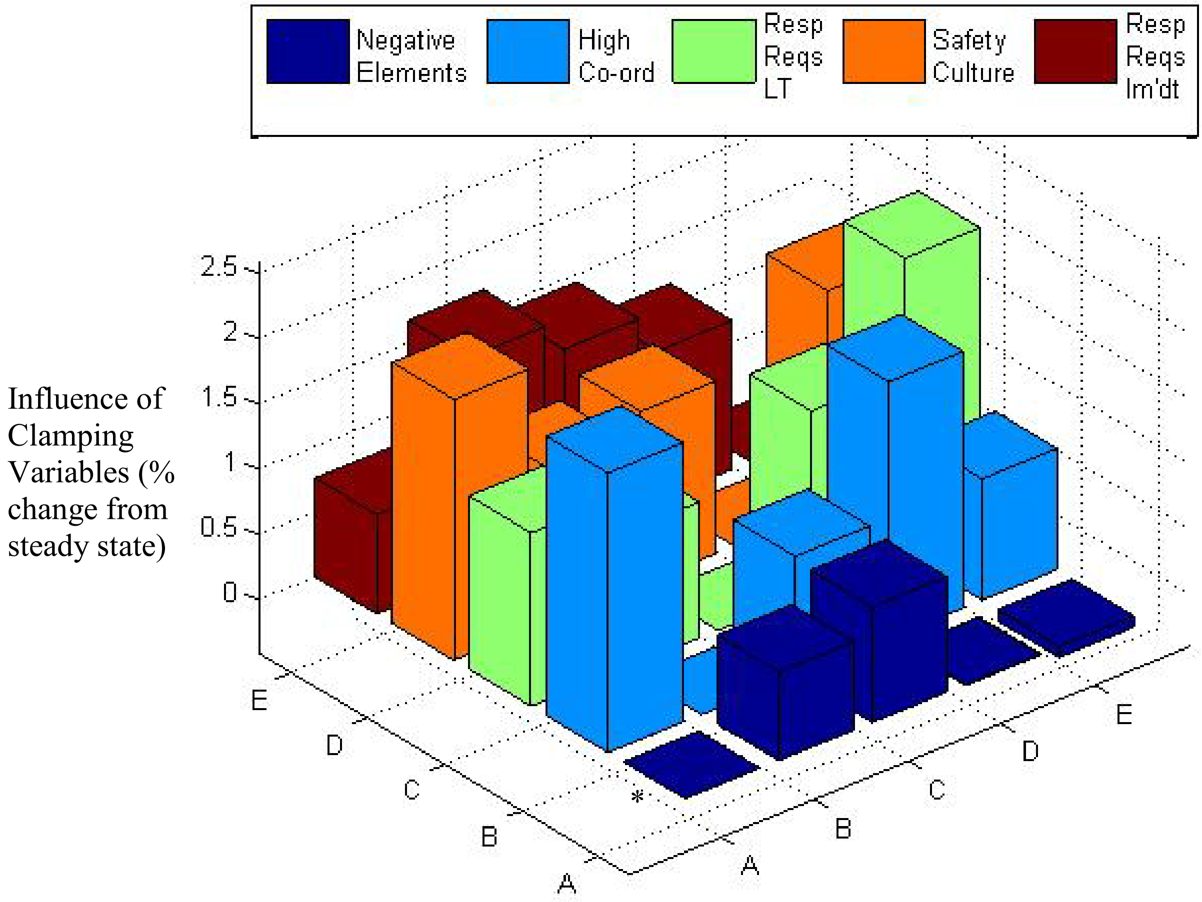


Figure 3.18 TSG Simple Scenarios Simulations A (Negative Elements are at a High Level), B, C, D, and E

Note: the influence of the clamped (independent variables) on the (dependent) non-clamped variables are shown. *The influences of the independent variables on themselves (i.e., along the diagonal) are removed to better represent the changes from steady state. The % change in value of the relevant variables from their steady-state values are shown.

In Scenario A: **Negative Elements** are at a high level. This means, for example, there has been a high intensity earthquake which causes rock falls and avalanches, damage to buildings and lifts and critical lifelines at a bad time, such as a busy weekend during the middle of the day leaving people in the ski area isolated. The scenario causes a slight increase to B – *High Coordination* and D – *Culture of Safety*, and there are very slight increases to C – *Response Requirements* (Long Term) and E- *Response Requirements* – (Immediate). This means that overall participants' maps represent a perception where all of the dependent variables B – E need to be enhanced when **Negative Elements** are at a high level.

3.9.6.1 Simple Scenario A –Explanation of Results

In Scenario A, the consideration in need of the most significant enhancement is B - *High Coordination*. Thus, if an earthquakes causes **Negative Elements** to manifest (i.e., Negative Consequences), it is critical to have a solid understanding of the risks posed by hazards to aid mitigation: good buildings (e.g., resistant to earthquakes); the community being ready to respond; a recovery plan in place; and an adequate resource inventory being available. The next consideration requiring enhancement is the *Culture of Safety.* This can be achieved by having well-trained emergency personnel able to carry out the emergency plan and procedures, such as evacuating people from lifts and buildings, and facilitate the evacuation of the ski area.

Another important consideration is ensuring *Response Requirements (Long Term)* are enhanced. This entails being aware of and being able to actively and passively control avalanches, communicating effectively with staff and clientele, being well aware of hazards such as rock falls, avalanches and aftershocks, being able to manage distraught people, and having access to basic survival items such as water, food and shelter. Last but not least, if **Negative Elements** are set high, then enhancements are also needed to Response Requirements (Immediate). This dictates that there is access in and out of the ski area. The access enables emergency services to support response, locating people, assessing and treating injuries, and gathering people to a safe area so that strategies for evacuating lifts, buildings, and eventually the ski area can occur.

3.9.6.2 Scenarios B to E – Summary of Results

Scenarios B to E differ from scenario A in that they treat management opportunities as dependent variables and Adverse Effects as independent variables. These four simple simulations of management scenarios were also run to examine their impact on other variables.

In scenario B – **High Coordination** is set at a high level; in this case, there is a slight increase to A – Negative Elements, moderate increases to C- Response Requirements (Long

Term) and D – Culture of Safety and a higher though still moderate increase in E-Response Requirements (Immediate).

In scenario C – **Response Requirements (Long Term)** set at a high level; in this case, there are slight increases to A –Negative Elements and B –High Coordination, and moderate increases to D –Culture of Safety and E – Response Requirements (Immediate).

In scenario D – **Culture of Safety** is set at a high level; in this case, there is no change to A – Negative Elements, a high increase to B –High Coordination, as well as moderate increase to C Response requirement (Long Term) and E – Response Requirement (Immediate).

In scenario E – **Response requirement (Immediate) set** at a high level; in this case, there is only a slight decrease to A- Negative Elements, a moderate increase to B – High Coordination (long term), a very high increase to C –Response Requirements (Long Term) and a high increase to D – Culture of Safety.

What is apparent from these simple scenario results is that no matter what the scenario is, there are mostly increases occurring, and thus enhancements are required for the other upper level considerations. In Scenario A – it is apparent that all of the upper level strategies require enhancement. Also, in scenario B – D, there are enhancements occurring in all concepts. Another interesting point is that there is only one slight decrease (i.e., lessening of impact) on *Negative Elements* that is, Scenario E - Response Requirements (Immediate) being set at a high level. This is notable because in the 23 concept simulations, a high level of Response Requirements (Immediate) had significant decreases to Adverse Effects, Damaged Infrastructure and High Intensity and Magnitude. Thus, with respect to social solidarities, it is difficult to make inferences in these highly simplified scenarios. However, one thing made clear is that, despite some indications of fatalism, participants did suggest that Response Requirements (Immediate) could curtail some of the negative consequences of an earthquake.

3.9.7 Summary of Policy Simulation Scenarios

The scenarios presented above show how FCM can highlight some interesting differences among participant groups, and how they represented the collective horizons of the earthquakes that affect an alpine ski area. The differences may result from the 'roles' participants play in the ski areas. The critical point is to consider how to extract insights from each of the scenarios, and then translate those insights to meaningful policy opportunity, in order to engage participants further in development of hazard mitigation plans.

It is apparent that the roles people have in the ski areas do affect their selection of variables, as well as the weights between concepts, which affect how scenarios play out. The differences between groups could help to highlight the sort of targeted messages that ought to be provided to particular stakeholders. For example, informing riders that bringing their own equipment for survival might go a long way to lessen the strain on workers and managers in responding to an earthquake. Another suggestion is to inform managers that riders perceived placing *Avalanche Considerations, Communication, Hazard Awareness, Managing People, and Survival (Food, Water, Shelter)* at a high level of importance, and resulted in significant increases to *Recovery of Ski Area* and *Emergency Personnel*. The latter might also be of interest to workers, as many of them (i.e., ski patrol) are in effect the *Emergency Personnel* who are responsible for fulfilling these duties.

Another interesting result of the simulations is that three social groups perceived different scenarios would decrease or increase Negative Consequences (e.g., *Adverse Effects, Bad Timing, Damaged Infrastructure,* and *High Intensity*). The riders group believed scenario D and E had the most significant decreases, specifically on *Adverse Effects*. The managers group on the other hand perceived an increase in these variables in Scenario C, while the managers perceived a major decrease to *High Intensity and Magnitude* in Scenario B and D. The workers perceived a decrease to Adverse Effects in Scenario D as well, but similar to managers, scenario E causes a decrease to *High Intensity and Magnitude*.

The simplified scenarios only saw increases to variables, which implies a desire to enhance the various adaptive strategies to mitigate an earthquake. However, these scenarios were arguably too simple, as they did not capture the level of detail of the complex scenario simulations, implying, in a sense, some degree of fatalism. Thus, the simple scenarios provide limited insight for better ways of organising. Overall, the results of the scenarios do indicate that further discussions regarding earthquake mitigation at alpine ski areas need to occur.

Chapter 4 **DISCUSSION**

4.1 Introduction

This chapter discusses the methodological and theoretical contributions of the case-study, while linking them to the overall results and conceptual framework. Initially, there were three overarching goals, and each of the questions had respective process objectives. The first goal of the thesis was to *assess the possible consequences of earthquakes for alpine ski areas from surface level empirical evaluation using geomorphic assessments*. The second goal was *to understand deeply how a small yet representative group of stakeholders from alpine ski areas perceived the natural hazards in situ*. The hazards of interest were severe weather and avalanches, and special attention was given to earthquakes as a novel hazard. The third goal was to *test the integrated methodology for identifying policy opportunities for improving resilience to earthquakes* by simulating policy options based on fuzzy cognitive maps. An emergent goal was the use of cultural theory to better understand ways of coping with compounding natural hazards. As a corollary to this goal, I contribute to the advancement of cultural theory.

Other process objectives emerged from the experimentation with different techniques for capturing interviews, fuzzy cognitive maps, and ways of processing information. These adaptations to methods evolved as a result of several factors. First, interviews had to work within contextually and culturally appropriate comportments, and had to adapt to the social environment at the ski fields. For example, there were situational constraints that led to adapted approaches for different participants, locations, and physical conditions. Second, the process of fuzzy cognitive mapping had to be modified to suit participants' availability and more significantly the investigation. The participants adapted their answers after deepening their thinking through the interviews. Third, processing participants' accounts from interviews and FCM were organized while seeking 'desirable configurations'. These configurations served to identify policy opportunities that fill apparent gaps in hazard mitigation *in-situ*. The results support several fundamental contributions to knowledge in methodological, theoretical, and contextual areas of hazard and disaster scholarship. I begin by discussing the methodological contributions of the thesis.

4.2 Methodological Discussion

This study began with geomorphic assessments, then continued to collect data using in-depth qualitative interviews and fuzzy cognitive maps. In doing so, this study demonstrated *methodological triangulation* using a *development* mixed method approach that identified risks, evaluated the risks, and identified possible treatments for the risks within an integrated framework. Multiple methods were used sequentially to study the problem - the occurrence of a high magnitude earthquake affecting a ski area. It was critical to gain an understanding of participants' perceptions of strategies regarding preparation for, response to and recovery from a high magnitude earthquake, and these were best studied using mixed methods. The triangulated methods enabled the weaknesses of one method to be offset by strengths of the others. For example, I used the qualitative interview transcripts to help condense and aggregate maps, and to help add details to results from policy scenarios. The integrated set of tools and conceptual framework helped identify some policy opportunities for mitigating contextually relevant natural hazards that were given little consideration.

The application and results from the three integrated methodologies will be discussed next. First, I explore geomorphic assessments of the physical context of earthquake hazards for alpine ski areas. Second, I review the semi-structured qualitative interviews which had the aim of probing into experiences and perceptions. Third, I explain the development of fuzzy cognitive maps (FCM) that captured the perceptions of stakeholders for modelling policy scenarios. Finally, the mechanics of processing and integrating these methodologies will be discussed.

4.2.1 Geomorphic Assessments

The case study started by examining the first goal of the research which was *to assess the possible consequences of earthquakes for alpine ski areas.* This was done by conducting geomorphic assessments (e.g., field studies) at six ski areas during the summer season to determine the possible consequences of earthquakes with respect to infrastructure. A summary of the results and how they were uncovered using three process objectives are now reviewed sequentially.

4.2.1.1 Objective 1.1:

Identify the possible consequences of an earthquake in mountain landscapes (i.e., specifically alpine ski areas) via geomorphic assessments.

The results of the geomorphic assessment conducted during this study indicated that there was potential for negative consequences for people and infrastructure in alpine ski areas as a result of earthquakes. The results also suggest opportunity for improvements to the monitoring and study of natural events in alpine areas. The latter will be discussed further in this section, but I begin by revisiting the potential consequences of earthquakes uncovered during the field studies. The main issues found in these assessments reflect the development of fields and infrastructure without appropriate considerations for seismic events. This type of development may place high numbers of people at an unnecessary and involuntary risk, and steps can be taken to adjust future development. Stakeholders of alpine ski areas should consider what can be done to improve current and future developments, with respect to seismically induced hazards. The main issues as related to co-seismic events were divided into primary, secondary and tertiary effects.

The primary effects of an earthquake result from the shaking of the ground. Shaking can cause damage to utilities, lifts, buildings, parking lots, and roads. The secondary effects of an earthquake result from the activation of other hazards caused by primary effects; that is shaking of the ground can activate slope hazards such as avalanches, landslides, and rock fall. The tertiary effects of earthquakes result from primary and secondary consequences and relate to the impact on infrastructure, such as fire, loss of critical lifelines, and major damage to facilities or infrastructure. All these consequences, therefore, exemplify the effects of earthquakes on ski area as *compounding natural hazards*, those that are characterised by high complexity and high uncertainty. The complexity results from the interaction between natural and technological hazards, and uncertainty, first, from the inability to predict earthquakes in terms of timing, location, and magnitude, and second, from that fact that consequences of these interactions are appropriately unknown unknowns. Nevertheless, there were some inferences drawn to advance the research.

4.2.1.2 Objective 1.2:

Assess different types of ski areas (e.g., commercial and club) to understand differences in development of infrastructure and their respective vulnerabilities to natural hazards.

Six different ski areas were assessed: three club fields and three commercial fields. The results indicated that buildings in commercial fields may be less vulnerable to earthquakes, as many are more modern and therefore built to higher seismic standards. However, given that the commercial fields in general (only one of those assessed) have elevated lift structures (i.e., chair lifts), these are a primary concern as they might require evacuation. In addition, the commercial fields had T-Bars, which can also be knocked out of alignment during an earthquake. Both chair lifts and T-Bars have towers that support the lift cable; if the towers are knocked out of alignment, the cost of repair is high and requires external expertise. Furthermore, if lifts are knocked out of alignment during the season, the cost of ‘downtime’ could be financially catastrophic, given the short length of the ski season. The club fields, on the other hand, may be more vulnerable to building damage, but less vulnerable to lift damage. For example, the ‘nutcracker’ lifts can be repaired quite quickly without external expertise and resources after being hit by an avalanche. However, ground based lifts do make those people riding the lifts more exposed to secondary effects such as co-seismic avalanches.

When dealing with secondary effects, commercial fields require more personnel to cater to higher numbers of clientele. The club fields, on the other hand, feature terrain that is more challenging; this in turn might suggest a clientele that are more experienced and aware of hazards. However, awareness also increases the risk of exposure to hazards such as avalanches. The majority (i.e., 4/6) of the ski areas assessed did not have buildings directly in avalanche run out zones, though one club field and one commercial field did. One precaution taken by these areas was to ensure that people are not allowed in the buildings until avalanche control has occurred, and further that people are not allowed to stay overnight in them.

Reservoir collapse was not likely to affect the club fields that were assessed, as they do not currently have snowmaking reservoirs. The commercial fields, on the other hand, do have snowmaking reservoirs and, in one instance, a lake that is also used for snowmaking; in some cases, these are elevated above critical infrastructure. Three of the commercial fields visited for assessments did have reservoirs with outflow paths that could affect roads. Two of them had outflows that could affect buildings, the lift unit stations and people waiting in the lift line.

For both club and commercial fields, responding to major earthquakes is a challenge due to loss of critical lifelines. Chief among these lifelines is energy, as without energy many other lifelines (i.e., communication, water, and heating systems) may not be functional. Furthermore, ski field access roads are likely to be compromised by a seismically induced avalanche, rock fall, and or landslide. This means that external assistance may not be able to respond quickly. Hence, catering for, and eventually evacuating participants once aftershocks have subsided, will be a significant challenge.

4.2.1.3 Objective 1.3:

Use the results of the GA to develop interview questions to pose to stakeholders of alpine ski areas.

These assessments helped develop targeted questions for qualitative interviews. The results of the GA could have been used to compare stakeholders' knowledge and awareness of hazards with the information gathered from assessments, but very few participants had considered the consequences of a high magnitude earthquake event; hence, comparison with potential geomorphic consequences was not possible. Instead, after a few interviews, the choice was made to adapt the scripts, and begin with questions about general hazard awareness. Given that the more obvious hazards from the assessments indicated risk for severe weather, avalanches and, to a lesser degree, earthquakes, the questioning instead focused on the aspects of participants' experiences and perceptions of preparation for, response to and recovery from severe weather and avalanches, and then shifted to earthquakes.

4.2.2 Summary: Efficacy of Geomorphic Assessments

A range of possible consequences were captured by geomorphic assessments. The two types of ski fields show a range of consequences that were contingent on the design and location of infrastructure to suit the business models of commercial or club fields. The commercial fields with more infrastructure buildings, elevated lifts and reservoirs for snowmaking could be perceived as more vulnerable; however, modern facilities are built to higher seismic standards. The club fields with older and comparatively less infrastructure could be perceived as less vulnerable, yet with decentralized infrastructure and overnight accommodation, combating fire and other consequences could be a major challenge. Both types of areas may experience loss of critical lifelines, which will make response efforts difficult. The most obvious result of the geomorphic assessments is that the assessments provide us with information about the possible consequences. These alone, however, are not enough. Input from different stakeholders is essential to enhance our understanding through the inclusion of their perceptions of natural hazards *in-situ* and the ability for triangulation. In that sense, geomorphic assessments were useful in better understanding the context, and developing a line of questioning to engage stakeholders.

4.2.3 Qualitative Interviews

The second goal of the research was to investigate how stakeholders perceive the risks of natural hazards (severe weather, avalanche and earthquakes). Achievement of this goal rationalized the use of semi-structured qualitative interviews, which also was strengthened by allowing some verification of FCMs after processing. The interviews helped support four process objectives. The achievement of these objectives will be reviewed in order.

4.2.3.1 Objective 2.1:

Gather accounts of direct and indirect experiences with natural hazards in mountainous environments (e.g., severe weather, avalanches, and earthquakes).

The vast majority of the participants confirmed having experienced incidents with severe weather. Participants' judgement of severe weather was based on individual subjective experiences, including common features such as high wind, low visibility and extreme temperatures, as well as high precipitation in various forms. Another common feature of participants' experiences with severe weather was the ability to adapt effectively in most circumstances, yet there were also reports of others who could not. Respondents have described at least six perceived consequences of severe weather: physical damage, psychological stress, behavioural expectations, managerial duty, ability to do one's job, and the disruption of critical lifelines. All of the accounts that have been discussed were instances of experiential learning; first hand experiences with severe weather are common in mountainous environments, and the consequences, much like the characteristics of the weather itself, are also diverse.

Avalanches also featured strongly in participants' accounts, especially in those of ski industry workers and ski area managers, and seasoned alpine snow riders. Some participants had witnessed avalanches with severe consequences, such as loss of human life and the destruction of infrastructure. Regardless of the severity of the consequences, participants were often humbled by witnessing avalanches of any size. The adaptation to avalanches was a common theme for ski industry workers who described a variety of tools they can employ to control avalanches. Use of technological control tools (e.g., bombing for avalanches) appears to be the dominant form of managing the risk of avalanches in commercial ski areas, and this depends on a mostly hierarchical form of organization. In the club fields, active control was also present, and there were also more alpine snow riders who reported to be using transceivers as a preparatory mechanism. The latter was also confirmed through participant observations. The wearing of transceivers might suggest higher awareness and risk aversion among club field alpine snow riders; however, statistics show that those who are avalanche aware are actually more likely to be involved in an avalanche (Irwin *et al.,* 2002; Irwin, Pers. Com. 2007).

Earthquakes are not part of ski area stakeholders' horizons, for the most part; at least not within the ski field context. When asked if they had ever considered how an earthquake would affect them on the ski field, most reported they had not. A few, on the other hand, had a passing thought about it, or had made minor changes to policies as a result of tectonic activity. But even this minority had not given it much thought beyond the initial consideration. Some ski industry workers and managers did report that their emergency procedures were designed for multi-hazards, yet there were a few who had doubts about whether they could manage an earthquake. Many of the participants believed their ability to adapt were contingent on the intensity of magnitude of the earthquake and its ensuing damage.

4.2.3.2 Objective 2.2:

Assemble participants' accounts of experiences regarding preparation for, response to, and recovery from specific natural hazards (severe weather, avalanches and earthquakes).

Participants provided detailed accounts of their experiences with severe weather, avalanches, and earthquakes during the qualitative interviews. Below I discuss major results and analysis from key themes.

When it came to severe weather, most participants reported some level of preparation such as proper equipment and clothing, as well as knowledge that the conditions can change fast. They were also able to respond reasonably well, with only a few reporting having being caught out or having near misses with the weather. There were also accounts of proximity to others who perished from weather related incidents.

Overall, there was a reasonable level of avalanche awareness. Those with limited experience did indicate some awareness of this hazard, while those whose responsibility it was to manage this risk provided in-depth accounts of their experiences preparing for, responding to, and recovering from avalanche events.

Very few of the participants had experiences with earthquakes. Most did not prepare for them specifically; implicit in participants' responses was that preparation for severe weather and avalanches could help manage the consequences of an earthquake. Despite the lack of consideration, participants were able to provide detailed and insightful perceptions of how an earthquake ought to be handled on the ski fields.

4.2.3.3 Objective 2.3:

Collect accounts of participants' risk perceptions towards the specific hazards.

The majority of the participants perceived that there would be adverse physical effects from an earthquake on the ski area, including avalanches, rock fall, and damage to buildings, as well as aftershocks that could pose major challenges to the response efforts. However, the participants also described that the fickle nature of earthquakes-- that is, the inability to precisely locate where, when and at what magnitude they are likely to happen--presented a dilemma to the participants, making it difficult to detail whether they would be able to manage the effects of an earthquake. It is evident that across the three stakeholder groups, the idea of an earthquake affecting the ski industry, and their particular ski fields, is a novel one. Furthermore, the idea of preparation for an earthquake occurring while they are in an alpine ski area is new. A few stakeholders did give evidence of a fleeting thought as to what would happen if there was an earthquake, but they pointed out that the thought did not manifest in any further preparatory action or planning. It is interesting that the respondents in club fields also mentioned that there is confusion as to whom they perceived as responsible for planning or preparing for an earthquake, unlike at commercial fields, where avalanche control was deemed the fields' staff and managers' responsibility. Some respondents indicated that they thought it was the responsibility of the operators to plan and manage for such an event, while others suggested that it is up to individuals to have the wherewithal to be prepared for *any* event.

The perceptions captured from participants across the three stakeholder groups indicate that important considerations (i.e., risk perceptions) to prepare for, respond to and recover from an earthquake at ski area included: communication, emergency plan and procedures, safety, training, strong buildings, survival, recovery, evacuation, first response and emergency personnel. This data could also be organized in a different configuration of twenty three themes, including: Adverse effects, bad timing, damaged infrastructure, high intensity or magnitude, analysis and reports, buildings, community assistance, recovery of ski area, resources, avalanche considerations, communication, hazard awareness, managing people, survival (water, shelter and food), emergency procedures, emergency personnel, external assistance, training, access, equipment, evacuation, first response and safety.

The calibration attempts at FCM identified a major limitation, and need for adaptive interviewing. Participants found it difficult to consider the earthquake hazards without drawing from hazards within their realm of experience. Therefore, severe weather and avalanches were added to the qualitative interview guide in order to attempt to intensify or calibrate the participants' consideration of the earthquake hazard by first going through their experiences and perceptions of severe weather and avalanches. The participants first added variables they perceived as important to prepare for, respond to, and recover from earthquakes. Then, while carrying them through the qualitative questions on experience and perceptions of severe weather and avalanches, they were told they could add variables as they went along. This adaptive interviewing did promote the addition of variables to the FCM in most cases. In that way, I have contributed to the methodology by showing that interviewing adds to the FCM richness in this particular context. Whether interviewing is recommended alongside FCM exercises in the order I used, and in all cases is still to be seen. Now that I have more experience with the interview process, in future research, I will try to interview in an unstructured manner similar to Ozesmi (1999).

4.2.3.4 Objective 2.4:

Organize the data to improve aggregation of participants into social groups, condensation of concepts into similar themes, and simulations of risk scenario for policy development.

The information gathered from the qualitative interviews helped to condense subjectively the concepts included in the fuzzy cognitive maps. It did so in two critical ways. First, some variables may appear similar at the superficial level, but using the recorded qualitative interview and FCM exercise allowed the researcher to use the details of the node to condense variables appropriately.

The attempt to aggregate participants based on how they responded to qualitative questions was however not successful. I attempted to decide whether their responses indicate a preferred viable way of life as laid out by the cultural theory, but instead, participants demonstrated different solidarities for different questions in a discursive manner. This is a straightforward and significant finding because it supports the use of the dynamic version of cultural theory.

4.2.4 Summary: Efficacy of qualitative Interviews

Qualitative interviews were conducted with ski field stakeholders in this project, but they were not conducted as standalone data collection. They consisted of semi-structured qualitative interviews and the drawing and refining of fuzzy cognitive maps (FCM). The application of qualitative interviews initially served two purposes. First, the interviews served to gather data about participants' hazard awareness in context, and second, the interviews were used as a reflexive tool to enable participants to draw from the experiences with common hazards to intensify thinking about rare hazards (i.e., earthquakes). The participants consideration of earthquakes were similar to severe weather and avalanches. The themes mentioned in the interviews when participants considered the consequences of severe weather and avalanches were similar those that were mentioned when participants discussed earthquakes. There were also other themes that emerged when considering earthquakes, such as more need for external assistance, difficulty of responding due to compromised infrastructure, and overall the novelty of considering earthquakes as a salient hazard. The social solidarities implicit in participants' responses changed from question to question, as well as in responding to particular questions. Occasionally it was evident that the participants settled on solidarities that were familiar, perhaps drawing from experiences with more common hazards; for example, a few managers hinted at fatalism, or egalitarian manners of organising, but then stabilized on hierarchy as a way of organising in the face of earthquakes. At the meta level this is an instance of paradigm protection--'if it works for this problem it will probably work for that'.

The data gathered from the qualitative questions also captured perceptions of hazards in a novel context, extending the tradition of qualitative interviewing for hazard and disaster research. All of the participants had some level of disaster/hazard awareness. Those with more experience had heightened context-specific knowledge that was linked to severe weather and avalanches. Those with high experience, such as avalanche controllers and ski area managers, also conveyed humility in the face of common mountain hazards. Participants with less experience in the mountains did demonstrate general awareness of mountain-specific hazards, though not with the same level of detail.

I was concerned that the interviews took different formats and involved choosing questions from the interview 'guide' depending on the social and temporal context of the interview; however, reflecting on the data and the processing that was required to configure the data both qualitatively and quantitatively, I realized that this may not be a limitation.

Instead, this adaptation actually extends a novel methodology of interviewing and FCM which was adaptive, based on the available time of the participant. This allowed me to capture perceptions of stakeholders who would not have been able to contribute had I been rigid in following only one interview guide.

Despite the limited consideration for earthquakes specifically, many participants were able to draw detailed and useful FCMs. The FCMs greatly extended qualitative interviews by enabling inferences to be drawn as a starting point for further engagement. Next, I begin to unravel how the FCMs contributed to the goals of the research.

4.2.5 Fuzzy Cognitive Maps

One of the big questions of this research was whether the information from the mixed-methodology can be used to identify opportunities for improving policy in areas of compounding natural hazards. To assail this question, fuzzy cognitive maps and artificial neural network simulations were designed, refined, and used in five scenarios. Supporting this goal, five process objectives were identified and their effectiveness is reviewed below.

4.2.5.1 Objective 3.1:

Gather fuzzy cognitive maps (FCM) of participants' perceptions of key considerations of preparation for, response to, and recovery from high magnitude earthquakes that can affect alpine ski areas.

The process of gathering FCM was a departure from other applications of FCM, as it was contextually appropriate and problem focused. This study adapted fuzzy cognitive mapping approaches employed in other studies, and had mixed success. Some participants took to the method straight away, detailing highly complex maps with many variables, while others struggled to understand the method and perhaps questioned its validity. The researcher was also a beginner at using the FCM technique. The first few attempts at calibrating the adapted approach were 'successful failures'. I quickly realized that participants needed a benchmark, given that they had not really considered an earthquake affecting a ski area. To overcome this, the successive interviews were conducted by beginning with the critical variables (important considerations) about preparation for, response to, and recovery from an earthquake that has a direct effect on the ski areas. Specifically, once the participants identified critical variables, their attention was shifted to a series of questions about their perceptions and experiences with catastrophic natural events (i.e., natural disasters, severe weather, mass movements, and earthquakes). The assumption was made that these questions would intensify participants' thinking about an event (i.e., earthquake) most had not considered.

Depending on the amount of time participants could allocate to the study, two different approaches to the FCM were used. The time- limited approach was to allow the participants to draw the connections that they felt were important. The other was a matrix focused approach, where the researcher asked participants the strength and sign of connection, variable by variable. The matrix focused approach captured much more detail, but was tiring for the researcher and the participants. This approach also resulted in a framing effect for some of the maps, in that some of those responses were more impulsive. This attempt to make the research adaptable to suit situated constraints was needed, but greater controls for each of the versions of participation would have allowed more methodological insights to be generated.

4.2.5.2 Objective 3.2:

Analyze participants' FCM in static form using indices from graph theory.

The FCM were analysed using graph theoretical indices in their original form and in successive levels of condensation and aggregation. The indices highlighted general perceptions of individuals and the overall perceptions of social groups once the maps were condensed and aggregated.

The graph theoretical indices were also slightly altered. The calculation of transmitter, receivers, and ordinary variables was based on a ratio, giving the researcher a more general indication of variable types. Rather than naming those with 'in and out' connection weights ordinary variables, those with a ratio very close to one were deemed neutral variables. This has a significant effect on the complexity ratio, which can be used to see how participants perceived the system overall. This limited the amount of conclusions the researcher could draw from graph theory indices for individuals and social group maps. However, by virtue of framing caused by the matrix focused (variable-by-variable) approach, there were so many 'ordinary variables' in the original sense of the term (i.e., where a variable has connections coming in and out) that it was difficult to generate deeper understanding from the results. Thus, reclassifying the variables as 'neutral' (i.e., when the connections coming and going out were of similar weight) enabled some insight to be generated about the general character of variables as transmitter, receiver, or neutral.

Still, some very general insights can be drawn from the structure of the maps. The riders' and managers' map complexity index indicates more utility outcomes and therefore less control from external factors. The workers group demonstrated more controlling functions and less utility outcomes, which means the map captures a perception that some things are beyond their control. It is interesting to note that the TSGFCM also captured this perception; that is, when all participants' maps are aggregated, there are more receiver variables than transmitters, but only just, thus implying a perception of slightly more influence from external factors. The external factors can be better understood by considering the most central variables in the maps.

Overall, all three social group maps placed *Communication* as a key consideration. The result that communication is the second most central concept in the TSGFCM lends support to such an emphasis. The most important variable in the TSGFCM was *Survival (Food, Water, and Shelter),* though this was driven by riders and managers, as it was not as central for workers. Conversely the riders and workers placed *Good Training* as highly central (i.e., in the top five), while for managers it was not as important. Another apparent alliance was how the managers and workers placed *EM Plan and Procedures* as central, while in the riders group, it was less important. Note though how the riders' map held *Emergency Personnel* as the third most central variable, which forced it to the third most influential concept in the TSGFCM. Similarly, the workers map assigned a high centrality on *Safety* considerations, which was instrumental in it being the top five in the TSGFCM, despite it being seventh for managers and twelfth for riders.

The agreements and disagreements between stakeholder groups demonstrate how power is a visible property of this self-organising system. The centrality of variables also provides an indication of role-based perceptions that may help to further bridge gaps and manage power struggles. Some of the differences helped to identify differences in knowledge between stakeholder groups, and may help identify focal points of discussions for improving policy and practice.

4.2.5.3 Objective 3.3:

Use qualitative and quantitative methods of condensing and aggregating FCM for policy simulation.

The FCM matrices required different stages of processing prior to simulations. The condensation and aggregation of the individuals FCM were conducted with a mix of qualitative and quantitative approaches. The initial condensation was based on the qualities of the nodes (i.e., key considerations) that participants provided. As mentioned above, the recordings from qualitative interviews helped this process as the researcher could use them to ensure the meanings of the nodes were consistent with the details in the participants' account. The SOM analysis of the condensed maps highlighted the limitations of subjectively condensing the maps, namely reducing the number of concepts and the complexity of the connections causes a loss of detail.

This limitation was also present when maps were additively superimposed for aggregation into social groups. A great deal of detail can be lost because the opposing strengths of connections cancel each other out, resulting in the lossy consensus. Thus, a key limitation of using positive negative neural calculus is that connection strengths cancel each other out when matrices are condensed. When disagreements arise; however, it captures *power* as an emergent part of this self-organising system by virtue of selection. Similarities in view are selected for, while disagreements from minorities are selected against in the total social group. The stakeholders' social groups were helpful for understanding how participant groups viewed the systems in a particular way.

Another processing step was experimented with to overcome some of the subjectivity of condensing and aggregating. The use of a neural networks tool allowed for the 'clustering' of the responses to occur in a non-subjective way through self-organization of similar response patterns. This additional step also provided the opportunity to experiment with a novel method called self-organising maps (SOM), which was first used to aggregate participants' condensed maps and then for further condensing variables. It proved useful for condensing variables and did uncover some possibilities for aggregating social groups based on roles and levels of experience (i.e., "specialization"), but more research regarding the technical aspects of this analysis method are under way.

When the variables were condensed using SOM, the results indicated that there were five categories of clustered variables. These could then be simulated using auto-associative neural networks. In addition, the twenty-three variables from condensation could be organized into their cluster features, enabling simulations of highly correlated variables with complex maps. While this was an emergent exploration of the data, it did enable new insights to be gained from the data that were not captured in qualitative interviews, or in an earlier configuration of FCM that was more subjective (see Strickert *et* *al.,* 2009). This was a first attempt at what could greatly enhance the use of FCM for highly complex systems by simplifying them with SOM. The results of the simulations are summarized in the following objective.

4.2.5.4 Objective 3.4:

Use auto associative artificial neural networks to run simulations of policy considerations to identify opportunities for improving resilience of people in alpine ski areas to catastrophic natural hazard events

Simulations did indeed highlight opportunities for improving policy, though this is only a first step and I only reported on five scenarios. One could explore the clamping of every permutation and combination of the variables, should time and processing capabilities allow. I used the simulations to test possible policy options where particular variables were clamped at a high level; in policy terms, this may be conducted by providing unlimited funding, resources, education campaigns, or other methods for the variables of interest. That does not often happen in real life. Policy creation and updating is another adaptive process, and though simulations are capable of examining policy scenarios that change over time, this was beyond the scope of my project, and my technical abilities as a researcher. Development of policy could continue to use and refine FCM and neural network simulations as a procedure, and thereby expand the results from this study, but it must be stressed that more engagement with stakeholders is needed for optimal participation, which can translate to enhanced stakeholder empowerment and ownership of policies that eventuate. These maps were too extractive to provide sufficient insight for direct policy development. Nevertheless, they did generate some insights for the next phase of the process. I will now present the practical insights drawn from the five policy scenario simulations.

4.2.5.5 Insights from Scenario A – Negative Elements

Scenario A was in effect a worst-case scenario, where all of the negative consequences of an earthquake were clamped at a high level. Interestingly, it indicated mostly agreements and only a few minor differences between the outcomes of stakeholder group maps. They all agreed that *Building Considerations* (e.g., Strong Buildings) would need to be enhanced. In addition, they agreed that *External Assistance* would need to be enhanced, but this was mostly pushed by the managers. Enhancing *Safety* (e.g., through a safety zone) was important, but mostly driven by workers. There were also some disagreements in Scenario A, but they were not fervent; rather more indicative of indifference. For example, the workers were the only group noting the limited impact of *Analysis and Reports* (e.g., identifying high-risk areas). Another example of one group pressing on a particular strategy was how the managers noted decrease to *Access* (e.g., blocked access road). As well, the workers saw higher increases to *First Response* than riders and managers. The outcomes of scenario A demonstrate how at the stakeholder group level, participants are selecting management strategies which are reflective of their roles and indications of preferences for particular solidarities.

First, the managers' selection of decreases to *Access* and enhancements to *External Assistance* showed a preference for hierarchical organising based on a risk handling style, learning style, desired system properties, engineering aesthetic, and latent strategy. That is, rejecting the risk of blocked roads, anticipating and thus absorbing the risk by help from external agencies (e.g., police or search and rescue) perhaps via helicopter.

Second, the workers' selection of enhancement to *First Response*, beyond being greater than that of riders or managers, might suggest that they prefer a learning style of trial and error, and a scope of knowledge that is sufficient and timely. Moreover, their inferences that *Analysis and Reports* would be of limited impact during an emergency situation, where the short term dominates the long term, is certainly more justifiable than involuntary myopia, if one is concerned with 'safety services', 'ski patrol', and 'avalanche control', which made up the vast majority of the workers groups. These two, coupled with the desire to enhance *Safety,* most often described as affording a 'safety zone', also suggested the workers' view of the system as exploitable through the ability to move people to these areas in a fluid manner. Thus, one might infer the workers' view nature as benign.

Third, the riders map advocates for enhancements toward recovery, strong buildings, and hazard awareness, which suggest a preference for egalitarian organising. To highlight this inference, a few short extracts from the qualitative interviews are helpful. They view the system as fragile (e.g., "Recovering back to normal skiing conditions after an earthquake would be difficult." ASR 12). They provided justification of critical rationality (e.g., "Some—many of them, maybe not in the commercial fields as much, but, ah, were built pre-seismic constraints" ASR 15). They desire for a scope of knowledge that is imperfect but holistic (i.e., "Yeah, because you've got to make the public aware that there's danger areas and all that sort of stuff and there is like teams in place, sort of vehicles of rescuers sort of thing. So it has a big part to play. So I'd better go with .8 of positive" ASR 9).

The outcomes of the social group maps in scenario A suggest the selection of adaptation strategies based on respective roles participants play in the context of managers, workers, or riders. First, the managers selected hierarchy in scenario A, with respect to a procedural rationality. Second, the workers appear to prefer individualism in Scenario A, by virtue of their selection of substantive rationality. Third, the riders appear to have a partiality for egalitarian organising based on a critical rationality.

4.2.5.6 Insights from Scenario B – High Coordination

Scenario B examined the changes (i.e., adjustments to both negative elements and other management strategies) when High Coordination is at a high level. Scenario B showed areas of disagreement and some agreement between the outcomes of participant maps. The disagreements highlight some interesting differences between how participants convey their understandings of the system. The outcome of this scenario based on the TSGFCM showed increases to *Adverse Effects* and *Damaged Infrastructure*. All three groups noted an increase to *Adverse Effects.* The workers, on the other hand, advanced the increase to *Damaged Infrastructure* thus viewing infrastructure as fragile while the managers perceived a decrease viewing the infrastructure as robust, and the riders indicated no change. The managers and workers, however, agreed that **High Coordination** would decrease the *High Intensity* of experiencing an earthquake, indicating the system is controllable, while the riders believe it would be enhanced, hence the system is fragile.

The outcomes of the social group maps in scenario B suggest that the group may view the system as capricious; that is, despite **High Coordination**, *Adverse Effects* are enhanced. The managers and workers selected some things as fragile and others as robust, thus implying a view that it may be perverse and tolerant. The riders seem to rest on the notion that the system is fragile.

4.2.5.7 Insights from Scenario C – Response Requirements (Long Term)

Scenario C also showed several areas of disagreement and some areas of agreement. First, there was an alliance between the managers and workers who perceived an increase to *Adverse Effects* and *Bad Timing*, while the riders perceived a minuscule decrease to *Adverse Effects,* and no change to *Bad Timing,* as it was inactive in their map. All three groups agreed that **Response Requirements (Long Term)** would enhance *High Intensity and Magnitude.* Though the managers and workers dominated the riders in two instances mentioned above, the riders were the sole proponents of the need to enhance *Equipment*, as the workers and managers indicated no change.

The outcomes of scenario C also indicate fatalism. The managers and workers believe that despite a high level of response requirements, *Adverse Effects* and *Bad Timing* are enhanced. The riders disagree, suggesting that adverse effects will decrease; thus, the system is robust. Though the riders agreed with the managers and workers that *High Intensity* would increase, their solution is to enhance *Equipment Considerations*; thus a change from their egalitarian organising of scenario A and B, suggesting fatalism based on individualised survival, given that most equipment was personal equipment.

4.2.5.8 Insights from Scenario D- Culture of Safety

Scenario D showed several areas of disagreement and some areas of agreement. First, a striking similarity: all three groups again showed increases in *Adverse Effects* and *Damaged Infrastructure*. Managers and workers were again in collusion with respect to increases to *Bad Timing.* Conversely, the managers and the riders shared a decrease to *High Intensity,* though the riders' change was very slight. The workers, on the other hand, perceived an increase. This demonstrates two more examples of alliances between two social groups that overpower another social group.

The social groups' outcomes of Scenario D also lean toward fatalism; despite a culture of safety, *Adverse Effects* and *Damaged Infrastructure* increase. Managers and workers also noted that *Bad Timing* increases. Interestingly, this presumption of fatalism was countered by an alliance between riders and managers who indicated that a high *Culture of Safety* could curtail *High Intensity*.

4.2.5.9 Insights from Scenario E – Response Requirements (Immediate)

Scenario E examined the changes that resulted from *Response Requirements (Immediate)* at a high level, and again there were similarities and differences among the social groups. First, at the TSGFCM level, Scenario E had the most significant decreases to *Adverse Effects* and *Damaged Infrastructure*. Interestingly, these were driven by different stakeholder groups. The decrease to *Adverse Effects* was driven solely by the riders, while the managers showed a slight increase, and the workers a moderate increase. Similarly, the decrease to *Damaged Infrastructure* was driven by managers and riders, whereas the workers perceived an increase. Another notable difference of this scenario was that the workers drove the decrease to High Intensity and Magnitude, and this perception overpowered both the riders and the managers, who perceived slight increases; another indication of "power", though this time, one stakeholder group view was strong enough to dominate two others.

Scenario E might be the only scenario where fatalism is not selected. That is, the cumulative result of all three social groups was decreases to the negative elements. Still, there were some differences of note. The robustness of the system in the face of *Adverse Effects* was being driven by riders only, yet was strong enough to overpower the managers and workers; thus, robustness prevails. In addition, the workers overrode the riders and the managers to cause an increase to *Damaged Infrastructure*.

4.2.6 Summary of Fuzzy Cognitive Map contributions

The policy scenario simulations show three meta-level insights, including role-based selection of risks, power as an emergent property, and the need for more discussion with stakeholders. The outcomes of the social group maps in scenarios did show some instances of fatalism, but overall it appears that the selection of adaptation strategies is based on respective roles participants play in the context. First, the managers selected mostly hierarchy, in line with a procedural rationality. Second, the workers appear to prefer mostly individualism, in line with a substantive rationality. Third, the riders appear to have a partiality for egalitarian organising, based on a critical rationality. Despite these apparent preferences, there were indications of switches, swaps and alliances that seem to pull the solidarities toward fatalism.

4.2.6.1 Objective 3.5:

Present the simulation results and then comment on the efficacy of development mixed-method integration.

The mixed-methods were useful for identifying policy opportunities. First, the geomorphic assessments uncovered some straightforward consequences (primary, secondary and tertiary effects) that merit discussion among stakeholders. Second, two emergent findings, reservoirs precariously positioned and the possibility for amplification of shaking to enhance the effects on infrastructure, are worth deeper investigation. A clumsy solution that links both of these findings is suggested in the conclusion. Overall, the geomorphic assessments served their intended purpose and helped develop a line of questioning about stakeholder perceptions of hazards *in-situ*.

The qualitative interviews were also quite useful. They identified several points that merit discussion among stakeholders. First, they captured participants' views of natural disasters as overtly fatalistic. Second, participants provided detailed accounts of adaptations to avalanches and severe weather that appear to embrace the notion of variety, though there were apparent preferences for particular ways of organising in some instances. Third, earthquakes were seen as a novel hazard that had received little considerations from stakeholders. Fourth, despite earthquakes' novelty *in situ*, participants were able to provide details on logical adaptations, which included the four social solidarities. Fifth, the interviews served as a primer (experiential references to severe weather and avalanches) prior to considering earthquakes in both qualitative questions and fuzzy cognitive maps. Finally, the qualitative interviews enabled the research to draw from participants' accounts in order to better understand the themes in the FCM, as well as attempt to find reference points indicative of social solidarities attached to situated risks.

The fuzzy cognitive maps were a functional extension of qualitative methods in several ways. First, they enable the participants to identify concepts (similar to themes in more traditional qualitative approaches) but additionally, they afforded the ability to capture participants' perceptions of qualitative relationships (connections between concepts) in numerical form. Second, the connections between concepts allowed the condensation and aggregation of individuals into social groups. Third, condensation and aggregations provided the opportunity to experiment with different techniques to support a desirable configuration of perceptions for running policy scenarios. Fourth, the policy scenarios presented comparisons among the three social groups and the total social group to express similarities and differences, power struggles, and apparent preferences for social solidarities. Fifth, the results (outcomes of the simulations) provide a tool for better understanding participants' perceptions and can therefore provide opportunities for filling gaps in policy and practice.

In summary, the integrated development mixed method approach was successful, but areas for improvement are suggested in the next chapter, after limitations are presented. Next, the results from each methodology are broken into their *dividual* components to facilitate a triangulated summary.

4.2.7 Triangulation of *Dividuals*

A summary of the 'dividuals' extracted from each of the methods are now presented.

4.2.7.1 Individualistic

Individualism was not apparent in the geomorphic assessments. Individualism, however, was apparent in participants' accounts from the qualitative interviews. When considering severe weather, many participants highlighted the need for personal equipment and knowledge of what to do in a manner that is sufficient and timely. Additionally, with respect to avalanches, participants' accounts of wearing or not wearing transceivers, and a right to the individuals' freedom of contracts that depends on the tit-for-tat- I'll-rescue-you-if-you'll rescue-me strategy, thus infers an implicit consent.

The outcomes of the scenarios also showed instances of individualism. In scenario D, which was characterised by Response Requirements (Immediate), the riders were the sole drivers of a significant decrease to *Adverse Effects*, thus providing justification for a scope of knowledge that is sufficient and timely.

4.2.7.2 Hierarchy

Hierarchy was noticeable in the results from the geomorphic assessments. First, the centralizations of infrastructure show controllability through inherent orderliness. In addition, it affords an ability to shelter people from hazards. Moreover, geomorphic assessments showed how buildings are located in known avalanche paths, thus implying a view of nature as perverse and tolerant. Some infrastructure is designed to resist forces, such as chairlifts for wind loading, which may also improve their ability to withstand shaking, an example of high-tech virtuosity. Furthermore, an understanding and view of infrastructure to combat fire infers hierarchical manners of organising. Additionally, the loss of critical lifelines from other hazards has led to a learning style of anticipation, where weather monitoring stations and electricity generators are present. The commercial ski areas also demonstrated hierarchy in an ideal scale that is relatively large.

Hierarchy was also noticeable in the qualitative interviews. First, both the managers and workers conveyed the ideas of forecasting, emergency procedures, providing shelter from the elements, and adaptations to equipment, all based on a scope of knowledge that is almost complete and organized and system properties that are controllable through inherent orderliness. Similarly, managers' and workers' perceptions of avalanches also indicated hierarchy through their accounts of active control, based on procedural rationalities via a scope of knowledge that is almost complete and organized.

Hierarchy was also implicit in scenarios A and E. In scenario A, the participants' maps suggest the adaptations strategies that need to be enhanced as a result of the high *Negative Consequences*; in particular, all participants were driving significant increases to Building Considerations, and the managers were indicating preferences for a procedural rationality that was related to evacuation, access, and external assistance. In scenario E, the consequences are curtailed more significantly than any of the other scenarios. Though the decrease to *Adverse Effects* was driven more by riders in an individualistic fashion, as mentioned above, the workers also drove a significant decrease to *High Intensity and Magnitude*. The outcomes from this simple scenario were an overall slight decrease to *Negative Consequences.* Thus, this is an example of different apparent preferences nesting into bounded groups in hierarchical form.

4.2.7.3 Egalitarian

Egalitarian manners of organising were noticeable in the context based on geomorphic assessments. First, the infrastructure at the club fields reflected an engineering aesthetic of frugality and gentle on the environment. Second, the ideal scale of the club fields was relatively small. The notion of reservoirs and infrastructure precariously positioned is a reflection of *my personal bias* to view these hazards from an egalitarian perspective.

The qualitative interviews also showed instances of egalitarian manners of organising in participants' accounts. First, accounts of communicating with everyone, making sure everyone is safe and accounted for, are instances of seeking survival of the collective, which depend on direction through multi-way communication. Second, avalanche response in the club ski areas depends on groups' knowledge and mental stability to respond when someone is buried by an avalanche, to ensure collective survival.

The scenarios also captured some instances of egalitarian preferences. The notion that some of the scenarios caused increase to *Negative Elements* might be an indication of a view that the system is fragile; however, it is also an indication that they system may be viewed as capricious.

4.2.7.4 Fatalism

Fatalism was apparent in geomorphic assessments as well. First, the location of infrastructure on peaks and ridges may have unknown consequences due to amplification. Second, the location of infrastructure in harm's way may also be construed as fatalism, in the sense that "ignorance is bliss".

The results from the qualitative interviews portrayed incidences of fatalism. First, participants' accounts of their views of natural disasters as unpredictable shows a view of nature as capricious. Second, the possibility of being "caught out" in severe weather elicited both a risk-handling style of acceptance and absorption, and latent strategy of survival of the individual. Third, the assumption that there are procedures in place to control avalanches, can force the snow riders to the margin of organized patterns when it comes to the response to an unexpected avalanche. Moreover, workers who were involved in avalanche control noted that sometimes expectations are exceeded, for example, when large avalanches justify a fatalistic rationality. Fourth, the considerations of earthquakes initially led some participants to describe fatalistic rationalities. Perhaps this is easiest when a scope of knowledge is clearly irrelevant when they have never considered the idea of an earthquake affecting them while at a ski area.

As well, Scenarios, B, C, and D also seem to provide some indication that participants are slightly fatalistic; that is, despite High Coordination, Response Requirements (Long Term) and High Culture of Safety, the outcomes of the scenarios still saw increases to variables that made up Negative Consequences.

4.2.8 Summary of contribution of 'dividual' as a methodological framework and future unit of analysis: GRIP

In an effort to provide a useful method of triangulating results, the dividual was selected as a unit of analysis, based on Thompson (2008). This was not an easy task, though I do believe it is a contribution to cultural theory in that it was an empirical evaluation that sought triangulation of three very different methodologies, while comparing apples to apples or least dividuals. Additionally, most studies on cultural theory appear to leave out the autonomous/hermit methodology. I feel I have a contribution to make in that regard.

4.2.8.1 Autonomy

The qualitative interviews demonstrated autonomy overtly, and in a few instances more subtly. First, the overt instances occur in the accounts of debriefing post hazard events, which enables learning from successive experiences toward an understanding that adaptation strategies necessitate variety. Second, the views that some hazards are beyond the control of individualistic, hierarchical, and egalitarian manners of organising might suggest fatalism; however, these may be more indicative of autonomy.

The autonomous solidarity was present in the context as it is present in Nature. We humans are shaping and being shaped by Nature in a hyper-cyclic self-organising system. First, the geomorphic assessments showed autonomy as a variety of hazards, that is, nature at the various stages of the adaptive cycle, or as I suggest, the adaptive hazard cycle (Figure 4.1).

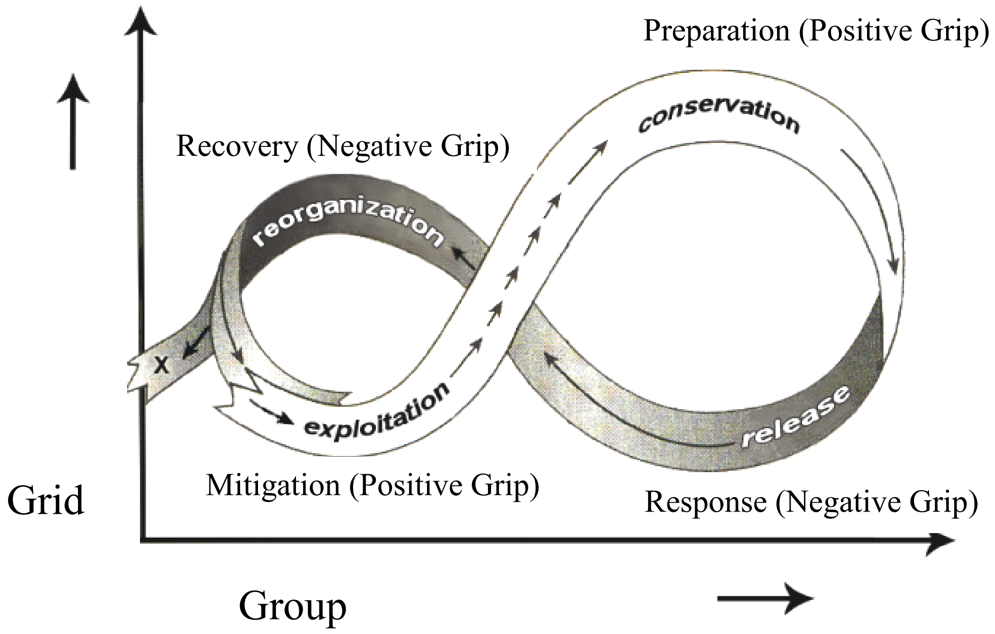


Figure 4.1 The Adaptive Hazard Cycle

The mitigation phase relates to the development of infrastructure in a manner that enables the exploitation of the resources while attempting to nestle the ball in the cup (i.e., good construction via appropriate building codes). Next, the preparation phase requires the development of policies and practices to keep the ball between the two humps (i.e., emergency procedures that are practised and refined). The response-phase is set in motion from some precipitating event and hence first response is required by all people to help satisfy collective survival (i.e., administering first aid, assessing the stability of structures, and attempting to manage everyone's safety when the system is in a precarious phase). Finally, the recovery phase, where a fatalistic rationality might be justifiable to enable us to accept and absorb the consequences of ineffective mitigation, response, and recovery, translating to improved future resilience for those who can pull themselves out of this 'gripless' position. Thus, the system is complete, and in this variety we experience the fifth way of life: the autonomous solidarity, which is a meta-myth that recognizes the elegance and incompleteness of the other myths insofar as each sees humans as separate from nature.

The scenarios may be an attempt to capture the autonomous solidarity, but in seeking reference points in outcomes and contradictory certainties between the different stakeholder groups, it may have been difficult to see the forest for the trees. Furthermore, given that the maps were static snapshots in time without real dynamics, the inferences may be biased away from the autonomous solidarity. However, in understanding the bits, we gain a better appreciation for the actual. The outcomes of the different scenarios show changing solidarities based on different sets of initial conditions for different groups of stakeholders. In real life, such changes from one solidarity to another would accompany moments of reflexive deliberation in the transitional niche of autonomy. In fact, it appears that the professionals involved in the management of natural hazards are now attuned to reflexivity and the need for understanding how the various manners of organising converge at the meta level toward autonomy.

The director of New Zealand's Civil Defence and Emergency Management Sector stated the following at the Austral-Asian Hazard Management Conference in Wellington, on August the 12th, 2010.

> To be successful, it will take huge amounts of collaborations and integration between researchers and their end users. It will take great leadership to ensure we continue to aim at the right target. And leadership to encourage staff to develop strong partnerships. It will take time, which will require patience and understanding and perhaps even some compromise from all players. As the director of Civil Defence and Emergency Management, I represent the practitioners and our key stakeholders, the public, saying nothing of those looking over our shoulders, the politicians who are ultimately responsible for our security. In my role, it is my goal to ensure that the public communities in their many guises are given the tools that enables them to be better able to cope with the hazards they encounter. My nirvana is having to do nothing in an actual emergency situation. Because in nirvana we will have plenty of warning that something was amiss. We would be able to inform the community, clearly and unambiguously. On their side the public would know what to do and they would do it in time to minimise harm because they were well prepared. As consequences they would not need or expect much in the way of extra assistance from the authorities, and they would be able to quickly return, reset, and continue on. Of course, life is not like that. In this business, we are dealing with two powerful forces, neither of which we fully understand or can control – Mother Nature and Human Nature. And that tends to work against us in attaining nirvana. (John Hamilton, pers. comm. August 12th, 2010).

To illustrate more on this insight, I will now shift towards a discussion of conceptual framework at a more theoretical level.

4.3 Theoretical Discussion: Sustainable Hazards Mitigation via Socio-cultural viability in method, theory, and practice

The conceptual framework employed in this thesis is in line with sustainable hazard mitigation in three ways. First, it focused on the problem in a holistic manner, using a sophisticated mix of methodologies in a multi-site case study, which sought trandisciplinarity. Second, it sought stakeholder participation as a starting point for improving policy, instead of using only an expert-centred decision approach. Third, it rejects the traditional planning model for a more modern model, which casts hazards as dynamic, and thereby mitigation as containing feedback needing non-linear processing.

Three approaches to participatory policy development were reviewed briefly in the introduction to highlight their strengths and weaknesses. They were the risk management approach, the empowerment approach, and the resilience approach. In my study, I was attempting to capitalize on the strengths and weaknesses of these approaches to create a novel advancement. Importantly, attention was drawn to the common message among the three approaches; namely, advancements are achieved through debate and eventual collaboration from different perspectives. The recombination of ideas seems to be critical to provide a mechanism for stakeholder involvement in the policy development process and in research process. And yet, taking a holistic/systems approach to study policy development for mitigating risks and natural hazards requires developing flexible and integrated methods. Hence, a triangulated development mixed-method approach was used for initiating policy development with mountain communities.

One of the obvious challenges of such an approach was to cross disciplinary borders. The calls for better integration of multiple disciplines in hazard research are legion and long standing. They are challenged chiefly by a lack of a common language, common methodologies, and common conceptions of the human and nature interactions. These are changing. The common language is being refined through productive exchange, and most are in agreement with the terminology laid out by the United Nations International Strategy for Disaster Reduction. A lack of common methodologies will likely always be an issue, but this can be looked at as an asset rather than a hindrance to progress. Similarly, conceptions of human and nature interactions are diverse and, as I have shown, the variety of social solidarities, ways of organising, or ways of life, give humans more strategies for adaptation, thus increasing our resilience. The challenge, therefore, is creating a deliberative process that is transparent, inclusive of sufficiently diverse stakeholders, and adaptive enough to enable the exchange of diverse perspectives to support a productive recombination of ideas. I have presented one model of how such productive exchanges can begin through incorporating applied computing simulations of social science data.

The theory that was woven throughout the thesis was cultural theory. It was chosen retrospectively, and arose from the data, not primarily as a theory to be tested for validity. Cultural theory was preferred to other theories for three main reasons: 1) its attempted integration of theories from social and natural sciences, 2) its functionalist stance, and 3) its novelty of clumsy solutions (a shift away from elegant solutions, which were the main weaknesses of traditional hazard planning models).

The simplicity of the cultural theory typology is what makes it so pervasive. Initially developed as the Grid and Group heuristic device or analytical scheme (Douglas and Wildavasky, 1982), it has been compared to many other theories in sociology (Thompson *et al.,* 1990). Initially a four-fold typology of individualism, hierarchy, egalitarian, and fatalism, it now includes a fifth component: the automonous/hermit way of organising (Thompson, 1996 & Thompson, 2008). Researchers who do not grasp its significance often cast this fifth solidarity aside (Grendstad and Selle, 2000). The autonomous/hermit is significant to this study for its view of nature as resilient; that is, rather than myths of human nature *and* physical nature as logically contradictory certainties, all of which in their extreme positions perceive humans and nature as separate, nature resilient is a deep understanding that we are very much changing and changed by nature, and thus are inescapably a part of it. Therefore, nature resilient rejects the underlying assumption of humans' separation from nature. Instead, the autonomous/hermit is biased away from the other myths which are actively engaged in subversion and coercion to disorganise the other solidarities.

In the hazard mitigation sciences, the four solidarities correspond to behavioural strategies for coping with hazard events. Individualism is represented through urging personal preparation to increase resistance and the ability to cope with perturbations. Hierarchy is implicit in the traditional approaches of centralized control to enhance latitude through the behavioural paradigm of engineering and emergency response. Egalitarian manners of organizing are becoming more common highlighted by the stress for community-based adaptation sometimes reflection the radical structuralist paradigm. Fatalism, which is always present, reflects a perceived helplessness in the face of some events (e.g. earthquakes) because these and other social factors have forced one into a precarious position. The hazard sciences recognize the strategies above as useful in certain cases. In the recent persuit toward resilience they have not recognized cultural theory as a functional device which begins to explain both how and why resilience needs to be the driving force. The explanation points us towards requisite variety.

The four characters introduced in the first chapter served to show the patterns of social relationships. Indy portrayed the ego-focused network deciding the appropriate time to defect for personal gain; Alita, the egalitarian bounded groups protecting snow riders' rights from those outside their 'boarder' of virtue; and Harry demonstrated the function of hierarchically nested groups, which is to preserve control through inherent orderliness, and protect their paradigms often by absorbing some risks (though not personally), while rejecting others. The story conveyed these extreme characters to illustrate the interactions and transactions between them. Moreover, two other solidarities were introduced. The character of Fata, a newly converted fatalist actor, shifted solidarities as a result of events (interactions and transactions) that surprised her, and thus she could no longer justify her view of nature as benign and instead her view changed to capricious. Similarly, Alita, who had a stabilized preference for egalitarian organization, learned the futility in her/their pursuits through a series of faulty transactions.

In response to these transactions, Alita had five options. She could have gone and worked for Indy at his new B & B and waited for him to pass on, whereupon she would be able to sell the B & B and buy her own ski area. She could have shifted solidarities and joined HierArchs, for an easy job where risks are absorbed through transferring them down the hierarchy, or rejected as somebody else's problem. She could have strengthened her adherence to egalitarian manners of organising and continued to shout, 'Damn that man and down with Higher Archs'! She could have cast aside her internal locus of control and, like Fata, given up altogether. However, she chose a fifth option. Instead of ignorance, she became one with nature.

The story and its characters served to demonstrate the five ways of organising in a hypothetical context of extremes and exaggeration, in order to illustrate to the reader how the ways of life interact. I deliberately chose not to weave hazards into the story so that cultural theory would be accessible to a transdisciplinary audience. The story stopped with disagreements immediately prior to an earthquake. The story will now resume, with four different strategies for adaptation. The first three ad hoc responses will demonstrate elegant solutions and their resistance to surprise. The final strategy is a clumsy one, and shows the benefit of satisfying requisite variety.

4.3.1 Elegantly *ad hoc* responses vs clumsy solution via requisite variety

4.3.1.1 Hierarchy and its resistance to surprise

Harry was sweating. He had not eaten or slept, and was pretty much out of adrenalin. He wasn't sure what to be more upset about: the injuries and deaths, the pain in his leg, or the complete and utter failure of the emergency response plan that he had developed. He was very surprised that communications failed and were still not up and running, and worried that the one functioning generator was running low on fuel. He was frustrated that the fuel truck had not arrived on time yesterday. It had been hit by an avalanche while travelling up the access road, and was likely in a much worse condition than him.

Part of their operations building had caught fire when the deep fryer in the galley overflowed. Fire extinguishers quickly ran out, and they decided to retreat to another building. En route, an aftershock hit. It seemed stronger and longer than the first earthquake, causing avalanches, landslides and rock fall. Worst of all, the water reservoir failed, with the outflow hitting their operations building and severely injuring three key staff members (safety services officer, medical officer, and communications director). Fortunately, it did cause the fire to be suppressed.

Clients were starting to panic. The pain in his leg was getting worse, and he was thirsty. He wanted someone to talk to—or, at least, someone else to blame. He thought of his father, Indy, who had warned him of such a scenario and was likely paragliding down from Mt. Sovereign.

4.3.1.2 Individualism and its resistance to surprise

Indy was in pain. His legs were definitely broken and he was sure his ribs were, too. He had almost made it. He had prepared himself for this day ever since the 1994 earthquake, which had killed his best Cat driver and destroyed their day lodge. His survival kit was impressive; it could have easily kept him alive for a month so long as he had access to clean water. But his escape route, which he practised subversively as a recreational pursuit, had failed him miserably. He had always known that it would not work in high wind. He had heard the rumble and crunching of an aftershock. He remembered the strange sensation of the earth beneath him blurring and then rolling. He was even more shocked when the rear face of Mt. Sovereign failed beneath him. He had pulled up to avoid the air-blast caused by the avalanche, and then suddenly he was spiralling out of control. His glider folded and he plummeted to the ground.

Now, he could only lie and wait, thinking about all the people stuck on Mt. Sovereign. They would think he defected. This would be backed up by his sale to HierArchs. Given that he would probably die among the collapsed rubble of his great mountain, the full genius of his plan would never be known. He was to paraglide to his home, well out of any known avalanche paths, jump in his helicopter (an old Sea Knight), which could easily take 20-30 passengers and shuttle people to his barn for shelter. He would have likely received compensation and a service reward.

He thought to himself, "If only I had told someone." Someone other than Harry, anyway, who never took his strategies seriously. Perhaps if he had told Alita, she would have been more prepared than he would.

4.3.1.3 Egalitarian organising and its resistance to surprise.

Alita was comparatively well, though she was, at the moment, a hostage of Fata, who had come for the memorial service of the recently lost club member, yet was now holding an avalanche bomb and demanding the key to the provision kit. Prior to this outrageous act of individualized survival, their plans had worked handsomely. A small avalanche had occurred in the initial earthquake, the consequences of which resulted in the partial burial of two club members. They were in the process of honouring the recent death by carrying his ashes for one more run down from Nervous Knob. It was both surprising and fortunate that more rock fall had not come down. The club members responded instantly to the burial, digging out the buried members, setting up a probe line and using transceivers to conduct a grid search for other possible burials. Once all had been accounted for, they retired to the main lodge to discuss their strategy.

In the usual style, they discussed issues and were in general agreement that the provisions should not be opened for 24 hours. Fata, who was only planning on a short appearance, had not brought her usual equipment, and thus argued vociferously to only wait 12 hours. The members, some of whom still blamed her for the recent death, ruled against her and reasoned they could all wait one day with little ill effect.

When the second aftershock occurred, Fata lost it. She was hungry and thirsty and needed to get out of these mountains. Her plan was to get enough provisions for herself and leave alone. She would bluff them into concession with an avalanche bomb (though she had removed the fuse).

Alita was surprised by the predicament, but her newfound resolve had left her calm, though she knew the club members were frightened. The looks on their faces said it all. They were all going to die. Alita thought to herself that the current situation is a direct result of club members desire to limit control with avalanche bombs, for fear of displacing the nesting Kea birds. Alita shouted, “The Keas. They got us into this mess and that’s our way out! Fata, come with me.” With that, they were off.

4.3.1.4 Autonomy and its adaptation to surprise: Clumsiness and why it is as easy as falling of a mountain

Alita and Fata raced to the storeroom, where the provisions were held. Fata inquired, “What are you going to do?” Alita said, “Fly. But first, we need the mountain radio. Quick, we are running out of time.” They grabbed the mountain radio, the back-up VHF radios, and the satellite phone. Alita began digging at the storeroom corner, beneath some old boxes. “Ah ha!”, she said. “Here it is”. Fata’s jaw dropped when Alita pulled out an old paraglider that Indy had given her when she was a teenager. Alita, said to Fata, “I need your help”.

Alita then went on to explain, “I need to catch the valley breeze so I can make it over Mt. Peasant. I’m heading for Mt. Sovereign. You get on the mountain radio and contact Harry and/or Indy. If they are not on, use the sat-phone. Tell them what I’m doing and I’ll contact you when I get there.” Then she organized the glider and was off. The club members gathered on the balcony and were in disbelief. First, that Alita would leave them like this with no explanation. Second, that Fata was barking orders at them like a seasoned admiral.

She shouted sharply, “You get on the Sat-phone and find out about access in and out of the Alps. “You two set up the Mountain radio. “You three, set up the spare VHF radio receiver. And the rest of you, use the barbeque cauldron to boil some water to make us all some food. We leave in an hour.”

When the mountain radios were up and running, it had become clear that Indy had defected and Mt. Sovereign was plunged into anarchy. In addition, Harry had lost his grip at Mt. Arc, losing his key staff to injuries and one to death. His emergency plan was now just words on a page. Fata was concerned about Alita, and whether or not she had made it to Mt. Sovereign. Just then, there was a call on the mountain radio. “Sovereign to Lower Archs. Do you copy?” It was Alita, giving Fata great relief. Fata then explained to Alita that Indy was nowhere to be found, that Harry was injured, and that people were self-evacuating from Mt. Arch on foot, but that things were in control at home base.

"I'll have to take one of the snowmobiles to the top of Mt. Sovereign to launch again. From there I'll be able to get a handle on access, and also, hopefully, find out what happened to Indy. We need him for this to work. I'll contact you again in two hours." Alita asked, "Any luck with Civil Defence?"

"We've contacted them with the sat-phone, but it looks like we are on our own. They've also asked us to refrain from using the sat-phone. The Alpine Fault and a large portion of the Wellington Fault ruptured. This is the big one. They say it could be weeks before help arrives." Alita replied, "Sit tight. And thank you for your help."

Once Alita was atop Mt. Sovereign, she could see that a large portion of the mountain had collapsed. It was an incredible sight. She also noticed a small green thing in the rubble below. Her stomach sank. Binoculars would confirm that it was Indy. She took out her VHF radio and began to call, "Alita to Indy. Alita to Indy, do you copy?" There was no response. She looked around and tried again. "Alita to Indy, do you copy?" Then a whimper came over the radio. "If that's you, love, I must be dead." Alita responded in kind. "I haven't killed you, so you can't be. I'm coming to get you."

Alita landed in the best spot she could find close to Indy. On finding him, she knew he was in trouble. His lips were blue, his legs were crooked, and he was drifting in and out of consciousness. She reached into his pack and grabbed an adrenalin kit. She administered the drug. He was more alert, though in visible pain. "We've got to get you off this mountain", she said. He nodded and then she apologised in advance before straightening his broken legs. She then strapped him in to a makeshift basket using her glider. She reorganized Indy's glider, and after awaiting a gust of wind, took off down the rest of the mountain. They landed close to Indy's house, and she ran to find something with which to carry him. Then they went inside the house to reorganise.

Once inside, Indy asked her to get him his satellite phone from the cupboard. He made a call to Civil Defence. The controller on the end was one of his best friends. "Indy?" "Yep, it's me, Shep. I need a favour. I'm banged up and we need a pilot to evacuate the Roman Range." "You know those areas are low on our priority list, but I'll see what I can do." "All we need is a pilot for a half an hour, then I'll get Harry to shuttle people to here". "How many people are up there?" inquired Shep. Indy's response was strategic, "Mt. Sovereign had a head count of 1245. Mt. Arc, a few-thousand. And Mt. Peasant had 80." Shep replied, "Give me an hour."

An hour later, a helicopter flew directly over the house and into the Roman Range. It returned quickly with Harry and few staff to help set up a field hospital. Harry greeted his father with a nod. It was the first time they had been face to face since their disagreement, but on this occasion, they set aside their differences. Harry climbed into the Sea Knight with Alita and headed first to Mt. Sovereign. They began by shuttling the injured and medical staff back to Indy's farm. He was riding around on a four-wheeler, setting up a makeshift hospital shouting orders to people. Then over the next day and a half they began flying back and forth to the successive fields to airlift people out, starting with the injured, then children and women, then men who could help. These were strict instructions from Indy, who would have otherwise not lent his helicopter.

The last flight would pick up Fata, and on approaching the helicopter, she said "Permission to climb aboard, I'm unarmed." Alita responded, "Of course. We could not have done it without you." Fata asked, "What did I do that was so important?" "For starters, your strategy of holding me hostage with a diffused avalanche bomb, though desperate and self-indulgent - seeing you shift from a victim to a self- empowered individual calling the shots; well it sent my neurons fluttering to the Keas, only to realize that one way of organising (even if it was my way) would not be enough. It was clear, we required a variety of different ways of organizing to be resilient".

4.3.2 Conceptual Framework Revisited: Disciplinary-isms

We need variety. Multi-disciplinary, interdisciplinary, and now transdisciplinary research have been stressed as essential for hazard and disaster research. Yet all three of these different research frameworks have their limitations. They all appear to be necessary for mitigating natural hazards, but exactly how to go about them is a worthy challenge. For multi-disciplinary research, the challenge seems to be integrating findings from the different 'silos' of research that are rigid, persistent, and resistant to change, whereas interdisciplinary hazard and disaster researchers struggle to find sufficient depth from 'specialized generalists' (oxymoron intended), hence lacking in scientific rigour, actionable outcomes, and efficient information transfer. Finally, transdisciplinary research and triangulated clumsy solutions are inherently abstract and thus can struggle to find ways of transforming results into meaning, and expressing results in forms that people can understand.

As this research has shown, transdisciplinary and integrating methodologies are possible. This was shown by integrating field-based geomorphic assessments to develop a line of questioning; using the qualitative interviews to support the consideration of an event beyond horizons; and finally extending qualitative methods by simulating social group fuzzy cognitive maps for identifying policy opportunities. Moreover, the framework identified other specialized lines of inquiry for future research that merit attention, such as using reservoirs in alpine areas to study the effects of topographic amplification, a new possible area of research that is distinctly transdisciplinary. Multi-disciplinary and interdisciplinary approaches may have uncovered similar findings, but the transdisciplinary framework was favourable for its holistic approach and favourability for triangulation. Triangulation, however, needs to be able to compare apples to apples. This was achieved by using the 'dividual' as the unit of analysis, rather than only the individuals, or stakeholder groups, or distinct ski areas, or the data from each methodology. Thus, the implicit manifestations of the social solidarities combined with data arising from each method proved to be a useful manner of triangulating the results.

4.3.3 Cultural Theory contributions and expansion

The sample investigated in this study reflected that solidarities, or ways of life according to cultural theory, are present in the context of mitigating hazards in alpine ski areas. The active solidarities of hierarchist, individualist and egalitarian were visible in participants' accounts of experiences and perceptions. The ski area managers showed preference for hierarchical solidarities, yet this may have resulted from the roles that managers are expected to play. Some managers also showed individualist and egalitarian solidarities. In fact, the accounts from all three targeted social groups highlighted that all three active solidarities were present. Each of the active ways of life was present in the participants' consideration of common hazards. Yet the initial consideration of the earthquake hazards may have rationalized fatalistic tendencies due to it being novel or uncertain, so as to force participants to select individualized survival as a latent strategy. Some participants, however, seemed to fall back on their preferences for ways of organising in the face of common hazards; hence, when describing earthquakes, some managers indicated hierarchy. Some workers opt for individualism, hierarchy, or egalitarian manners of organising. And riders seemed to prefer egalitarian or individualist, though it was by no means so clear.

Extracting the viable ways of life from the results of FCM proved even more difficult. Are the selected variables in participants FCM an indication of preferred solidarities? For example, does the selection of Emergency Plan and Procedures (i.e., a hierarchist solidarity) mean that that participant attaches themselves to that way of life? Not necessarily. However, if they selected a variable that is more or less a hierarchist solidarity and then chose to map that variable as the most central variable in their map, that might indicate a hierarchist leaning. However, this would not be a sufficient indication of a preference for an 'overall' way of life, generalized to all contexts.

Instead, I chose to focus on the dividual as the unit of analysis, where a cultural functional explanation of outcomes from the FCM provided some insight as to the more obvious solidarities that were manifesting in the results. This is certainly a novel use of cultural theory and of FCM, but it begs the question, do the viable ways of life that were extracted from the results satisfy the *compatibility condition* of congruence between social relations and cultural biases?

4.3.3.1 On the Compatibility Condition

The compatibility condition suggests that social relations and cultural biases must correlate for a distinct way of life. While I think this is true, I believe it is contextual and may be rather a case of extremes. Similar to the FCM, which are only a snapshot in time, solidarities that are reflective of the compatibility condition may only exist as pseudo-stable reference points. As I have shown, people tend to mix the solidarities, but they also seem to stabilize in particular places that can be helpful for drawing inferences. In the qualitative interviews, for example, some participants changed solidarities discursively throughout the interview, as well as within a particular response. Sometimes they might hint at a myth of nature as capricious, but then shift to describe a belief that procedures (i.e., a system that is controllable through order) will be effective. The challenge, as Mary Douglas points out (see Thompson 2008) out, is attempting to stabilize the solidarity, or else it will jump around. In running the policy scenarios, I was trying to find these stable reference points for the different social group maps, and some of them did emerge. Instances of fatalism were consistent in scenarios B, C, and D, and some of these could be triangulated with responses from the interviews suggesting that fatalism was an apparent solidarity. Other solidarities were also implicit in the outcomes of the scenarios, but another question of compatibility becomes, is it the scenarios or the FCM that is driving the apparent preference for a particular solidarity?

Moreover, these outcomes do appear to capture cultural biases, and implied behavioural strategies, but are they sufficient to imply social relations? These are questions I am not able to answer, though I do believe the framework herein is a step in the right direction toward empirical studies that can validate the links between social relations and biases based on FCM and qualitative interviews.

One possibility, however, is that with a new sample, more emphasis could be placed on the differences between participants who preferred club and commercial ski areas. These types of ski areas certainly have different social relations and cultural biases attached to those relations, yet I chose not to do so here because I felt it was moving away from the initial problem, which was what to do about an earthquake affecting a ski area. Stakeholders from both types of ski areas provided an invaluable contribution, and though some attention was given to highlight the distinctions, initially I was interested in synergies between the different stakeholders from the different types of areas. In the future, I will not let my bias confirm areas of agreement in the collection of data, but rather focus even more on the differences of stakeholders from different contexts. Thus, more solid comments will be made on compatibility of social relations and cultural biases, and whether *preferences for solidarities are formed through experience in particular environments* (physical, social, and economic). I think they are, but I also know that preferences shape the environment that they are a part of.

Chapter 5: **Adapting to Change and Mitigating Future Hazards**

5.1 A guide to the conclusions

The following section outlines the limitations of each of the methodologies. It then revisits the limitations of Cultural Theory and how they were overcome. Next, it gives salience to the context under investigation outlining basic facts, my personal reaction, and one ski fields' response and recovery to the September 4th, 2010 Canterbury earthquake. After that, a section outlines changes that have occurred in understanding natural hazards and the need for participation from stakeholders toward sustainable hazard mitigation. Some recommendations are then made for improving policies and practices *in situ*. Finally it argues that understanding natural hazards, and in particular hazard mitigation, benefits from the productive recombination of ideas offered in social cultural viability – *the collective wisdom of all five ways of life.*

5.1.1 Limitations of Method and Theory

The thesis presented above has several limitations. The limitations are both specific to the components of the individual methods and the overall framework. The geomorphic assessments are limited in that they were superficial assessments and an expert-centred approach. The qualitative interviews suffer from all the shortfalls of qualitative methods. The fuzzy cognitive maps also have several limitations. Overall, the greatest limitation is the limited experience of the researcher. This was my first project of this magnitude, and the methods and their integration were very much a learning process. I will now provide more details on the limitations of each method based on the application *in situ*.

5.1.1.1 Limitations of Geomorphic Assessments

One key limitation of this approach is that earthquakes are a rare hazard and therefore we have only a limited number of cases and empirical studies to draw on. With a reasonable understanding of the system (i.e., the changes that occur in mountain environments as a result of earthquakes), the geomorphic assessments were based on an expert-centred approach, thus the researcher could overestimate or underestimate particular consequences identified. This is especially true when considering the superficial nature of the assessments that looked only at the visible surface of the ski area, without detailed geological or other physical data.

I have a reasonable understanding of the system, but this can lead to drawing inferences that result from the researcher's bias. As mentioned, the researcher was looking for the changes in the system as a result of earthquakes, and in particular how these changes could affect people and infrastructure. This exercise is loaded with bias--I admit that I adopted an egalitarian perspective insofar as I was looking at the system as fragile… though perhaps in trying to find the worst-case scenario in terms of 'what could go horribly wrong' when an earthquake affects a ski area, I was viewing nature as capricious. Yet the overall conclusion that was drawn ("The main issues found in these assessments reflect development of ski fields without due considerations for seismic events. This type of development may place high numbers of people at an unnecessary and involuntary risk; and steps should be taken to avoid such vulnerable developments in the future") definitely reflects a critical rationality. Moreover, such a conclusion reflects desired system properties that are sustainable through inherent fragility. Now, a distinction needs to be made here. I am referring to the ski field system (physical, social, economic, and cultural) as fragile, and directly linked to the consequences that the surrounding environment can deliver. In reflecting on the inferences drawn from the geomorphic assessments, it appears that the physical consequences indicate a predilection toward negative 'grip'; it is only through the inclusion of social process (i.e., experiences and perceptions) to tease out social relations and other cultural biases that the other dimensions of sociality are made apparent. In summary, limitations of the expert centered 'elegant' approach can be *clumsified* through integration and triangulation with other methods.

5.1.1.2 Limitations of Qualitative Interviews

The limitations of qualitative interviews are well documented. Interviews may be experienced by participants as more intrusive and time-consuming than are quantitative approaches; participants may say more than they intended to say, and later regret having done so; and, interviewees may be more reactive to personalities, moods, and interpersonal dynamics between the interviewer and the interviewee than methods such as surveys. Furthermore, conducting interviews can be expensive and time-consuming, because qualitative interviewing requires considerable skill and experience. As the principal researcher, I had neither. Furthermore, analysis and interpretation of qualitative interviews can be particularly time-consuming. In addition, qualitative interviews are more subjective than quantitative methods because the researcher decides which quotations or specific examples to report (Kvale, 1996; Patton, 1990; Creswell, 2003; Sewell, n.d.). The research information sheets, questions, the interviewer's tone of voice and demeanour of the interview can all have a framing effect on participants' responses. The framing effect is a cognitive bias that means presenting the same questions in slightly different formats can alter people's responses (Kahneman and Tversky, 1981). Due to these factors, attempts were made to be as consistent as possible during the interviews and remain alert to both the respondents, and my own fatigue and biases.

5.1.1.3 Limitations of Fuzzy Cognitive Maps

The limitations of fuzzy cognitive maps are linked to their underlying assumptions. It is assumed that individuals have cognitive (mental) models that are internal representations of a partially observed world (Norman, 1983; Bauer, 1975), and that cognitive structure can be modelled using symbols; that is, they are linguistically mediated (Carely and Palmquist, 1992), and that they can be represented as networks (Joanssen *et al.,* 1993). Other key assumptions are that the meaning of concepts are embedded in the relationships to other concepts, and derived from the intersection of different individuals' mental models (Carely and Palmquist, 1992). Another fundamental assumption is that if such models exist, people can readily access the model and represent it accurately (Jonassen *et al.,* 1994; Hearnshaw, 2009). Recall if you will Downs and Stae (1980), who commented that a cognitive map exists if an individual (or in the case of stakeholders, a group) behaves as if the cognitive maps exists. To put it another way, the outcomes of the cognitive map can only be validated if a real world scenario similar to those undertaken in modelling generates outcomes/expectations similar to those that were generated by the model. In the case of an earthquake affecting a ski area, this could have taken a long time. Yet on September 4, 2010, a scenario such as this played out, and though it proved to be by no means a worst-case scenario, as depicted in *Scenario A*, it did hint directly at the social solidarities that could have been expected by particular social groups and in particular contexts (See section 5.1.2).

Another limitation of the study was caused by the deviation from norms associated with fuzzy cognitive mapping as a tool for eliciting expert information. It could be argued that most, if not all, of the participants were 'beginners' with respect to their experiences and knowledge of earthquakes *in situ*. Thus, what use is the data being gathered? Notwithstanding their apparent lack of experience with earthquakes, and limited experience in the context with more common hazards, they are all indeed experts. Whether described as experts or lay-experts, all of the participants have some experience to draw from, and thus their maps enhance our inquiry by providing *variety*.

5.1.1.4 Limitations of cultural theory as the theoretical framework

Cultural theory (CT) has been criticised for three key reasons: rigidity and situational transfer; that risks are linked to worldviews, its functionalist's stance, it being insufficiently deterministic, and that myths of human nature and physical nature may not be linked (See section 1.4.3).

First, the rigidity and situational transfer is resolved by using the forms of solidarity as the units of analysis – the 'dividuals' the 'five ways of life' complete with their cultural biases, behavioural strategies, and social relations. Previous studies have demonstrated that the solidarities of cultural theory are not intended to be rigid; rather, individuals drift from one viable way of life to another depending on the situation and context. As people experience life, transactions and interactions with people adhering to the various solidarities can create, destroy, and reinforce preferences for ways of life and their respective risk perceptions. Allegiance to particular solidarities is situational, as they appear to change according to context and previous experiences.

And the early criticisms of rigidity all relate to the grid-group typology (static version of the theory) all assume invalidly that the individual or the society has to be the unit of analysis (Thompson, 2008). Most social sciences makes a distinction between the individual and the society – the micro and the marco – slicing right through the patterns that hold the two together (ibid, 2008). It makes no sense to aggregate up (methodological individualism) to the best social choice from disparate individual social values and to disaggregate down (methodological collectivism) when the macro and micro are each the cause of each other (ibid, 2008). When the 'dividuals' are examined based on how the five patterns manifest themselves within and across differing contexts, the criticism of rigidity and situational transfer become mute. The changes that result from interactions and transactions between the five ways of life – force us to go beyond the grid-group typology as we witness the dynamic version of cultural theory.

Second, Lupton (1999) criticism of risk selection linked to world views comes short of a key point made by cultural theory, that the world views (i.e. solidarities) are linked with positive feedback loops that maintain each of the contending solidarities. Cultural theory goes further than Lupton to say that the five solidarities (i.e. linked social relations, cultural biases and behavioural strategies) shape the selective attention of salient risks. So, through the interdependent maintenance of all five contending solidarities – plural rationality can ensure risks are attended to.

Third, Thompson *et al.* (1990) also acknowledge that the embedded functionalism in the cultural theory commits one to an ideologically conservative perspective, and can be used to preserve the existing institutions of power. Still, this is only problematic if the functions are treated as functional for the totality - the whole society. This was a major limitation of Parsonian/Radcliffe Brownian Functionalism (Thompson *et al.,* 1990).

A more relevant criticism of cultural theory's functionalism is in Grimmen (1999) who notes that cultural theory does not distinguish between intended and unintended consequences and that one must be able to distinguish between logical and causal connections. Grimmen's criticisms are relevant to this thesis given some of the surprising results of the SGFCM and the ensuring scenarios – unintended or at least unexpected consequences - patterns that resulted from participants and the researcher also not being able to distinguish between logical and causal connections. This area deserves more attention in future research. Still, this is also a strength of the research's functional nature – it demonstrated that a reversal of the independent and dependent variables (as in the management scenarios) captures these unintended and unexpected consequences thereby putting functionalism to good use with respect to the methodology.

Fourth, the charge of cultural theory being insufficiently deterministic has been countered by 6 and Mar (2008). Ryaner (1992) criticized cultural theory while comparing it against one (e.g. Rational-choice theory) that predicts mobility over time in response to feedback process – likely a protest that cultural theory privileges structure over agency (6 and Mars, 2008). Cultural theory offers a richer account of what kinds of agency are possible and what agency would mean in different institutional settings (Douglas and Ney 2004 in ibid, 2008). With respect to insufficient determinacy, the charge is really one of unfalsifiability. The only way to falsify cultural theory would be to demonstrate that:

1) The characteristics, for example, of thought style or sociometric forms, predicted to be produced by the underlying intersection of the dimensions of social integration and social regulation, are not in fact observed; or
2) The specific outcomes predicted for the feedbacks dynamics were not observed (ibid, 2008, p. 26).

Neither has occurred. Showing determinism requires a consistency of assignment between the 3 analytically distinct levels: social relations, cultural biases (values and beliefs and behavioural strategies (See Dake and Thompson 1999).

Perhaps a similar criticism of cultural theory in light of this largely qualitative research is the inherent subjectivity in assigning accounts, variables, concepts, results of simulations et cetera to particular social solidarities. Cultural theory works mostly as an explanatory tool, and herein the engagement of research participants was extractive. Gaining insight into whether people actually view things the way the researcher does would require prolonged and iterative engagement with participants… something that, unfortunately, this research has not achieved, making the efficacy of cultural theory within this framework limited. It is limited by the constraints of the research, by the researchers' inexperience, and by the adaptive nature of data collection, processing, and analysis.

At a higher level, though, the implied strategies of the interviews and the results from the policy scenario simulations can be framed according to viable ways of life set out in cultural theory – demonstrating behavioural strategies, cultural biases and social relations. The strategies, biases, and relations that participants outlined in the interviews and the simulations of policy scenarios imply certain myths of nature, selections of technology, and manners of organising that are central to cultural theory. This is a critical element of the cultural theory framework, which points us to the dividual as the unit of analysis.

For instance, the common theme of snowmaking to improve 'sustainability' of the ski areas (i.e., economic sustainability) indicates a myth of nature from the hierarchists' perspective, selecting technology that enables ski areas to extend their season, keeping the ball firmly planted in the trough. Snowmaking infrastructure depends to a large degree on a commercial scale that enables the ski areas the means to afford the relevant technology.

Yet as the geomorphic assessments highlighted, in some instances, the reservoirs can increase the hazards caused by earthquakes. *The view of reservoirs collapse as a hazards shows a selective attention that is indeed characterised by the egalitarian solidarity in six ways.* First, it is distinctly a view that nature is ephemeral (e.g., give the ski area a shake and the reservoirs come splashing down). Second, there is a social construction of time in the view that if we don't change the reservoirs now, we are doomed later. And third, there is a mild information rejection "expulsion" that snowmaking reservoirs are needed or not needed. Fifth, the egalitarians technological preferences are low tech. Sixth, the egalitarian solidarity weighs the severity of harm much more heavily than probability (6 and Mars, 2008). All of these preferences infer that they must band together when they need to adapt, their collective experiences reaffirm their belief favouring the egalitarian solidarity.

The creation of the reservoirs is a mix of solidarities, an alliance between hierarchical and individualist forms of organising. The hierarchical way of life is obvious with respect to the myth of nature perverse and tolerant. The individualist solidarity assumes a business-as-usual approach, with the advent of snow-making technology. Yet in the instance of an earthquake, I saw the reservoirs from an egalitarian myth, seeing nature as ephemeral. None of these myths in isolation can provide solutions that are sufficient, though they can certainly suggest elegance as a viable strategy; it is likely that such strategies are *ipso facto* prone to surprises, for viability depends on variety and the truths inherent in all five social solidarities.

In Summary, despite limitation levelled by other authors, with the mix of tools applied herein, the dynamic version of cultural theory goes beyond its descriptive forbearer (grid-group typology) toward a deterministic formalism of for understanding mutually dependent worldviews that manifest in our institutions and ever present in the policy making process. A real world example will help highlight this view.

5.1.2 The September 4th, 2010 Earthquake

The 2010 Canterbury earthquake occurred on the 4th of September 2010 and is a great example of unknown unknowns. It took place at 4:35 am, 40 kilometres from Christchurch, New Zealand, and was a 7.1 magnitude earthquake at a depth of 10km on a previously unknown fault. A 5.8 magnitude foreshock (which is only recognizable in hindsight) occurred just five seconds before the main quake. Though damage was widespread, serious injuries and deaths were very low, attributed to good building codes and the timing of the event (good timing).

5.1.2.1 My personal experience of the Canterbury Earthquake

When I heard about the earthquake, it caused a rather significant emotional reaction that can be described according to the five ways of life. First, some context may be needed. At the time of the Canterbury Earthquake, I was not in New Zealand. I had just returned to Canada, leaving Christchurch on the 30th of August, 2010. When I first heard about the earthquake, I was driving along the North shore of Lake Superior, on my way to Thunder Bay to start a job teaching Expedition Management at Lakehead University. I was between Sault St. Marie and Wawa when the first news of the earthquake came over the radio. Like many hazard scientists, my first reaction, I must admit, was a slight rush of adrenalin, followed by an immediate desire to know more. The CBC broadcast stated that "a 7.1 magnitude earthquake has rocked Christchurch, New Zealand, causing widespread damage, and reports are coming of injuries, though no deaths have yet been reported". Over the next four hours, I was in an isolated region, and radio and cell phone coverage was very limited. My initial excitement quickly changed to distress upon hearing the next news report: "…buildings have collapsed…".This immediately quelled my excitement, and created a strongly negative emotional reaction, as I began fearing for the friends and colleagues whom I had only just left five days earlier. I had mental pictures of buildings that I knew collapsing: the Hilgendorf, the Canterbury Geology building, the libraries. I thought to myself, "If only I had taken the flight on the 7th of September I would be there". This thought definitely arouses a variety of solidarities. I felt slighted that I was missing out. I felt relieved that I was safe and close to family, at least in a relative sense. I wondered if they had activated the Civil Defence Teams...there was a flurry of thoughts and a feeling of helplessness in my current position, disconnected from knowing and wishing there was something I could do to help those helpless people. Once I had collected my thoughts, realising that I had to calm down and drive for another 4 hours, I began to think about the ski areas.

My first thought about the ski areas pertained to the reservoirs. Did they collapse? Was it caused by displacement, structural failure, or seiching, or perhaps all of the above? Next, I thought about avalanches, about the roads, and about whether or not the ski areas were open. Given that I had heard about the earthquake on a Friday, I began to have thoughts of a worst-case-scenario busy Saturday, and these thoughts were unsettling. If only I had warned them. I was angry that my presentation to a representative of the Mountain Safety Council on the 28th of August had been cancelled. I felt like my years of research had been in vain.

When I finally came into cell phone range, I attempted to phone my friend and colleague Tom Wilson, of the University of Canterbury geology department. The phones were down. I was, however, able to get some good news via the web. No deaths, though two serious injuries, one of which turn out to be another friend from my hockey team. Good timing and good buildings contributed to reducing the number of injuries. I then turned my attention to the ski area and their responses.

5.1.2.2 One Ski Field's Response to the Canterbury Earthquake

Mt. Hutt, which is 44 kilometres from the epicentre of the earthquake and an area where I had spent considerable time, responded in the following manner. First, they opened at midday on the 4th, which aroused some suspicion from guests. They responded by issuing a press release and a posting on NZSki.com (Appendix 5.A). This was a rather quick response to the event, but I must draw attention (somewhat egocentrically of me, perhaps) to the seventh bullet in their list: "We checked the snowmaking reservoir for cracking/integrity". Thus, I seemingly overestimated the risk of reservoir collapse; at least it did not meet my expectation of fragility. Still, it was nice to know that the managers and staff looked at it, and in addition that the clients were asking questions. The responses showed a relationship to the outcomes of the maps, in particular as they relate to Scenario A:

1) Infrastructure was assessed for damage, including lifts, buildings and roads.

2) The snow pack and terrain were assessed for stability.

3) Active avalanche control was used (e.g. bombing to bring down rocks dislodged in the quake).

4) Contacted policy and the Westpac (i.e. search and rescue) to ascertain if they had issue with them opening.

5) Advised guests to check their route to the mountain prior to travel

Additionally, they noted their ongoing monitoring and adjustments to the shaky reality:

> As you are are [sic all] well aware, the mid-Canterbury district is still receiving regular aftershocks. If we get a noticeable shake during operations, we will stop the lifts until things have settled down. If a subsequent aftershock is large enough we may have to repeat one or more of the processes outlined above – potentially whist guest remain on the line. We would also consider evacuation of the base lodge by sounding the fire alarm system. Building wardens assigned to the specific areas will check through the base facility to ensure guests and staff are clear of the building. Remember our assembly point is out in from of the cafe deck. If anyone has any questions or concerns, please feel free to contact me. (James McKenzie, September 5th, 2010).

A media interview with Mt. Hutt's safety manager also highlights a view of the experience of an earthquake:

> "at least 12 'reasonably large' avalanches were set off...it was certainly a good rattle...the ski-area is looking good, but outside the boundary is another thing. There's no control out there, so it's very important people stick to the tracks...We

like to bring it down before it brings itself down,...**business as usual**...Methven locals are pretty resilient, this wouldn't put them off a good day on the mountain" (The Star, 4th September, 2010)

The safety manager's interview mostly reflects a perspective of positive grip, characterised by both hierarchy and individualism. Hierarchy was apparent in his account of control and imposition of rules about people staying on designated tracks. Individualism was apparent is his stressing the safety within the ski area's boundary and his notion that locals are resilient, it won't stop them from skiing. Thus, from his perspective the ball is nestled in the basin. A few weeks later, I interviewed a different mountain manager to get an account from someone experiencing both the response and the recovery. I asked about the social impacts.

> Yes quite a lot. Actually a significant drop in school groups, but that was not necessarily to the fact that they thought the mountain was unsafe. It was just the schools were closed and um that they couldn't get organized, as there was too much to organize in Christchurch to worry about taking kids on a ski trip. So, there was quite a significant impact you know about 1200 kids that week didn't arrive. And the next week it was about 4 or 5 hundred. So yeah. And general numbers dropped off too. General numbers of people cause they were all, you know, all had things to do (Ski Field Manager).

Additionally, the manager describes what they learned from the experience in terms of future preparation, response and recovery, based on having experienced an earthquake first-hand.

> Well it would certainly be a robust sort of checking system and then a communication plan especially for guests and staff to know what's actually be done to check to make sure everything is safe for people to come back in. That is one thing that I probably didn't realize. You know once I check it I felt safe. And I thought by opening and saying yes we are open, everyone would think we would be safe, but in actual fact people want more information, both staff and guests, about what had actually been done to check the place. So that's always um that was an interesting one. You know even when we tried to open. There was a comment about trying to find out the true road conditions was important. We were told that this bridge was closed and that bridge was closed and Christchurch was cut off from the south and in actual fact it wasn't. But they close it for a while and we were trying to find out if it re-opened or anything like that. It was just very difficult.
>
> We'd probably communicate earlier about the things that we've done and um possibly you know have more regular checks afterwards just in case anything moved. Yeah maybe it didn't move in the big quake but it might have moved in some of the little shuffles for some reason.
>
> I think the effect on the after, you know I probably had no idea there could be so many aftershocks. And also understanding how much it impact that can have on people has been quite interesting really. And how much you know that impacts us, by having that impact on people's lives you know. That's been a big learning experience. So information back um I mean, information as well about how the earthquake effects maybe in the hills compared to the flats. You know so if an

> earthquake happens somewhere in the Southern Alps, near us, would it be different? Or would there be as many aftershocks. I've never heard of so many aftershocks, but apparently it's just normal practice for a lot of major earthquakes…. But it really has an effect on people.

5.1.3 Understanding Natural Hazards/Disasters

The results from this research indicate that there is growth in the understanding of the occurrence of natural disasters as a part of a system in mountain communities. Still, few consider one of the key mechanisms that create the environment, namely plate tectonics. This might be because of the time scales, and low frequency as compared to more immediate and common hazards of severe weather and avalanches.

Humans' ability to understand our world has advanced significantly since the industrial revolution. Advances in technology have enabled better understanding of weather systems, mass movements, and geological cycles. The advancement of weather forecasting has enabled warnings to be issued in a timely manner, which saves lives and reduces damage to infrastructure. Weather forecasting also plays a key role in predicting mass movements, especially avalanches. Seismology has also made huge strides, yet the goal of predicting with accuracy when, where, and at what magnitude an earthquake occurs still eludes. What seismology and the general study of earthquakes do show, is that major earthquakes will continue to happen; therefore we must be aware so we can cope with their consequences.

The coping mechanism for managing the consequences of natural hazards has taught humans to try and engineer hazards out of our lives. It is only in recent history that this paradigm has begun to change. It is still important to design infrastructure that is resistant. We have learned that sometimes resistance can make the consequences of hazards worse. Instead of trying to dominate nature in order to reduce or eliminate hazards, we are seeing success in attempts to adapt our behaviours, infrastructure, and understanding of how we experience hazards. The goal is to design a more resilient co-existence with natural systems through more sustainable development, and a longer-term view of the role we have as stewards of the systems that we depend on for survival.

This new 'paradigm', known as sustainable hazard mitigation, is viewed as more effective when public participation is included in disaster management and community planning. Yet the plethora of multi-stakeholder processes has been criticized as being too costly and too slow, as well as overemphasizing public interests, while usurping the role of elected officials. Moreover, consensus-based approaches may be desirable, but they can also heighten expectations of empowerment for actual decisions, when the actual role of stakeholders is advisory. Whatever the role stakeholders play, participation needs to be underpinned by a philosophy that emphasizes empowerment, equity, trust and learning. Similarly, cultural theory argued for high responsiveness and high accessibility to achieve a high deliberative quality. Though I don't believe I achieved the high deliberative quality, I stress that, where relevant, participation should be considered as early as possible and throughout the process of policy development. This can avoid the pitfalls of a closed hegemony where one voice drowns out all others. I am certain that I have avoided the closed hegemony, but thus far it is an extractive participatory approach.

5.1.4 Participation and Next Steps

The logical next step in the process for managing earthquakes, in particular, is to continue to engage stakeholders of ski areas to begin discussions regarding the development of their own policies and practices for managing this hazard. Many theoretical approaches have been developed that attempt to optimize stakeholder involvement in order to improve policy development, such as participatory disaster risk assessments (PDRA), the risk management approach, the resilience approach and the empowerment approach. PDRA, which attempts to engage stakeholders in the assessment of hazards, vulnerability, coping capacity and risk, appears to happen informally in the club ski areas because club members work in concert with ski patrol to develop, implement, and refine the emergency management plans that help them manage hazards. The commercial ski areas appear to favour a more traditional risk management approach, where the engagement of clientele does not also extend to considering earthquake hazards, rather only common hazards.

A significant part of the study was in integrating, adapting, and learning how to apply the methods in the context. In this sense, the study became more about developing and refining tools for future research than participation. Still, the toolset was able to capture the notion that the concepts of resilience and adaptive capacity are present in the communities of practice of both types of ski areas (club and commercial) in terms of how they adapt to severe weather. When it comes to avalanches, a command and control mentality is present. The club fields have many people who also use transceivers as an adaptive mechanism, yet in the commercial fields, this is not common among clientele, though it is mandatory for ski patrol. The commercial fields also cater to higher numbers of patrons who have lower experience, putting the managers and staff in a position of responsibility which might reinforce the command and control mentality, and push patrons to the margins of organization. Based on the finding above, it is possible to make some recommendations for engaging in policy discussions.

5.1.5 My “elegant” recommendations for policy discussions

The need for developing, practising and refining a communication plan that functions without critical lifelines is perhaps the most important finding of my study. Evaluating current communication plans is an action ski areas can do to improve their ability to cope with major earthquakes or other lifeline damaging natural hazards. Back-up communication technology such as EPIRBs, mountain radios, and satellite phones can help to coordinate response efforts. Other simple powerless technology could also be in place, such as signal flares, mirrors, smoke, whistles or other noise-making devices (Strickert, 2007).

Temporary shelter is a consideration for post-earthquake recovery, due to the risk for infrastructural damage from primary, secondary, and tertiary effects of an earthquake. The assessment discovered that many of the ski field’s primary infrastructural bases are located in outflow paths. With that in mind, the availability of temporary structures should be considered. The harshness of alpine weather and remoteness of the ski field locales dictate that temporary shelter must be able to withstand high winds, precipitation, cold temperatures, and aftershocks. Though tents are viable solutions, they might have to accommodate tens to thousands of people for weeks. Military style canvas tents might be the most logical solution for offering mass shelter for the clientele. These must be stored in a safe zone away from hazards. Temporary shelter provides the ability to cope in extreme environments. Moreover, they afford the time to wait until aftershocks reduce in intensity and frequency, to treat the wounded and care for clients, and to prepare for an evacuation.

Toilet facilities will also be needed, and, in the worst-case scenario without running water (if perhaps, the water line is damaged by the effects of the earthquake), alternatives such as composting toilets and portable ‘dunnies’ are valuable tools (Chapman, in Riser, 2005). Water for sanitation is also essential to maintain basic health. Clean water may also be needed for medical treatment of minor and major injuries, which can easily become infected. Thus, water supply stability and back-up might be a further consideration enlightened by the geomorphic assessments.

The survey also uncovered that the most viable evacuation strategy is either by foot, or by helicopter if aerial assets are available. Critical to an evacuation by foot for individuals are sturdy footwear, food/water provisions (which could be emphasized in campaigns for individual responsibility), first aid kits, shelter and communication means (which could be implemented as a site-specific policy for ski fields). Evacuating to a safer location may take an indeterminable amount of time, depending on location of the field, fitness level of the patrons, and the number of injured. The club fields would likely be able to evacuate by foot given their low numbers and high level of experience among club-members who could support the evacuation, whereas the commercial fields with thousands of patrons may be better to wait until help (such as military-based evacuation) arrives.

The logistics of an evacuation of up to several thousand people from an alpine environment after a major earthquake might be beyond the capabilities of even the most professional of agencies. This is not a criticism but rather a challenge; that is, for alpine ski areas to test their evacuation plan with their patrons at full capacity. Yearly trials such as this would raise awareness about the hazards. Furthermore, mock evacuations can facilitate improvements to communities of practice to shift ski areas from a vulnerable culture to a more resilient culture that can cope with low probability high consequence natural hazards. The likelihood that an earthquake will affect one or more New Zealand ski areas in the next fifty years is high[36]. It is not if, but when. Unfortunately, at the present time we do not know when, where and how big the next one will be.

Based on the interviews and the fuzzy cognitive maps, the managers as a collective social group perceive some degree of control over the ski area, and a belief that they will be able to respond to and manage the consequences of an earthquake, despite earthquakes not being a significant part of their horizon. The workers perceptions were similar to the managers, but also indicative of major challenges to their response capabilities in the face of an earthquake. The riders perceive themselves as affected by their environment, instead of in control of the environment, and held that preparations both personal as well as collective survival considerations are a critical component of responding to an earthquake. Thus, as an initial step toward high deliberative quality for the development of future strategies for managing earthquakes, it is up to the stakeholders to explicitly engage all three of the active solidarities, and perhaps the fatalist and the hermit as well. Although the latter two represent a challenge, doing so can be a significant step forward. Serious discussions with stakeholders

[36] This was written prior to the Canterbury Earthquake on September 4th, 2010 that was a magnitude 7.1

about how to manage an earthquake in alpine ski areas are needed to move beyond the "elegance" inherent in my personal recommendations (garnered from the methods expressed herein, as well as significant amount of participant observation) toward "clumsiness" where groups of stakeholders make their recommendations and respond to those of others. This is reflected at a more global level in how we have come to understand natural hazards. What were once unknown unknowns are beginning to be understood.

5.2 Understanding Hazards and Sociocultural Viability

The evolution of approaches to manage natural hazard risks has moved through macro-level changes in terms of viable ways of life. The following section gives an example of a possible transition through the five viable ways of life linked to understanding natural hazards. Early approaches of superstitions, taboos, and oral traditions had most people viewing natural hazards from fatalist positions (alternatively, from an external locus of control). The allocations of sufficient resources to meet basic needs were seen as gifts from deities delighted by the reverence of pious followers. It has been suggested that as humans began to recognize patterns in nature and unlock many of her secrets, the myth of *nature capricious* changed toward the myth of *nature as perverse and tolerant*. The enlightened hierarchist could then prey on the existing fatalism to control the populace through religious doctrine, colonial expansion, etc., all of which command resources and needs with functional prescriptions. Those who wished for less domination gave rise to individualist ways of life. The individualist wanted to harness nature for their own exploitation (nature is robust and abundant), leading to significant advances in technology (i.e., the behaviourist paradigm) engineering the hazards out of the path of human progress. Some of these technologies may have enhanced people's ability to reduce risks of hazards (e.g., improve construction practices to provide more solid shelters), whereas other innovations enabled command and control, which offered incredible benefits while increasing risks to natural hazards unknowingly (e.g. hydro-electricity and irrigation, the burning of fossil fuels, and cloud seeding). The exacerbation of risks through cavalier meddling with Mother Nature solidified the position of the growing egalitarian movement (i.e., the structuralist paradigm).

Similarly, humans' understanding of terminology follows comparable trajectories to our understanding of natural hazards. All of the participatory approaches, paradigms, and theories outlined above embody different perspectives, or "lenses" that can be represented by plural rationalities, certainties and the solidarities of cultural theory, or, as I prefer to call them, the five socio-cultural viabilities. For without the requisite variety, our ability to understand uses behind different approaches is limited to elegance.

Historically, the dominant premise for managing hazards appears to be that of the hierarchist, managing risks, hazards, and disasters from highly centralized bureaucracies, such as (in New Zealand): Civil Defence and Emergency Management, the Earthquake Commission, and many research institutes and universities, each contributing 'elegant' solutions pitted against the chaos of nature's occasional surprise. However, a current look at the modern risk/hazard-scapes confirms that more of the viable ways of life are in place. As humans organize and disorganize with the goal of developing policies that enable ways of life that are viable in the face of natural hazards, we must reconcile the views of risks. The current approaches recycle values, beliefs, heuristics and biases, but are locked in a dynamic 'hyper-cycle', which has thus far, for most of us, proved somewhat resilient. What is needed for managing natural hazards is *to harnesses the collective wisdom of the five viable ways of life*, competing, cooperating, and subverting each other; trying to make transactional sense of where we happen to find ourselves within nature's sequences.

If we want to play in the mountains, we have to be prepared to respond and recover from all of the cycles the mountains can deliver. Complex and dynamic processes form mountains. Their metaphorical quest to create a boundary condition with the sky is 'virtually' balanced by their expedition back to the sea. The thunderous collision of two continents, perceived as one surging to the heavens and the other banished to the depths is manifest through landscape transforming events. The winners' resistance is rewarded with a short visit to the podium, only to be beaten down again. The weather cycles wear the mountains away from giant monoliths to dust. Eventually, they journey back to the sea, resettling into the earth and ultimately released again, proving their resilience.

Human' encroachments alter the mountains on their perpetual journey. Brief interactions shape, mould, and refine the mountains for our needs. Our overt influences transform some mountains into playgrounds ripe for catastrophe through forgetfulness of where the mountains came from and where they are going. We are vulnerable witnesses of the fantastic cycle in motion, informing legends with dreadful consequences. Those who wish to risk the mountains' experience are forced to adapt; making adjustments to the constant changes of physical events, experiences and perceptions, the things that attract us to mountains. Our interaction with and influence over one mountain is small, while collectively the human weight is massive, forcing even mountains to sink beyond our horizon.

5.3 Summary:

The approach taken in this case study was an extractive participatory approach. It tried to achieve two difficult and perhaps mutually exclusive goals: first, to identify the risks and hazards associated with earthquakes in ski areas, and second, to apply an integrated framework, including an adapted and novel use of FCM. The approach is not intended to be a haphazard replacement of the risk management approach, the empowerment approach, or the resilience approach; rather, to complement them by engaging stakeholders, using FCM as a precursor to more emancipatory, conscientious, and longitudinal approaches. Weakness of other approaches could be overcome by using the FCM tool presented in this framework or improvements thereof.

The strength of the approach is that it provides a rigorous conceptual framework, augmented with computational algorithms and powerful methodologies. The latter extends the adaptive management/resilience paradigm by identifying policy opportunities where trial and error can occur in simulation instead of in the real world, where adverse consequences of policies can be severe. The challenge in the case of earthquakes and ski fields is that the managers, the workers, and the users are not overtly aware of the earthquake hazards. Hence, the mixed method proposed herein is not intended to replace other forms of engagement, but rather it is an initial form of consultation/communication that can enhance and accelerate the social learning required for later participatory policy development.

With respect to the policies mentioned above, I believe that the framework presented can enhance the policy-making process. Fundamental to advancing this end, the process of gathering, analysing and interpreting FCM needs to be standardized and made even more transparent. This can be achieved through prolonged engagement with participants while undertaking several iterations of the mapping process within existing conceptual frameworks. Simulations can be run with wide varieties of participant groups beyond the three that were targeted in this study. For example, social groups can be created from demographics, expert and lay-expert groups, or creating SGFCM from people with similar responses to qualitative questions.

5.4 Conclusion

The framework presented in this thesis provides several contributions to knowledge. The contributions can be broken down into methodological, contextual, and theoretical pursuits, as well as opportunities for improving future research. A transdisciplinary conceptual framework was developed in an attempt to support an approach whose application can be transferred to many other areas of research where integration is desirable. The triangulated mixed methodology was advantageous because the research problem of earthquakes and ski areas has had little consideration. Thus, the context provided an opportunity to test methods, and their integration, as a means to deal with the challenges of researching in a novel context and to select methods which achieved two key purposes: First, to triangulate methods using the development mixed method approach; and second, to build an approach that suited the problem. The framework applied in the case study required advances to methods, synthesis of current approaches, and a functional use of cultural theory. Cultural theory was selected as a foundation for the thesis because of its preferences for plural rationalities from the five fundamental arrangements that underlie cultural theory. This is a shift away from dualisms of "methodological individualism" and "methodological collectivism" by stressing the dividual as the unit of analysis. Moreover, instead of anchoring on dominant dualistic "elegant solutions" such as individualized preparation and hierarchical procedures as key strategies for coping with hazards, I sought a philosophical framework that sustains *requisite variety* by teasing out the other solidarities such as: community-based egalitarian manners of organizing, and how fatalism may be present as both a healthy view of catastrophic hazards and a first impulse for the rare natural hazards that exist beyond our horizons. The approach suited the challenges of studying low probability, high consequence natural hazards (i.e., cases of high complexity and high uncertainty). Essentially, the methods selected to approach the research problem stabilized in a 'desirable configuration' (i.e., a transdisciplinary meta-methodology) that sought to reflect the structure of the problem; the solution being requisite clumsiness.

This requires that policies for mitigation (more appropriately, resilience) need to achieve the *requisite variety condition* as laid out by cultural theory. The requisite variety condition is achieved by including insights from all five of the viable ways of life advocated by cultural theory: the individualist, the hierarchist, the egalitarian, the fatalists and the hermit ways of life. A departure from what cultural theorists call 'elegant solutions' from one viability (i.e. characterised by 'closed hegemony'), the transdisciplinary methods and theoretical framework can enable balanced participation from experts (e.g. scientists, managers, and emergency responders) and lay-experts (ski patrollers, ski areas service workers, and skiers and snowboarders) from different viabilities. The result are 'clumsy solutions' (Verweij and Thompson, 2006; Thompson, 2008) whose pinnacle is high deliberative quality where each solidarity is heard and responded to by the others by integrating high responsiveness and high accessibility.

I presented a conceptual framework and methodology for policy development research in complex, uncertain, and data poor environments, with the emphasis on sustainable hazard mitigation. A mixed-methodology was applied for identifying gaps in hazard perception and awareness and developing policies to manage earthquakes in mountain landscapes. Ski areas provided context and communities of practices for applying a triangulated mixed-methodology. Expert and lay-expert participants provided rich data about the experiences and perceptions of hazards in mountainous environments. All three groups perceived that developing strategies in preparation for, response to and recovery from earthquakes could reduce their adverse consequences. Furthermore, participants indicated that experiencing an earthquake would lead to greater resilience in the future. The results indicate that the gap hazard analysis (Strickert et. al., 2010), embedded within a policy framework for improving resilience to earthquakes in New Zealand ski areas, does work well to identify gaps in stakeholders' hazard perceptions and awareness. Furthermore, the framework is also a good starting point for identifying opportunities to improve policy for managing low probability high consequence natural hazards. Refining the mix of methods used in this case-study can advance sustainable hazard mitigation and aid participatory approaches in vital areas of research.

Moving from elegant solutions based on single solidarities or dualistic mixes of solidarities, we are trying moved towards *clumsy solutions* and thus avoid the "pits" of policy development (i.e., science for policy). The pits exist within a closed hegemony of *elegant solutions* based on one or two solidarities. *Clumsy solutions* involve moving up the hill toward a high deliberative quality by engaging diverse stakeholders to benefit from, at least three, but ideally all five of cultural theory's social solidarities. Cultural theory is a social and relational theory that shows us the selective attention, with the different arrangements of blind-spots being generated by social process; as a consequence, that is not of what is within each of us, but of the different ways in which we bind ourselves with others. Thus, policy development in the face of compounding natural hazards, although messy, contentious, and challenging is socially and culturally viable when integrated within a cultural theory framework.

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Appendix 1.A The four political cultures Adapted from Schwartz and Thompson (1990).

	Hierarchical	Egalitarian	Individualistic	Fatalistic
Preferred way of organising	Nested bounded group	Egalitarian bounded group	Ego-focused network	Margins of organized patterns
Certainty (Myth of Nature)	Nature perverse and tolerant	Nature ephemeral	Nature Benign	Nature Capricious
Rationality	Procedural	Critical	Substantive	Fatalistic
View of Resources	Scarce	Depleting	Abundant	Lottery
Scope of Knowledge	Almost complete and organized	Imperfect but holistic	Sufficient and Timely	Irrelevant
Learning Style	Anticipation	Trial without error	Trial and Error	Luck
Social Context	Positive group/positive grid	Positive group/ negative grid	Negative group / negative grid	Negative group / Positive grid
Desired system properties	Controllability (through inherent orderliness)	Sustainability (through inherent fragility)	Exploitability (through inherent fluidity)	Copability (through inherent chaos)
Ideal scale	Large	Small	Appropriate	---
Engineering aesthetic	High-tech virtuosity	Frugal and environmentally benign	Appropriate (as cheep and cheerful as possible	___
Cultural Bias	Ritualism and sacrifice	Fundamentalism / milleniariansim	Pragmatic materialism	Inconsistent eclecticism
Energy Future	Middle of the road (technical fix)	Low growth (radical change now)	Business as usual	What you don't know can't harm you
Perception of Time	Balanced distinction between short and long term	Long term dominates short term	Short term dominates long term	Involuntary myopia
Preferred form of governance	Leviathan	Jeffersonian	Laissez-faire	It doesn't matter who you vote for…
Salient Risks	Loss of control (i.e. of public trust)	Catastrophic irreversible and inequitable developments	Threats to the functioning of the market	_____
Model of consent	Hypothetical consent	Direct consent	Implicit consent	Non consent
Risk-handling	Rejection and	Rejection and	Acceptance and	Acceptance and

style	absorption	deflection	deflection	absorption
Latent strategy	Secure internal structure of authority	Survival of the collective	Preservation of the individual’s freedom to contract	Survival of the individual
Commitment to Institutions	Correct procedures and discriminated status are supported for own sake. Loyalty	Collective moral fervour and moral fervour and affirmation of shared opposition to outside world. Voice	Only if profitable to the individual. If not, then exit	___

Appendix 2.A Permission to access ski areas

Telephone Script

Graham Strickert
Environment, Society and Design Division
P O Box 84
Lincoln University, Lincoln 7647
Phone: 64 3 325 3820 or 64 3 325 2811
Facsimile: 64 3 325 3854 or 64 3 325 3857

The following script will be used to contact ski field managers and obtain their permission to conduct geomorphic assessments of alpine ski areas at various sites:

Researcher:
Hello. My name is Graham Strickert and I am a PhD student in the Natural Resources Engineering Group at Lincoln University. You are invited to participate in a project that aims to build resilience in the New Zealand Ski fields in the context of Catastrophic Natural Events. Your telephone number was selected from reference from (insert Contact list/Web Site).
Your participation in this research will involve allowing two researchers permission to access your site for one day on (instert date) to conduct geomorphic assessments of your facility. These assessments are superficial assessments to gauge the possible consequences of earthquakes for alpine ski areas.

Participation in the research is voluntary and you may decline permission or withdraw at any point without questioning. If you do withdraw at any stage, any information you have already provided will be destroyed.

All information will remain confidential to me as researcher and my supervisor(s). Your ski area will be assigned an area number so other researchers will not have access to your fields name upon publication of results.

The project has been reviewed and approved by the Lincoln University Human Ethics Committee. Are you prepared to participate in this research project?

Thank you for your time. I will follow this up by sending you a Research Information and Consent Form and setting up a time for a first meeting. If you have any further questions about this study please feel free to contact me or my main supervisor who can be contacted at:

Dr Keith Morrison
Environment, Society and Design Division
Lincoln University, Lincoln, Christchurch, New Zealand
Email: Morrison@lincoln.ac.nz
Tel: (03) 3252811, ext. 8716
Thank you.
Graham Strickert

Appendix 2.B Permission to interview managers, workers and riders

Telephone Script

Telephone Script
Graham Strickert
Environment, Society and Design Division
P O Box 84
Lincoln University, Lincoln 7647
Phone: 64 3 325 3820 or 64 3 325 2811
Facsimile: 64 3 325 3854 or 64 3 325 3857

The following script will be used to contact ski field managers and obtain their permission for further contact, in-depth interview, and to perform my study at their site:

Researcher:

Hello. My name is Graham Strickert and I am a PhD student in the Natural Resources Engineering Group at Lincoln University. You are invited to participate in a project that aims to build resilience in the New Zealand Ski fields in the context of Catastrophic Natural Events. Your telephone number was selected from reference from nzski.co.nz.
Your participation in this research will involve: One interview lasting approximately 45 to 60 minutes, plus additional time spent verifying the interview transcripts and drawing a cognitive map. Further interviewing may be required at a later point in the research. I am also asking permission to conduct research with patrons of your facility. This will involve short oral surveys that I will conduct on chair lift rides during the ski season. A final focus group meeting will be held a year from the completion of data collection for which you will be invited.

Participation in the research is voluntary and you may decline to answer questions or withdraw at any point without questioning. If you do withdraw at any stage, any information you have already provided will be destroyed.

All information will remain confidential to me as researcher and my supervisor(s). You will also be assigned a subject number so other researchers will not have access to your name upon publication of results.

The project has been reviewed and approved by the Lincoln University Human Ethics Committee. Are you prepared to participate in this research project?

Thank you for your time. I will follow this up by sending you a Research Information and Consent Form and setting up a time for a first meeting.

If you have any further questions about this study please feel free to contact me or my main supervisor who can be contacted at:

Dr Keith Morrison
Environment, Society and Design Division
Lincoln University, Lincoln, Christchurch, New Zealand
Email: Morrison@lincoln.ac.nz
Tel: (03) 3252811, ext. 8716
Thank you.

Graham Strickert

Appendix 2.C: Permission form and script for informed consent

Adaptive Risk Management of catastrophic Natural Events in New Zealand Ski Fields

I have read and understood the description of the above named project. On this basis, I agree to participate as a subject in the project, and I consent to the publication of the results of the project understanding that my anonymity will be preserved. I understand that I may at anytime withdraw from the project, including withdrawal of any information I have provided up until the time the results are analysed.

Name: ________________

Signed: _______________ Date: ___________________

Informed Consent Script

Graham Strickert
Environment, Society and Design Division
P O Box 84
Lincoln University, Lincoln 7647
Phone: 64 3 325 3820 or 64 3 325 2811
Facsimile: 64 3 325 3854 or 64 3 325 3857

The following script will be used and recorder on digital recorder to obtain informed consent for the Stage 3 Oral Surveys:

Researcher:

Hello, my name is Graham Strickert. I am a PhD student at Lincoln University doing research on catastrophic natural events at New Zealand and Canadian ski hills. Today I am collecting short oral surveys which will take approximately 10-15 minutes of your time. The project has been reviewed and approved by the Lincoln University Human Ethics Committee. Your participation is voluntary and your name will not be collected for this research. The survey will be recorded. Are you interested in participating?

Thank you. We will begin the survey right away.

Graham Strickert
PhD Candidate, Lincoln University

Appendix 2.D: Interview Guide for Full Interview

A) Demographic Questions
1) What is your age as a range?
2) What gender to you identify with?
3) What is your occupation?
4) What is your home community?
5) How far did you travel today and what was your means of transport?

B) Key Considerations for Preparation, Response, and Recovery to earthquakes:
1) What are the most important key considerations of preparation for an earthquake that has direct effects on the ski fields?
2) What are the most important key considerations of response for an earthquake that has direct effects on the ski fields?
3) What are the most important key considerations of recovery for an earthquake that has had a direct effect on the ski field?
Now I am going to ask you a series of questions regarding your level of preparation, response and recovery for catastrophic natural events that could occur during the ski fields. At any time if you wish to change or update your cognitive map I encourage you to do so.

C) General Questions
1) What can you tell me about natural disasters?
2) Has any of your life experience change your ideas (perceptions) about natural disasters?
3) Have you every experience any natural disasters, if so, what can you tell me about your experience?
4) Do you have any preparations in place for dealing with the following hazards: severe weather, slope related hazards (avalanche, rock fall, landslide, debris flow)?
5) Do you feel you are educated to prepare for, respond to, and recover from natural disasters when it occurs?

D) Severe Weather
1) Have you ever been affected by severe weather while on the ski field? If so, what can you tell me about the experience?
a. What preparations did you have in place to deal with severe weather?
b. Were you able to respond to severe weather in a manner that kept you and your clientele safe?
c. After the weather had cleared, how did you recover back to normal operating conditions?
d. When you face severe weather in the future, would you approach the situation any differently?

E) Slope Hazards
2) Have you ever witnessed and avalanche or other slope related hazards such as: rock fall, land slide, or debris flow? If so what can you tell me about the experience?
a. What preparations did you have in place to deal with the slope related hazard?
b. Were you able to respond to slope hazards in a manner that kept you and your clientele safe?
c. After the slope hazard occurred, how did you recover back to normal operating conditions?
d. When you face a slope hazard in the future, would you approach the situation any differently?

F) Earthquakes
3) Have you ever thought about how an earthquake would affect you while on the ski field?
a. What preparations do you have in place to deal with an earthquake?
b. Are you able to respond to an earthquake in a manner that will keep you and your clientele safe?
c. After an earthquake, how will you recover back to normal operating conditions?
d. When you face an earthquake in the future, how will you approach the situation?

C) General Questions Revisited
4) Do you feel you have been educated to prepare, respond, and recover from natural disasters that might occur on the ski fields?

G) SHM Questions:
a. Is the ski industry sustainable environmentally and economically?
b. What changes could been made at your preferred ski field to improve sustainability?
c. What changes have been at your preferred ski field to improve sustainability?
d. Can you think of any management strategies that would both improve sustainability and resilience to catastrophic natural events?

B) Completing Connections in the Fuzzy Cognitive Map
4) Now that you have identified these variables, will draw connections between the concepts to outline the interconnections between variables. There are two approaches we can take.
a. You can simply look at the concepts and try to identify which variables are connected. This is time efficient, but does not gather as much detail on the connections in your map, or;
b. We take a matrix focused approach, looking variable by variable to identify all of the possible connections between the maps. This takes considerably more time, but capture a great amount of detail regarding the connections between the concepts in your map.
How would you like to proceed?
When you draw connections you can use a red marker if you believe the connection has a positive influence or a blue marker if you believe that the variable has a negative influence. Then add a number between 1 and 10 indicating the strength of the connection. Alternatively you can use linguistic variable to indicate the connection, for example weak, moderate, strong, very strong, or other descriptive terms you would like to use.

Appendix 2.F: Condensed Interview

A) Demographic Questions
1) What is your age as a range?
2) What gender to you identify with?
3) What is your occupation?
4) What is your home community?
5) How far did you travel today and what was your means of transport?

B) Key Considerations for Preparation, Response, and Recovery to earthquakes:
1) What are the most important key considerations of preparation for an earthquake that has direct effects on the ski fields?
2) What are the most important key considerations of response for an earthquake that has direct effects on the ski fields?
3) What are the most important key considerations of recovery for an earthquake that has had a direct effect on the ski field?
C) General Questions
1) What can you tell me about natural disasters?
2) Has any of your life experience change your ideas (perceptions) about natural disasters?
3) Have you every experience any natural disasters, if so, what can you tell me about your experience?
4) Do you have any preparations in place for dealing with the following hazards: severe weather, slope related hazards (avalanche, rock fall, landslide, debris flow)?
5) Do you feel you are educated to prepare for, respond to, and recover from natural disasters when it occurs?

C) General Questions Revisited
4) Do you feel you have been educated to prepare, respond, and recover from natural disasters that might occur on the ski fields?

G) SHM Questions:
1) Is the ski industry sustainable environmentally and economically?
2) What changes could been made at your preferred ski field to improve sustainability?
3) What changes have been at your preferred ski field to improve sustainability?
4) Can you think of any management strategies that would both improve sustainability and resilience to catastrophic natural events?

Appendix 2.G: Matlab script for Graph Theory Indices

```
%Graph Theoretical Indicies for Fuzzy Cognitive Maps


% sets an FCM to absolute values and x
x = abs (SIW_14_FCM)




% OUTDERGEE, INDEGREE, CENTRALITY
% Calculates Outdegree Od(vi) the row sum of absolute values of a variable
% in the adjacency matrix and shows the cumulative strengths of connections
% exiting the variable
Od = sum(x')

% Calculates Indegree Id(vi)the column sum of absolute values of a variable
% in the adjacency matrix and shows the cumulative strengths of connections
% entering the variable
Id = sum(x);

% Calculates Centrality (c) the summation of indegree and outdegree which
% is the contribution of a vairable "importance" in a cognitive map.
c = Id+Od;

% Provides the number of variables
N = numel(c);


cn = (x~=0)
% adds the number of connections together by column
cnId = sum (cn)
% add the
Cns = sum (cnId)


 % Claculates the Density of the maps
D = Cns/N^2


% RECEIVER, TRANSMITTER, OR ORDINARY VARIABLES
% Divides the arrays of Indegree by Outdegree to decide if a variable is

RTO = Id./Od

% The ratio of indegree and outdegree delimits if a variable is a
% receiver or transmitter variable

% The treshold for receiver variables is more than 1.15
r = RTO >= 1.15
rn = sum(rn)
R = sum(r)

% The threshold for transmitters is less than 0.85
t = RTO <= 0.85
tn = sum(tn)
T = sum (t)

O = N - (T+R)

% Ordinary variables are those left over from Receivers and Transmitters;
% their treshold is set between 0.85 and 1.15
O = N - (T+R)

% this doesnt work because of inf...

% TURE COMPLEXITY
C = R/T

%GENERAL COMPLEXITY
% Calculates Complexity ratio between sum of indegree and the sum of
% outdegree
%
Cmp = Id/Od;

% HIERARCHY INDEX
% Calculates the hierarchy index
%....left side of the hierarchy index

%...
ns = (N-1)*N*(N+1);
%...
i= (12/ns)
```

```
%...right side of the hierarchy index

% Calculates the sum of the Outdegree
s = sum(Od)

% Calculates the average of the Outdegree
m = s/N

% Calculates an array (q) of each variables Outdegree minus the average
% outdegree
q = (Od - (m))

% Calculates an array of the of each (q) ^ squared
f = q.^2

% Calculates the sum of array (f)
e = sum(f)

% Calculates the final hierarchy index
h = i*e


SIW14 = struct('NumVars', N,'Connections', Cns,'Density', D,...
    'Indegree', Id, 'Outdegree', Od, 'Centrality', c, 'Receiver', R,...
    'Transmitter', T, 'Neutral', N, 'Complexity', C, 'Hierarchy', h )
```

Appendix 2.H: Matlab script for extracting Graph Theory Indices

```
% m-file to extract paricular indice from individual FCM that are sub-substructures for
SGFCM super-structures. In this case density is being extracted for each participant in
order. This enables easy comparison and calucation of averages using the output.

alldensity = [
    ALL(:).ASR1.Density;
    ALL(:).ASR2.Density;
    ALL(:).ASR3.Density;
    ALL(:).ASR4.Density;
    ALL(:).ASR5.Density;
    ALL(:).ASR6.Density;
    ALL(:).ASR7.Density;
    ALL(:).ASR8.Density;
    ALL(:).ASR9.Density;
    ALL(:).ASR10.Density;
    ALL(:).ASR11.Density;
    ALL(:).SAM1.Density;
    ALL(:).SAM2.Density;
    ALL(:).SAM3.Density;
    ALL(:).SAM4.Density;
    ALL(:).SAM5.Density;
    ALL(:).SAM6.Density;
    ALL(:).SAM7.Density;
    ALL(:).SAM8.Density;
    ALL(:).SAM9.Density;
    ALL(:).SAM10.Density;
    ALL(:).SIW1.Density;
    ALL(:).SIW2.Density;
    ALL(:).SIW3.Density;
    ALL(:).SIW4.Density;
    ALL(:).SIW5.Density;
    ALL(:).SIW6.Density;
    ALL(:).SIW7.Density;
    ALL(:).SIW8.Density;
    ALL(:).SIW9.Density;
    ALL(:).SIW10.Density;
    ALL(:).SIW11.Density;
    ALL(:).SIW12.Density;
    ALL(:).SIW13.Density;
    ALL(:).SIW14.Density]

asrdensity = [
    ALL(:).ASR1.Density;
    ALL(:).ASR2.Density;
    ALL(:).ASR3.Density;
    ALL(:).ASR4.Density;
    ALL(:).ASR5.Density;
    ALL(:).ASR6.Density;
    ALL(:).ASR7.Density;
    ALL(:).ASR8.Density;
    ALL(:).ASR9.Density;
    ALL(:).ASR10.Density;
    ALL(:).ASR11.Density;
    ]


samdensity = [
    ALL(:).SAM1.Density;
    ALL(:).SAM2.Density;
    ALL(:).SAM3.Density;
    ALL(:).SAM4.Density;
    ALL(:).SAM5.Density;
    ALL(:).SAM6.Density;
    ALL(:).SAM7.Density;
    ALL(:).SAM8.Density;
    ALL(:).SAM9.Density;
    ALL(:).SAM10.Density
    ]

siwdensity = [
    ALL(:).SIW1.Density;
    ALL(:).SIW2.Density;
    ALL(:).SIW3.Density;
    ALL(:).SIW4.Density;
    ALL(:).SIW5.Density;
    ALL(:).SIW6.Density;
    ALL(:).SIW7.Density;
    ALL(:).SIW8.Density;
    ALL(:).SIW9.Density;
    ALL(:).SIW10.Density;
    ALL(:).SIW11.Density;
    ALL(:).SIW12.Density;
```

```
ALL(:).SIW13.Density;
ALL(:).SIW14.Density
]
```

Appendix 2-G: Location of Geomorphic Assessments.

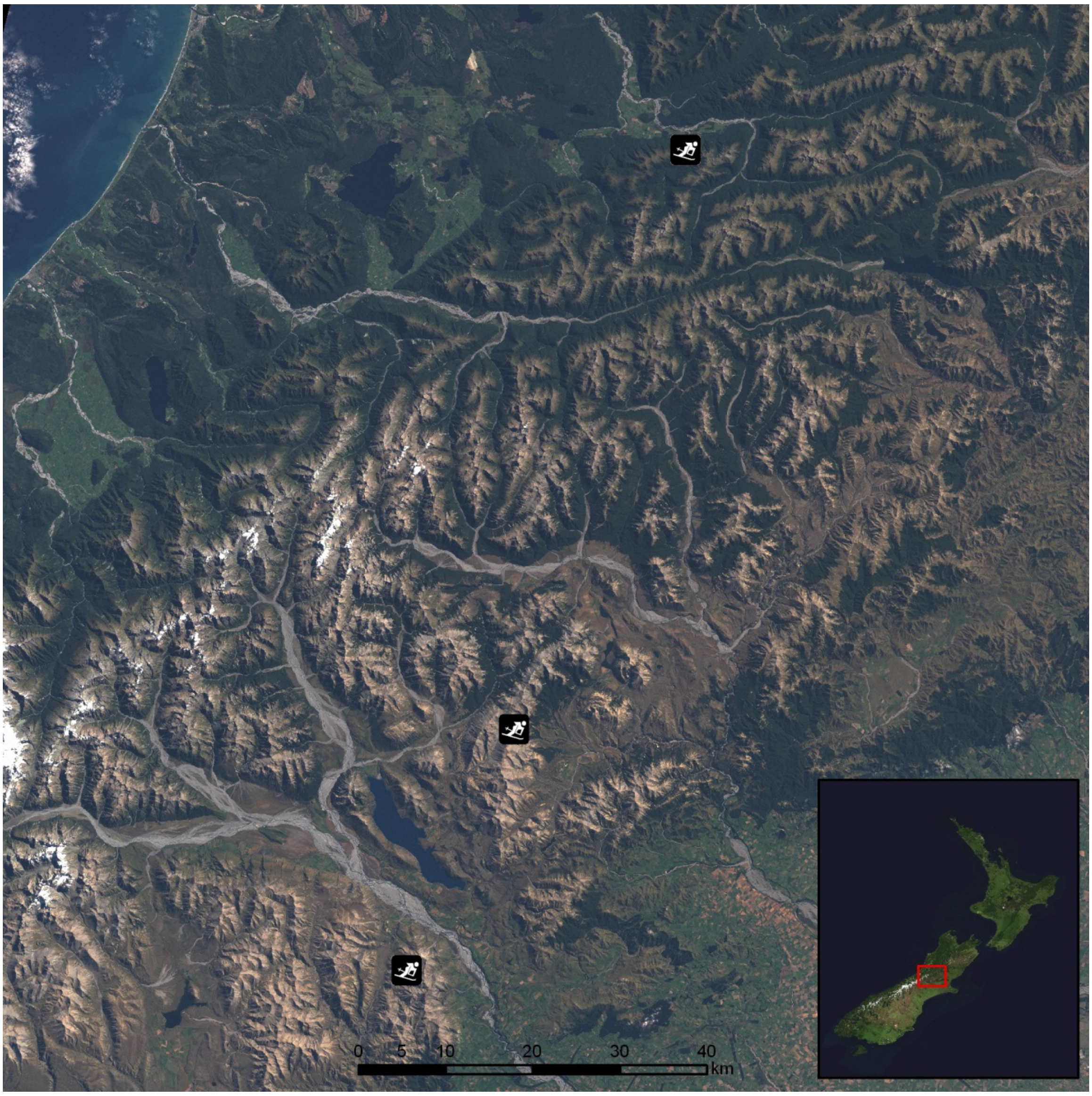


Photo: Figure created by Ryan Garnett.

Appendix 3.A: Photos of Different Types of Lifts

Lift unit station at commercial ski area.

Appendix 3.B: Photos of Roads to Ski Areas

Mt Cheesman Access Road. September 23, 2008.

Appendix 3.C: Avalanche and Rock Fall over roads

Mt Cheesman Access Road – September 2008
Warning Sign: No Stopping Avalanche Danger Next 1.2KM.

Appendix 3.D: Table of Key Considerations

Condensation CDL3	Participant	Reported Variables	C-Scaled	V-Type
Access Considerations	SIW 8	Access road	1.00	T
	SIW 10	Access road	1.00	T
	SAM 2	Access	1.00	R
	ASR 10	Road safe	0.86	N
	ASR 6	Access to EMS	0.77	R
	SAM 6	Road equip	0.63	T
	SAM 9	No access road	0.63	T
	ASR 8	Road	0.62	T
	SIW 7	Road access	0.61	R
	SAM 8	Location	0.26	R
Adverse Secondary Effects (Landscape)	ASR 6	Land changes	1.00	T
	SIW 13	Wild Environment	0.95	T
	ASR 10	Rock fall	0.86	T
	SIW 2	Earthquakes' effect land	0.80	T
	ASR 7	Stable landscape	0.78	T
	SIW 5	Physical effects	0.75	R
	SAM 5	Lack of land stability	0.71	T
	SAM 9	Isolation	0.54	T
	ASR 9	Avalanche zones	0.44	T
	SAM 3	Geography of area	0.36	T
	ASR 10	Trees	0.33	T
	ASR 2	Locate of ski	0.33	R
	ASR 8	Location	0.30	R
	SAM 3	Change in skiing terrain	0.27	T
Analysis and Reports	SIW 2	Cautionary measures	0.98	T
	SIW 5	Identify high risk areas	0.50	R
	SIW 11	Analysis & reports	0.46	N
	SIW 11	Event reports	0.46	T
	SIW 14	Hazard registry	0.29	N
Avalanche Considerations	ASR 8	Avalanche control	1.00	R
	ASR 9	Avalanche education	0.88	T
	SIW 7	Avalanche Awareness courses	0.65	T
	SIW 2	Snow avalanche hazard	0.58	R
	ASR 6	Avalanche aware	0.40	R
	ASR 11	Snowpack stability	0.10	N
	SAM 3	Avalanche paths	0.07	T
Bad Timing	SAM 5	Time frames	0.99	R
	SAM 9	Time (recovery)	0.59	R
	SIW 4	Winter	0.35	R

	SAM 4	Early season	0.21	T
	SAM 9	Seasonal (Winter)	0.19	T
	ASR 11	Bad time of day	0.10	T
	ASR 11	Time (Duration)	0.10	T
Building Considerations	SAM 7	Facilities and buildings adhere to building code	1.00	N
	SAM 5	Structural Integrity	1.00	T
	SAM 6	Stability	0.84	T
	ASR 10	Good buildings	0.68	R
	SIW 1	Strength of buildings	0.66	T
	SIW 13	Building standards	0.65	R
	SIW 7	Infrastructure Stability	0.64	T
	ASR 2	Better buildings	0.50	R
	SIW 2	Number of buildings	0.43	R
	ASR 8	Buildings	0.39	R
	ASR 11	Location of buildings	0.19	R
Communication Considerations	SIW 5	Communication	1.00	R
	SAM 1	Emergency Communication	1.00	T
	ASR 9	Communication	1.00	T
	SIW 1	Chain of command	0.84	T
	SIW 9	Communication	0.83	N
	SIW 9	Information to clients	0.79	R
	SIW 7	Well informed clientele	0.76	T
	SIW 12	Communication alternative (in & out)	0.76	R
	ASR 2	Communication	0.71	T
	SAM 6	Communication	0.67	T
	SAM 7	Informed communication effective	0.67	T
	SAM 2	Communication	0.59	T
	ASR 3	Guest Briefing	0.57	T
	SAM 9	Communication	0.56	T
	ASR 8	Contact	0.55	R
	SIW 6	Communication	0.48	N
	ASR 7	Communication	0.47	R
	SIW 8	Communications & power	0.45	R
	ASR 8	SOS	0.40	R
	ASR 5	Cell/Radio	0.29	R
	SIW 4	Emergency contacts	0.27	T
	ASR 3	Radio Communication	0.24	R
	SAM 3	Contact emergency help	0.23	T
Community Assistance	SIW 13	Customer involvement	0.79	T
	SAM 4	Community assistance	0.71	T
	SIW 2	Community support	0.56	R

	ASR 2	Com support	0.48	R
	SIW 1	Volunteers in response and rebuilding	0.43	N
Damage to Infrastructure	SAM 4	Damaged Infrastructure	1.00	T
	SAM 10	Damage from Earthquake	1.00	T
	ASR 11	Disruption of power, water, and communications	1.00	R
	SIW 2	Earthquake effect infrastructure	1.00	T
	SIW 13	Fire risk	0.87	T
	SIW 14	Infrastructure disruption	0.85	T
	SIW 2	Re-building infrastructure	0.81	N
	ASR 10	Infrastructure	0.73	T
	SIW 3	Check systems	0.70	N
	SIW 3	Power	0.70	R
	SIW 12	System management (Water, Sewage, Food, Infrastructure)	0.70	T
	SAM 3	Infrastructure	0.68	R
	SAM 9	Power (Loss)	0.58	T
	SAM 1	Chair Derailment	0.57	T
	SIW 5	Analyze danger and damage	0.54	R
	SIW 2	Number of lifts	0.42	R
	SAM 1	Recertify Infrastructure	0.38	R
	SAM 4	Physical Facilities	0.36	R
	SIW 13	Assessing buildings	0.34	R
	SIW 10	Infrastructure to aid response	0.31	T
	SIW 4	Severely damaged buildings	0.28	T
	SAM 3	Assess Damage	0.27	T
	SIW 4	Lifts	0.27	T
	ASR 11	Lifts (Location)	0.10	T
Emergency Personnel	SIW 2	Trained and skilled people	0.92	R
	SIW 8	Trained medical officer	0.91	R
	ASR 6	Ski patrol	0.89	R
	SIW 2	Emergency medical support	0.70	R
	SAM 6	Medical staff	0.53	R
	SIW 4	Key people to respond	0.47	R
	ASR 4	Emergency personnel	0.46	T
Emergency Plan and Procedures	SIW 14	Pre plan	1.00	N
	SIW 11	Emergency procedures	1.00	R
	ASR 2	Plan & Prep	1.00	R

	ASR 10	Emergency procedures	1.00	R
	ASR 4	Emergency procedures	1.00	T
	SAM 10	Immediate (Public Safety, Communication, Infrastructure)	0.95	R
	ASR 8	Government	0.95	T
	SAM 10	Secondary	0.80	R
	ASR 8	International	0.73	R
	ASR 9	Warning system	0.71	T
	ASR 3	Emergency procedures	0.66	T
	SIW 2	Emergency plan	0.65	R
	SIW 5	Emergency planning	0.59	R
	SIW 10	Emergency response plan	0.52	R
	SIW 4	Emergency plan	0.40	R
	ASR 6	Emergency plan	0.35	T
	SAM 7	Monitoring and warning	0.33	R
	SIW 10	Contingency plan	0.32	R
	SAM 3	Risk management plan	0.27	N
	ASR 2	Difficulty of Prediction	0.15	T
Equipment Considerations	ASR 5	Wind bag	0.79	T
	ASR 1	Shovel	0.78	T
	ASR 1	Probe	0.75	T
	ASR 1	Transceiver	0.71	N
	ASR 7	Safety equipment	0.49	N
	ASR 1	Snowboard	0.48	R
	ASR 5	Pack, peeps, probe, shovel	0.46	T
	ASR 9	Rescue equip	0.42	R
	ASR 5	Warm clothing	0.39	R
	ASR 5	Tool & gaffa tape	0.36	R
	ASR 8	Ski equipment	0.33	R
	SIW 11	Equipment checklist	0.11	T
	ASR 9	Snow equip (Snowmobile)	0.11	R
	SIW 11	Equipment	0.08	T
Evacuation	SAM 6	Evac Plan	1.00	R
	SIW 6	Evacuation plan	1.00	R
	SAM 8	Evacuation	1.00	R
	ASR 1	Escape/Evac	1.00	R
	SIW 4	Evacuation	1.00	R
	SIW 1	Evacuation procedure	0.77	R
	ASR 3	Evac plan	0.64	T
	ASR 6	Evacuation	0.45	R
	SAM 1	Evac lift	0.28	R
	SAM 1	Evac buildings	0.21	R
	SAM 3	Evacuation of Guests	0.14	T

External Assistance	SAM 4	[Locations Removed) assistance	0.86	T
	SIW 9	External support	0.83	N
	ASR 10	External help	0.80	R
	SIW 2	Outside resources	0.72	N
	SAM 9	External EMS	0.60	R
	ASR 4	External medical assistance	0.45	R
First Response	ASR 5	First aid	1.00	T
	SIW 3	Injuries	1.00	T
	ASR 3	Register	1.00	T
	SIW 13	Immediate Attention	0.93	T
	SIW 12	Immediate first aid supplies and response	0.93	R
	ASR 1	Buddy system	0.86	R
	ASR 1	Injuries	0.79	R
	SAM 2	First aid	0.72	R
	SIW 9	Speed of response	0.71	R
	SIW 7	Location of people	0.59	R
	SIW 3	Rapid care	0.50	R
	SIW 3	Triage	0.50	R
	SAM 8	First aid	0.48	R
	ASR 6	Buddy system	0.45	R
	ASR 4	Short response time	0.42	N
	ASR 6	On Site EMS	0.40	R
	SIW 13	Injuries	0.38	R
	ASR 6	Locating People	0.19	R
	ASR 4	Repatriation/Hospitalization	0.17	N
	SAM 3	First response	0.14	T
Hazard Awareness	ASR 7	Education	1.00	T
	SAM 9	Awareness	1.00	R
	ASR 1	Experience	0.86	T
	ASR 8	Education	0.85	T
	ASR 2	Know CNE	0.75	T
	SIW 7	Aftershock awareness	0.68	N
	ASR 9	Educated Rescuers	0.49	R
	SIW 6	Hazard Aware	0.43	T
	ASR 9	Lahar Crater Lake	0.40	T
	ASR 9	Public Awareness	0.29	R
	SAM 3	Aftershocks	0.23	T
High Intensity and Magnitude	SAM 5	Large Scope Scale	0.90	T
	SIW 4	High intensity of magnitude	0.22	T

	ASR 11	Severe of shaking	0.18	T
Managing People	SIW 7	Emotional Aspects	0.83	R
	SAM 4	People Safe	0.79	R
	SIW 9	Management of People	0.75	T
	SIW 1	People (Too Many)	0.67	R
	ASR 6	Head count	0.57	T
	SIW 6	Leadership	0.52	N
	SIW 6	People	0.43	N
	ASR 10	Psyche	0.14	R
	ASR 11	Panic (People's Behaviour)	0.10	T
Recovery of Ski Area	SIW 12	Revised plan	1.00	N
	SIW 1	Learning and reflection	1.00	T
	SAM 3	Debrief	1.00	R
	SAM 4	Business moving forward	0.93	R
	ASR 7	Update Emergency Process	0.93	T
	SAM 10	Post earthquake	0.82	T
	SIW 3	Long term effects	0.75	R
	ASR 7	Repair infrastructure	0.71	T
	ASR 8	BBC	0.67	T
	ASR 2	Money	0.66	T
	ASR 7	Re-marketing post event	0.65	R
	SIW 2	Manage message in media	0.55	R
	SAM 3	Insurance	0.34	R
	SAM 1	Media	0.31	R
	SIW 4	Summer to recover	0.28	T
	SIW 10	Follow up debrief	0.13	R
	SIW 10	Adapting plans for future events	0.09	R
	SAM 3	Media	0.04	T
Resources Considerations	SIW 1	Resources available	0.87	R
	SIW 3	resources	0.75	T
	SAM 5	Resources available	0.60	N
	SIW 14	Resources inventory adequate	0.56	R
	ASR 2	Available Resources	0.34	T
	SIW 11	Additional resources	0.12	T
Safety	SIW 7	Secure Risk Zone	1.00	R
	SIW 13	Safety	1.00	T
	SIW 12	Public Safety	0.98	N
	SIW 8	Safety Zones	0.91	R
	ASR 1	Safety	0.87	R
	ASR 1	Safe Zone	0.79	T
	SAM 6	Safety	0.76	R
	SIW 4	Staff Safety	0.61	R
	SIW 1	Vehicles in safe position	0.50	N

	ASR 3	Safe Zone	0.37	R
	ASR 4	Safe Zone	0.32	R
	SIW 7	Safe Zone	0.28	T
	SAM 3	Safety of All	0.14	T
Survival (Water, Food, & Shelter)	ASR 1	Warmth	0.78	R
	ASR 1	Hydration	0.69	R
	SIW 8	Safe accommodation	0.64	R
	SIW 2	Accommodation	0.64	T
	ASR 2	Food & Water	0.63	R
	SAM 2	Shelter	0.63	T
	ASR 2	Heat & Warmth	0.59	R
	ASR 5	Water & snack	0.57	N
	ASR 1	Water	0.56	T
	SIW 2	Food & Water	0.54	R
	SAM 6	Food & water	0.50	R
	ASR 7	Provisions	0.48	R
	ASR 3	Water	0.46	T
	ASR 8	Stores	0.46	R
	SIW 6	Survival	0.42	R
	SAM 8	Self Rescue	0.42	T
	SAM 9	Personal preparation for any event	0.39	R
	SAM 8	Shelter	0.36	T
	SAM 2	Water & food	0.36	T
	ASR 3	Generator	0.34	T
	ASR 3	Food	0.28	R
	SIW 8	Food & water stocks	0.27	R
	ASR 4	Housing Shelter	0.24	T
	SAM 1	Water & services	0.21	R
	ASR 11	Weather (Severity)	0.14	T
	ASR 10	Food	0.05	T
Training Considerations	SIW 9	Training company wide	1.00	N
	SIW 14	Training	0.88	R
	SIW 1	Training and scenarios	0.81	N
	ASR 9	Trial runs	0.80	R
	ASR 2	Train staff	0.76	T
	ASR 4	Training	0.69	R
	SIW 11	Training	0.69	R
	ASR 3	Drills	0.65	N
	SIW 4	Training	0.49	R
	SIW 6	Training	0.44	T
	ASR 6	Good training	0.41	T
	ASR 3	Training first aid	0.24	R
	SAM 3	Training staff	0.14	T

Appendix 3.E: Modified Mercalli Intensity Scale

MM	Consequences of various earthquake intensities for people and infrastructure.
MM2	Felt by people at rest, on upper floors or favourable placed
MM3	Felt indoors; hanging objects may swing, vibration similar to passing of light trucks
MM4	Generally notice indoors but not outside. Light sleepers may be awakened. Vibration like passing of heavy traffic. Doors and windows rattle. Walls and frames of buildings may be head to creak.
MM5	Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed. Some glassware and crockery may be broken.
MM6	Felt by all. People and animals alarmed. Many run outside. Furniture or objects may move on smooth surfaces. Objects fall from shelves. Glassware and crockery broken. Slight damage to some types of buildings. A few cases of chimney damage. Loose material may be dislodge from sloping ground. A few very small (e.g <1000m3) shallow landslide and rock falls occur.
MM7	General alarm. Furniture and appliances may be shifted and unstable items overturned. Unreinforced stone and brick walls cracked. Some pre-earthquake code buildings damaged. Roof tiles may be dislodged. Many domestic chimneys broken. Small falls of sand and gravel banks. Some fine cracks appear in sloping ground and ridge crests. Rock falls from steep slopes and cuttings are common. A few small to moderate landslide (e.g. 1000 to 10000m3) occur on steeper slopes. Some instances of liquefaction at susceptible sites.
MM8	Alarm may approach panic. Steering of cars greatly affected. Some serious damage to pre-earthquake code masonry buildings. Most reinforced domestic chimneys damaged, many brought down. Monuments and elevated tanks twisted or brought down. Some post-1980 brick veneer dwellings damaged. Houses not secured to foundations may move. Cracks may appear on slopes and in wet ground. On slopes in steep or weak ground, numerous small to moderate landslide and some large landslide (e.g. 100 000m3). Collapse of roadside cuttings and unsupported excavations. Small sand fountains and other instances of liquefaction.
MM9	Very poor quality unreinforced masonry destroyed. Pre-earthquake code masonry buildings heavily damaged or collapse. Damage or distortion to some pre-1980 buildings and bridges. House not secured to foundation shifted off. Brick veneers fall and exposed framing. Conspicuous cracking of flat and sloping ground. On steep slopes, many small to large landslides and some very large (> 1 000 000m3) landslides and rock avalanches that may block narrow valleys and form lakes. Liquefaction effects intensified, with large sand fountains and extensive cracking or settlement of weak ground.
MM10	Most unreinforced masonry structures destroyed. Many pre-earthquake code buildings destroyed. Many pre-1980 buildings and bridges seriously damaged. Many post-1980 buildings and bridges moderately damaged or permanently distorted. Widespread cracking of fault and sloping ground. Widespread and severe landsliding on sloping ground. Very large landslides (>106m3) from steep mountain faces and coastal cliffs. Widespread and severe liquefaction.

Appendix 3.F Indices for Participants Original FCMs

	NumVars	Connections	Density	Receiver	Transmitter	Ordinary	Complexity	Hierarchy
ASR1	13.00	139.00	0.82	5.00	3.00	5.00	1.67	0.25
ASR2	12.00	93.00	0.65	6.00	5.00	1.00	1.20	0.24
ASR3	11.00	80.00	0.66	3.00	4.00	4.00	0.75	0.73
ASR4	8.00	30.00	0.47	3.00	3.00	2.00	1.00	0.25
ASR5	7.00	21.00	0.43	3.00	3.00	1.00	1.00	0.06
ASR6	11.00	35.00	0.29	6.00	3.00	2.00	2.00	0.41
ASR7	8.00	34.00	0.53	3.00	4.00	1.00	0.75	0.53
ASR8	12.00	70.00	0.49	8.00	4.00	0.00	2.00	0.42
ASR9*	10.00	45.00	0.45	5.00	4.00	1.00	1.25	0.51
ASR_10	9.00	38.00	0.47	3.00	4.00	2.00	0.75	0.31
ASR_11	10.00	11.00	0.11	2.00	8.00	0.00	0.25	0.01
SAM1	7.00	16.00	0.33	4.00	2.00	1.00	2.00	0.83
SAM2	5.00	17.00	0.68	2.00	3.00	0.00	0.67	0.43
SAM3	15.00	22.00	0.10	4.00	10.00	1.00	0.40	0.03
SAM4	7.00	18.00	0.37	3.00	4.00	0.00	0.75	0.44
SAM5	5.00	23.00	0.92	1.00	0.00	4.00	Inf	0.15
SAM6	7.00	43.00	0.88	4.00	3.00	0.00	1.33	0.20
SAM7	10.00	8.00	0.08	2.00	1.00	7.00	2.00	0.14
SAM8	5.00	13.00	0.52	3.00	2.00	0.00	1.50	0.36
SAM9	9.00	44.00	0.54	4.00	4.00	1.00	1.00	0.19
SAM10	4.00	11.00	0.69	2.00	2.00	0.00	1.00	0.60
SIW1	9.00	65.00	0.80	3.00	1.00	5.00	3.00	0.37
SIW2	15.00	151.00	0.67	8.00	3.00	4.00	2.67	0.37
SIW3	9.00	6.00	0.07	3.00	2.00	4.00	1.50	0.08
SIW4	11.00	65.00	0.54	4.00	4.00	3.00	1.00	0.39
SIW5	11.00	19.00	0.16	2.00	2.00	7.00	1.00	0.21
SIW6	7.00	49.00	1.00	1.00	1.00	5.00	1.00	0.08
SIW7	9.00	47.00	0.58	4.00	4.00	1.00	1.00	0.34
SIW8	6.00	9.00	0.25	5.00	1.00	0.00	5.00	0.27
SIW9	6.00	30.00	0.83	2.00	1.00	3.00	2.00	0.30
SIW_10	6.00	8.00	0.22	4.00	2.00	0.00	2.00	0.95
SIW_11	7.00	13.00	0.27	2.00	5.00	0.00	0.40	0.24
SIW_12	5.00	24.00	0.96	1.00	1.00	3.00	1.00	0.13
SIW_13	8.00	41.00	0.64	2.00	3.00	3.00	0.67	1.18
SIW_14	6.00	15.00	0.42	1.00	1.00	4.00	1.00	0.55
Total	**300**	**1353**	**17.87274**	**118**	**107**	**75**	**46.5**	**12.53042**
AVG	**8.571429**	**38.65714286**	**0.51065**	**3.371429**	**3.057143**	**2.142857**	**1.367647**	**0.358012**
STDV	**2.302041**	**24.54040816**	**0.212701**	**1.36**	**1.386122**	**1.771429**	**0.642445**	**0.190162**

Appendix 3.F: Matlab script for scenario simulations

```
clear in
clear m
clear out
clear delm
clear del0
```

% nn is the number of nodes(i.e., variables, concepts, key considerations....
% that represent preparation for, response to, and recovery from earthquakes...
%...that can affect alpine ski areas)

```
nn=23
```

% start with in (i.e., inputs) of 1 for all nodes

```
in=ones(1,nn)
```

% w is a particular fuzzy cognitive map (i.e., FCM)or social group fuzzy
% cognitive map (SGFCM). In this example it is TSGsom5 which stands for...
% the total social group fuzzy cognitive map configured in the
% appropriate order of the five high level categories based on the...
% highest ward likelihood index self organizing maps.

```
w=TSGsom5
```

% transpose of inputs...

```
in=in'
```

%STEP 1: STATUS QUO EQUILIBRIUM
% This section caluclates the status-quo equilibrium for any FCM or SGFCM;
% it activates the FCM with all ones and allows them to settle into a
% steady state. It is an auto-associative artificial neural network in
% 'open-box' form. The connections or weight from the FCM provide the
% structure of the network.

```
k=1
del0=ones(1,nn)
```

% k is the conditional ending with the number of iterations set at < 40
% (i.e., less than 40). If condition is met jump the loop.

```
while (k<40)
```

% % input for each iteration in STEP 1 is the product of weights...
%...and initial inputs of 1 (i.e., weighted sum)

```
in=w*in
    for i=1:nn
   out(i)=1/(1+exp(-in(i)))
    end
```

% m is the output of each node for 40 iterations

```
 m(k,:)=out
```

% input is now output transposed

```
in=out'
```

% stores the difference in k at each position. Once again delm (k,:) is
% change at each interaction, while m (k,:)-del0 is initial change from
% the previous interation.

```
delm(k,:)=m(k,:)-del0
del0=m(k,:)
k=k+1
end
```

%mSQ is the output of the last iteration (i.e., output at steady state...
%...equilibrium,...iteration 39 hence k-1. There is no 40th iteration)

```
mSQ=m(k-1,:)
```

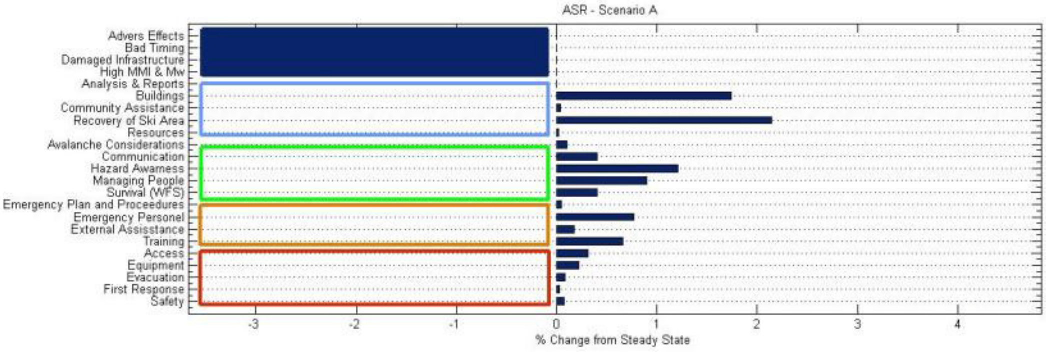
%mTr is node output for the iterations Transposed

```
mTr=m'
   for j=1:nn

   end
  subplot(2,1,1)
```

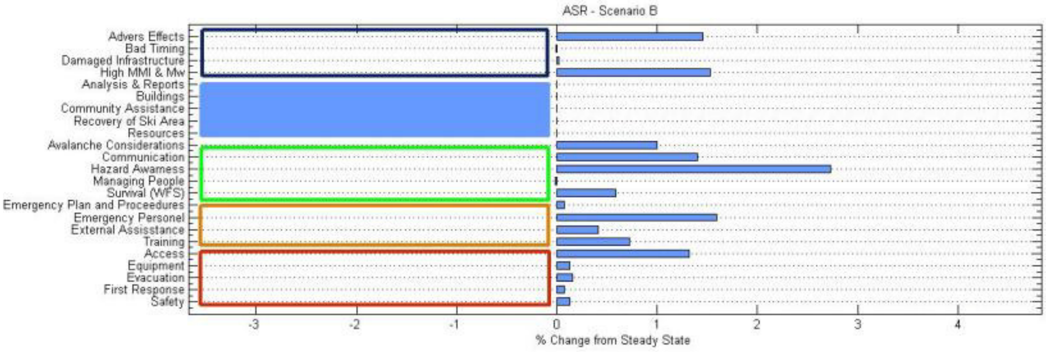
```
   bar3(mTr), title('output')
subplot(2,1,2)
   bar3(delm'),title('change in output')
   %hold on
%subplot(1,2,1)
   %bar3(mTr), title('output')
%subplot(1,2,2)
%   bar3(delm'),title('change in output')


%SCENARIO SIMULATIONS
%
clear i
clear j
clear k
clear m1
clear delm1
for j=1:nn
    in=ones(1,nn)
    in=in'
    k=1
  while (k<40)
 in(j)=1
      in=w*in
    for i=1:nn
   out(i)=1/(1+exp(-in(i)))
    end
    in=out'
    k=k+1
  end
  m1(j,:)=out
    for n=1:nn

 %PercentDelm1 is the % change in output of each node w.r.t. their status
 %quo values

  PercentDelm1(j,n)=100*(m1(j,n)-mSQ(n))/mSQ(n)
    end
end
subplot(2,2,1)
bar3(PercentDelm1'), title('scenario simulations')


% POLICY SCENARIOS INVOLVING MULTIPLE VARIABLES

clear i
clear j
clear k
    in=ones(1,nn)
    in=in'
    k=1

% j below contains the label of the nodes that are clamped at 1 (meaning a
% high level) in the simulation.  The scenario below indicates Scenario A:
% (i.e. Adverse Effects, Bad Timing, Damaged Infrastructure, and High
% Intensity and Magnitude at a High Level meaning of High Importance or
% Influence).

j=[1,2,3,4]

 % The number of interations k below are set to 40 but this could be changed...
% ...without changed to a lower or high number of interations.

 while (k<40)
      in([j])=1
      in=w*in
    for i=1:nn
   out(i)=1/(1+exp(-in(i)))
    end
    in=out'
    k=k+1
  end
  m2=out
    for n=1:nn
  PercentDelm2(n)=100*(m2(n)-mSQ(n))/mSQ(n)
    end
subplot(2,2,2)
bar3(PercentDelm2'), title('TSG: Scenario A')
```

Appendix 3.H: ASRFCM scenarios A – E

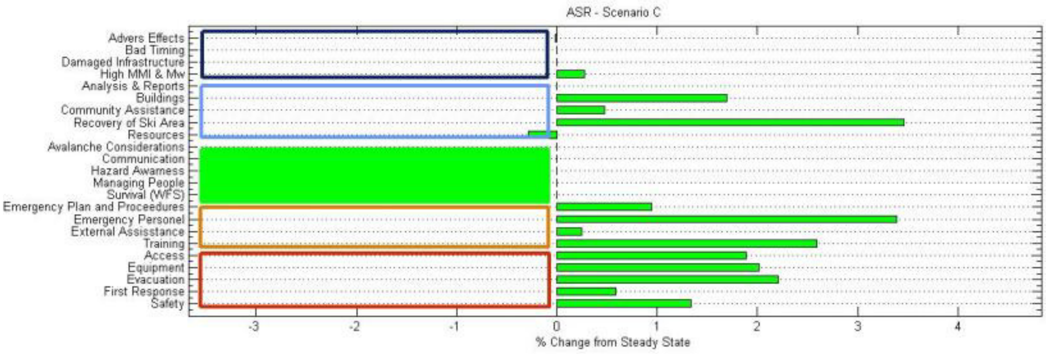
ASR Scenario A



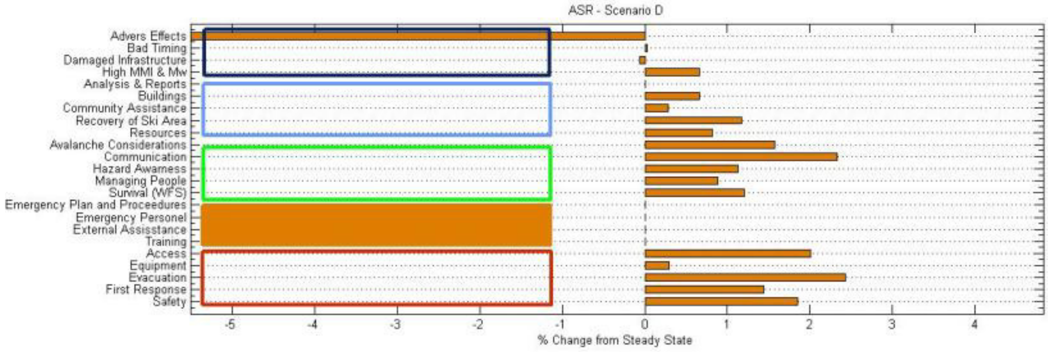
ASR Scenario B



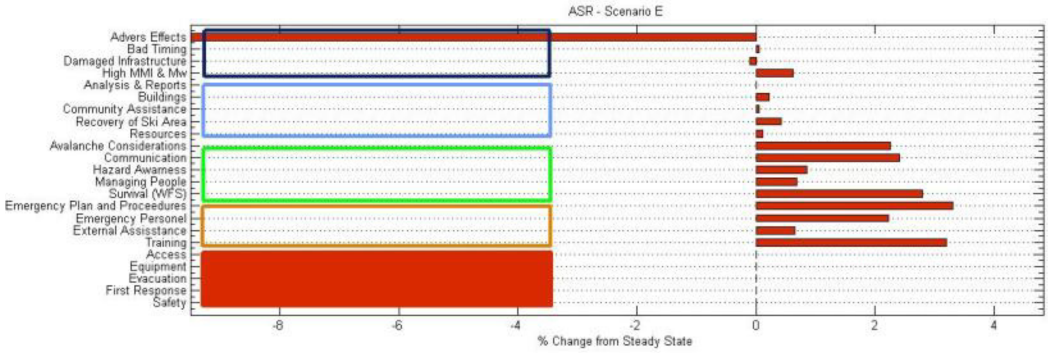
ASR Scenario C



ASR Scenario D

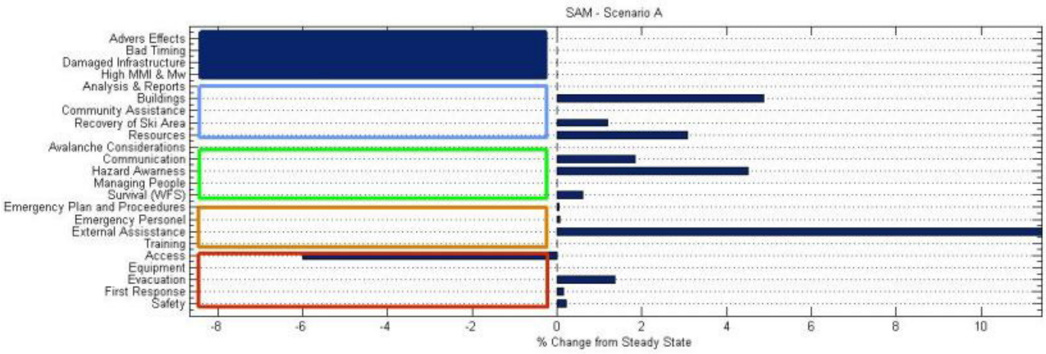


ASR Scenario E:

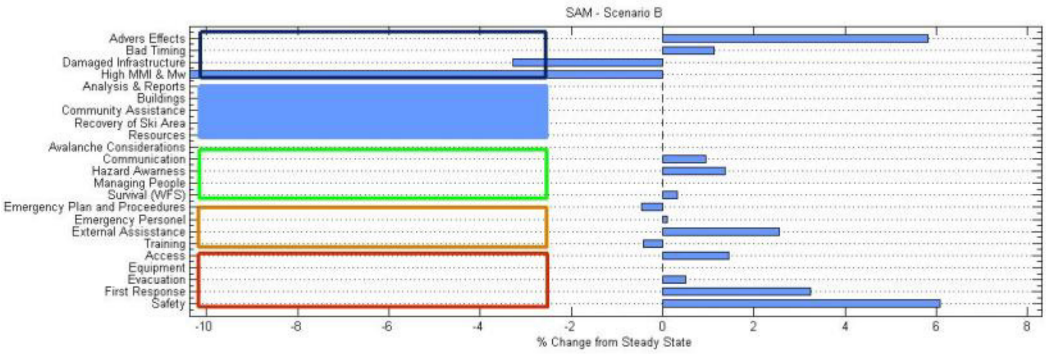


Appendix 3.I: SAMFCM scenarios A – E

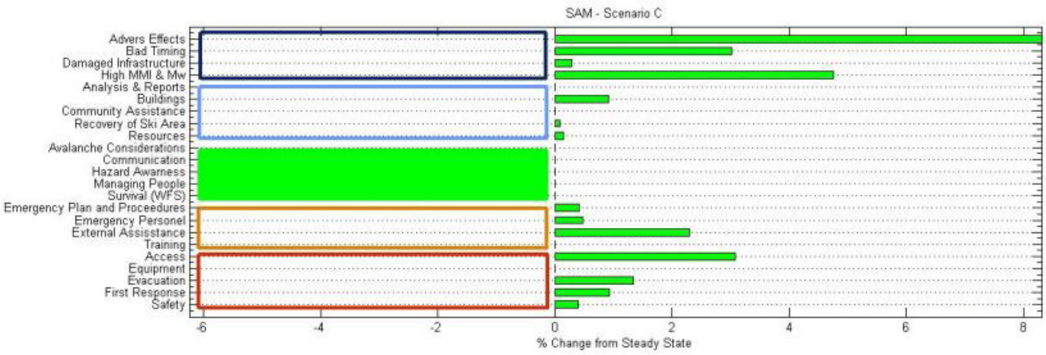
SAM Scenario A



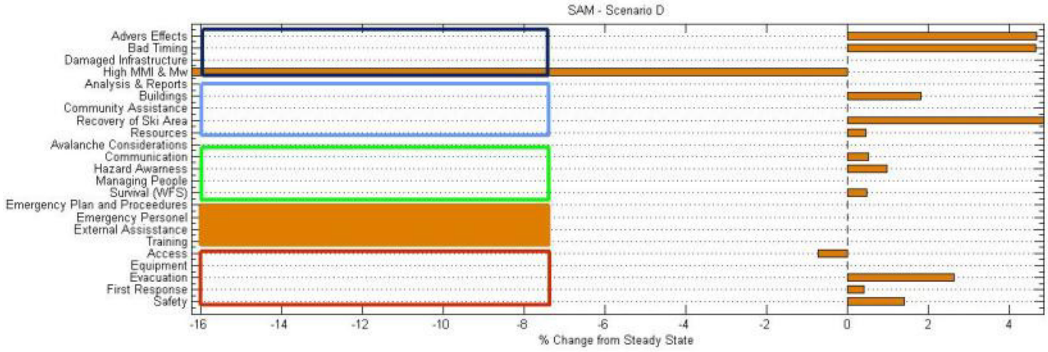
SAM Scenario B



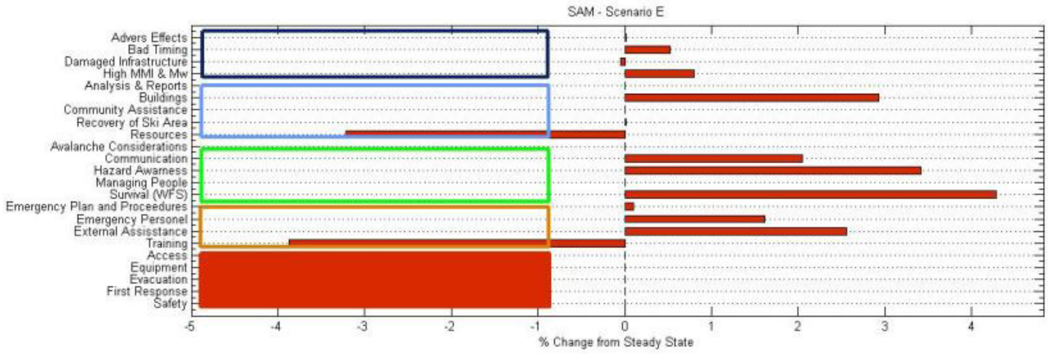
SAM Scenario C



SAM Scenario D

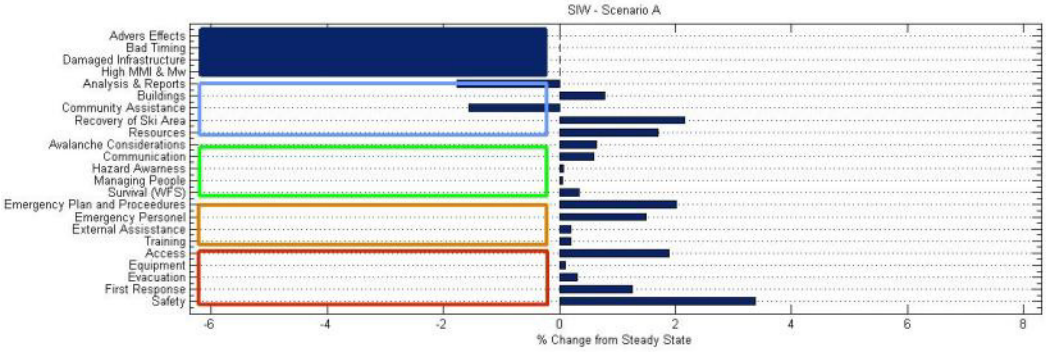


SAM Scenario E

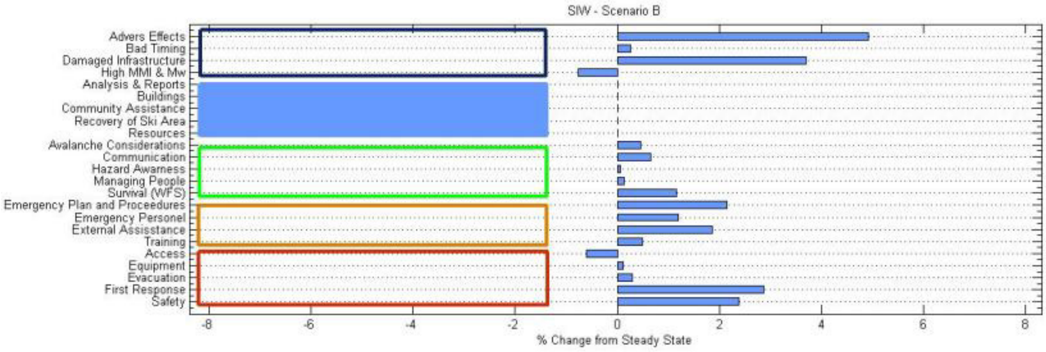


Appendix 3.J: SIWFCM scenarios A – E

SIW Scenario A

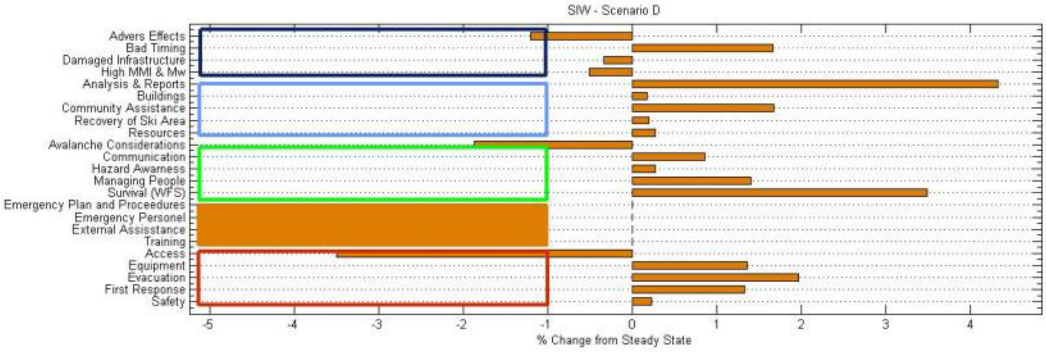


SIW Scenario B

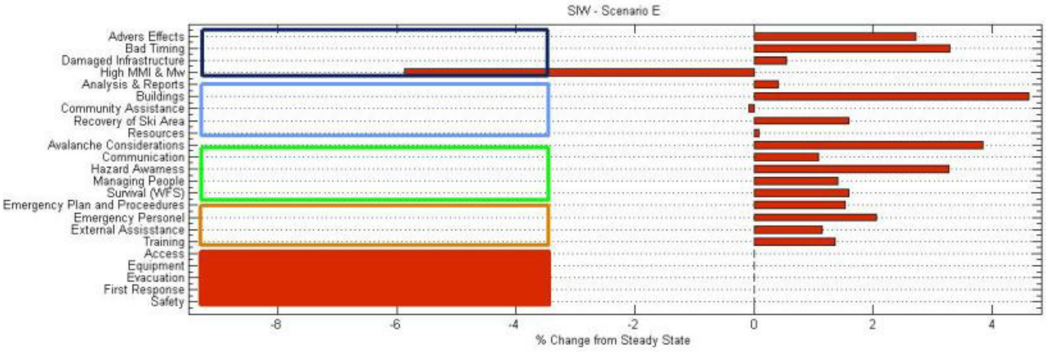


SIW Scenario C

SIW Scenario D



SIW Scenario E



Appendix 5.A: Press Release from NZski.com

A number of guests have asked what was done prior to opening the mountain to guests after the major earthquake on Saturday. Hopefully after reading the steps that we took (below) you will feel assured that safety was our primary focus in the decision making process:

- Our maintenance team climbed every lift tower and inspected the alignment of each sheave assembly as chairs passed through. The standard safety checks were also carried out which include running the lifts at full speed. This is procedure is in line with recommendations from our lift manufacturers and our independent lift certifier/inspector.
- Our Patrollers conducted an assessment of the snow and terrain and were satisfied that the snow pack within the ski area was safe.
- Some sections above the access road were bombed to bring down any rocks that may have been dislodged by the quake.
- We carried out a preliminary building inspection to check for cracking, distortion and other signs of structural damage. This was followed up with a more detailed structural examination. Thankfully the integrity of our base buildings, sewerage treatment facility, underground diesel storage tanks, electrical systems and LPG gas supplies do not appear to have been compromised in any way.
- We contacted both the local police and the head of Westpac to ask if they had any issues with us opening. Both were happy to support our decision to open.
- We checked the snowmaking reservoir for cracking/integrity.
- In our snow report we advised that guests first check their route to the mountain prior to travel.

As you are are well aware, the mid-Canterbury district is still receiving regular aftershocks. If we get a noticeable shake during operations, we will stop all lifts until things have settled down. If a subsequent aftershock is large enough we may have to repeat one or more of the processes outlined above - potentially whilst guests remain on the line. We would also consider evacuation of the base lodge by sounding the fire alarm system. Building wardens assigned to specific areas will check through the base facility to ensure guests and staff are clear of the building. Remember our assembly point is out in front of the cafe deck.

If anyone has any questions or concerns, please feel free to contact me.

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