Mitigation of Natural Hazards and Disasters

International Perspectives

Edited by

C. Emdad Haque

Springer

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Reprinted from *Mitigation and Adaptation Strategies for Global Change* Volume 10: 3 (July 2005)

Springer

A.C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN (HB) 1-4020-3112-2

Published by Springer,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

www.springeronline.com

Printed on acid-free paper

Cover illustrations: “C. Emdad Haque, 1991: Cyclone 2B that struck Chittagong coastal area Bangladesh in 1991.”

Printed in the Netherlands

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FOREWORD

At a stage in world history when the volume of social risk is mounting at an unprecedented rate due to variations in the global environment, it is especially timely to critically appraise the likely consequences of continuing or modifying the present public mitigation policies. The precise character of those remedies and consequences is unfolding rapidly. This collection of papers explores their possible significance as influenced by prevailing trends in technology and in public policy.

Just what the full character of prospective changes will be is a matter of conjecture, but the available widens on what the experience has been to date and is highly illuminating and sobering. For a variety of physical and social environments, the effectiveness of major mitigation measures is appraised in this volume. It is recognized that various measures, such as engineering work or land-use regulations, may have quite different consequences according to prevailing public policies and their administration.

It is important to recognize that no country in the world has achieved a completely effective policy for dealing with the rising tide of costs from natural hazards. The papers in this volume appraise a number of administrative policies that will require revision if socially wise mitigation is to go into effect, and if rising social costs are to be controlled.

It is also important to recognize that there may be factors at work that, in the course of a few decades, may alter the character and magnitude of extreme events in the natural systems of atmosphere and hydrology. There currently are changes underway in patterns of temperature and precipitation as a consequence of alteration in air quality and temperature resulting from human activities. The failure to control the chemical quality of air emissions and to maintain the quality of soil and vegetation are hypothesized to be affecting atmospheric temperature.

Just how significant these human alterations on environmental systems may be is still largely speculative but it raises persistent doubts as to the degree to which climate averages will remain unchanged. It is possible that some of the current estimates of environmental means will be changing. In that event, the prevailing judgments as to socially sound policies for disaster mitigation may require revision.

For example, the estimated frequency of a flood requiring mitigation by land-use regulation is once in one hundred years in some places and once in five hundred in others. In some administrative areas, strong reliance is placed on government land-use regulations. In other areas, heavy weight is placed on the role of flood insurance availability cost. In some areas, reliance is placed on the use of engineering remedial devices, at government or private cost.

For these and other reasons the findings reported in this volume will be of large significance as future policy decisions are made in a wide variety of natural and social environments.

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ADAPTATION OPTIONS STRATEGIES FOR HAZARDS AND VULNERABILITY MITIGATION: AN INTERNATIONAL PERSPECTIVE

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(Received 15 May 2004; accepted in final form 17 July 2004)

Abstract. The broad objective of this special issue of *Mitigation and Adaptation Strategies for Global Change* is to address some of the gaps in our knowledge and understanding of the policies, programs, and measures that might be applied to natural hazards and their impacts in an era of climate change. Given the global impacts of climate change and world-wide pattern of increasing losses from natural hazards we necessarily adopt an international perspective. The specific goals of the special issue are to: (a) encompass experiential aspects, emphasizing current practice of mitigation and its associated measures, and their results; and (b) explore primary or root causes of alarming shifts in human and economic costs of environmental extremes. Special emphasis is placed on how human activities are playing a key role in enhancing vulnerability to NTEE (nature-triggered environmental extremes), quite independently from the anthropogenic causes of climate change. The goals are also (c) to examine costs, risks, and benefits (of all kinds including social, political, ecological) of mitigation, and adjustment and adaptation measures; and (d) analyze policy implications of alternative measures. These components are expected to make significant contributions to policy considerations – formulation, implementation and evaluation. There is much uncertainty about the rate of climate change; however, the fact of increase of the atmospheric temperature in the last century is no longer a subject of scientific or policy debate. Due to such changes in the geophysical parameters, certain types of nature-triggered environmental extreme events are likely to continue to increase. How global warming will affect regional climates and pertinent variables is not well known, limiting our ability to predict consequential effects. This factor poses serious constraints against any straightforward policy decisions. Research findings of the work of this volume reaffirm that human dimensions, specifically our awareness and decision-making behavior, are powerful explanatory factors of increasing disaster losses. Disaster mitigation through addressing human, social, and physical vulnerability is one of the best means for contributing to 'climate change adaptation plans', and sustainable development goals. Recent lessons from various countries have depicted that the formulation of mitigation strategies cannot be exclusively top-down as it requires social, political, and cultural acceptance and sense of ownership. An interactive, participatory process, involving local communities, produces best expected outcomes concerning mitigation, preparedness, and recovery. An emerging consensus is that there is a need to move towards the 'mission' of the International Strategy for Disaster Reduction which aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters. Sharing of best practices and lessons globally is certain to produce more efficiency and understanding in policy and decision making.

Keywords: adaptation, climate change, environmental extremes, loss, mitigation, policy, resilience, vulnerability

1. Introduction

The focus of this volume is on environmental hazards. Conventionally, environmental hazards have been analyzed in relation to their potential for damage; but actual usage almost invariably is made in terms of an objective geophysical process, such as a flood or hurricane, as ‘the hazard’. A pioneering study by Hewitt and Burton (1971) exhibited methods of how such ‘damage potentials’ can be measured in terms of inherent energy embodied in various types of natural phenomenon, such as a storm or a flood. A deviation of an environmental event, in terms of its energy parameters, from the ‘average’ or ‘normal’ trend thus can help to define ‘extremity’ of a ‘natural’ process and associated events. In recent years, such a concept has been challenged as it neglects the aspects of human risk and vulnerability (Hewitt 1983; Smith 1999; Blaikie et al. 1994), and human coping capacity (Haque 1997). In the latter terms, an environmental or ‘natural’ extreme event is one that surpasses the human coping threshold, and the geophysical processes would have unusual characteristics (Hewitt and Burton 1971).

The frequently used distinction between natural and anthropogenic or non-natural extremes events presents some difficulties, and has often been questioned (Cannon 1994). The International Federation of Red Cross and Red Crescent societies have offered a classification of disasters according to the initiating event specified as a ‘natural’ or ‘non-natural trigger’ (IFRCRC 1997, 1998). This is useful in making a distinction between the two generic sources of extreme environmental events. In this paper, we are employing this notion in the term *Nature-Triggered Environmental Extremes (NTEE)*, which refers to a relative perspective of geophysical processes and events, in reference to remarkable deviation from the norm, and potential adverse impact on human and other lives, property, assets, and other resources.

As stated above, in both the natural hazards school of research and the climate change school of research, the importance of societal dimensions of hazards, disasters, and vulnerability reduction was recognized only in recent years. Environmental hazards and disasters policies and responses were long dominated by the urgent requirements of disaster relief and humanitarian assistance. Most resources were allocated to responses whereas, for most people in the world, specifically in the developing world, the avoidance of hazards and disasters was closely correlated with minimizing vulnerabilities. In the rush to provide assistance in disaster and emergency situations, the long-term processes of reducing vulnerability were commonly neglected, and the further expansion of human activities in high hazard zones or the lack of adequate building codes and design standards, or the lack of their enforcement could sometimes increase vulnerability. While these problems have by no means been adequately overcome, the work of the International Decade for Natural Disaster Reduction (IDNDR), 1990–1999, has done much to refocus the emphasis on the need for mitigation. Recent efforts by the International Strategy for Disaster Reduction, the activity that evolved from IDNDR, continue this focus for example in its publication *Living with Risk*, which seeks to enhance understanding of policy and process through a global review of disaster reduction initiatives.

Global warming and other associated environmental changes are serious concerns for all stakeholders that remain highly relevant to disasters and their reduction (Briceno 2004). Measures are needed to enhance our ability to adapt to the existing climate, by determining and reducing current and future environmental change risk and by promoting disaster mitigation as a climate change adaptation strategy.

Against this background the objective of this special issue of the *Mitigation and Adaptation Strategies for Global Change* is to address some of the gaps in our knowledge and understanding of the policies, programs, and measures that might be applied in dealing with natural hazards (NTEE) and their impacts at a time of rapid climate change. The specific goals of the special issue are as follows: (a) the volume is intended to encompass experiential aspects, i.e., to report and analyze how government and concerned agencies, in policy and strategic terms, have recently addressed various types of risks, hazards and disasters; what has been the nature of policy debate discourse in a specific country or region; and what has been the result of various types of efforts; (b) this special issue also aims at exploring primary or root causes of alarming shifts in human and economic costs of environmental extremes. Special emphasis will be placed on how human activities are playing a key role in enhancing vulnerability to NTEE, outside the anthropogenic interference into greenhouse gases. Exploring the mitigation and adaptation potential in dealing with particular types of NTEE or cumulative hazards, and examining their associated options are the best possible ways to address the emerging problem of alarming loss due to the NTEE. It is believed that critical examination of various alternatives, their feasibility and effectiveness, would help develop effective policies. In addition, identifying the areas of intervention for eliminating and reducing vulnerability and risk is of greater interest among policy and decision-makers; (c) examination of cost, risk, and benefits (of all kind including social, political, ecological) of mitigation, and adjustment and adaptation measures is another goal of the studies of this volume; (d) analyses of policy implications of different measures and options have been regarded as significant aspects of this special issue as they are expected to make significant contributions to policy considerations – formulation, implementation and evaluation.

The discourse of the debate over recent global warming, associated changes in the climatic norms, and the correlation of the enhanced variability of environmental extremes with global atmospheric warming exhibited serious interest and participation from various scientific, regulatory, and other knowledge stakeholders as well as from numerous policy and decision-making quarters. Because of their complexity and non-testable nature, consensual directions on such issues yet could not be ascertained. Nonetheless, several interesting inferences, on which there is no general disagreement, have been confirmed by recent research findings and discussions. These could be synthesized under the following three major inferences.

(i) The atmospheric thermal regime in the last few decades exhibited a trend of consistent rise, particularly in the northern hemisphere (IPCC 2001). The

Intergovernmental Panel on Climate Change (IPCC) 2001 concedes that "an increasing body of observations gives a collective picture of a warming world and other changes in the climatic system" (p. 4). The Panel further asserts that the rise in surface temperature over the 20th century for the Northern Hemisphere is likely to have been greater than that for any other century in the last thousand years.

(ii) The IPCC models projected that increasing atmospheric concentrations of greenhouse gases will result in shifts in temporal variability on all scales (daily, seasonal, interannual, and decadal) as well as in frequency, intensity, and duration of extreme events (IPCC 2001, p.14). The various component features of the geophysical (e.g., volcanic activities, earthquakes, landslides, avalanches) and climatic extremes (e.g., hurricanes, storms, tornadoes, hailstorms, droughts, dry-spells), however, demonstrated mixed and thereby inconclusive trends, with considerable variations at different geographical scale. A recent special journal (i.e., *Natural Hazards*) volume (Khandekar and Gönnert 2003), entitled *global warming and extreme weather: an assessment*, attempted to examine the pertinent questions in the atmospheric spheres, specifically to seek an answer whether there is a link between global warming and extreme weather.

A clear association between global warming and climatic extremes in all areas cannot be established by our current state of knowledge, although several of the climatic features and regions indicate a trend of extreme variability. In the United States, for example, heavy precipitation events have increased during the period of historical records, but for many other severe weather categories, the trends have been downward over the past five decades (Balling and Cerveny 2003). In an analysis of the trends in blizzards on the Canadian Prairies, a significant downward trend of weather observing locations in the most westerly part was noticed (Lawson 2003). This is consistent with other studies that found a decrease in cyclone frequency over western Canada. A decrease in cold spells during 1950–1998 in western Canada was noted by Shabbar and Bonsal (2003) whereas winter warm spells have increased across most of Canada. In a sub-regional context, prediction has been made that, as global temperatures continue to increase, the frequency and magnitude of floods in North Carolina will correspondingly increase in the future (Robinson 2003). As well, evidence from other continents and hemisphere indicates mixed results. By examining, in the context of global warming during the last century, rainfall changes in southern Africa, Fauchereau et al. (2003) concluded that interannual variability has risen since the 1960s. Droughts became more intense and widespread in this part of the African continent. More importantly, they further asserted that teleconnection patterns linked to Southern African rainfall variability shifted from regional to near global after the 1970s. Some macro-regional studies have revealed contrasting or varied patterns. For example, by examining four monsoonal macro-regions, Chase et al. (2003) found no association between reported surface warming and intensity of the monsoon circulations in southeastern Asia, western Africa, eastern Africa, and the Australian continent. With respect to the proposition that there is a positive correlation between global warming and extreme weather, Khandekar and Murty (2003), in their 'guest editorial' article in the special issue of the *Natural Hazards* journal, concluded that most of the scientific studies "do not suggest an affirmative answer at this time (p. 101)". We find that in the scientific community there is considerable disagreement with regard to the effects of an increase in concentration of greenhouse gases and consequent change in temperature upon the specific component of climatic system (such as, precipitation, wind, storms, cyclones and anticyclones, tornadoes), but there is little disagreement about the certainty of the enhanced temporal and spatial variability of some of these components. This observation signifies the seriousness of the enhanced risk to humans and our resources to NTEE in the future.

(iii) One of the most intriguing inferences made recently is that the past few decades, specifically since the mid-1970s, have experienced increasing global economic costs as a result of nature-triggered extreme events (Figure 1) and consequent damages (Munich Re., 2003; Figure 2) and increasing loss of human life in the developing world (Hewitt 1997; Burton et al. 1993). Paradoxically, the trend of increasing global costs due to NTEE was established at a time when the United Nations International Decade for Natural Disasters Reduction

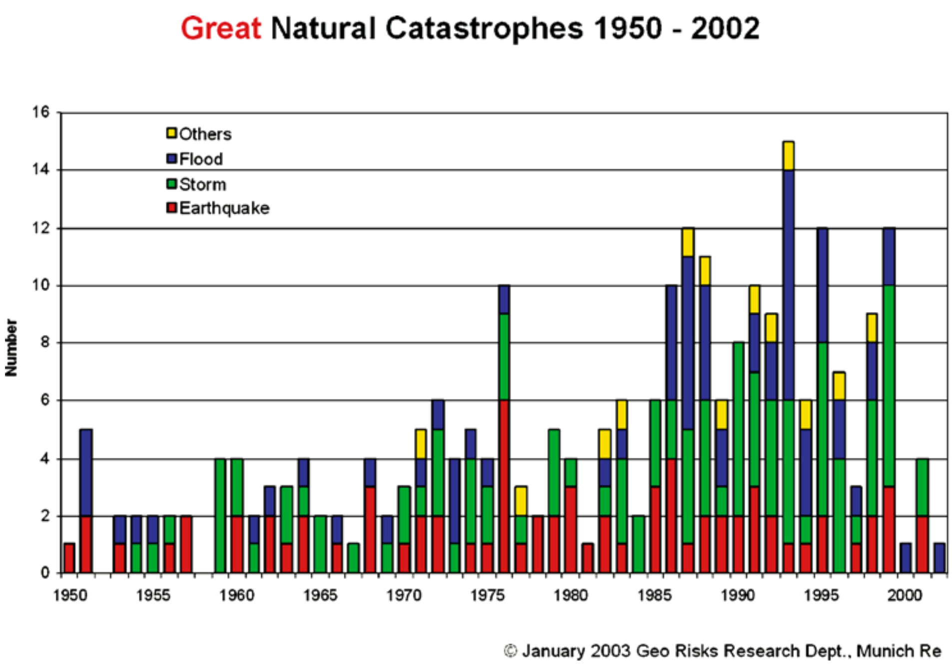

Figure 1. Trend of catastrophic disaster events by type and frequency globally, 1950–2000 Source: Munich Re. 2002.

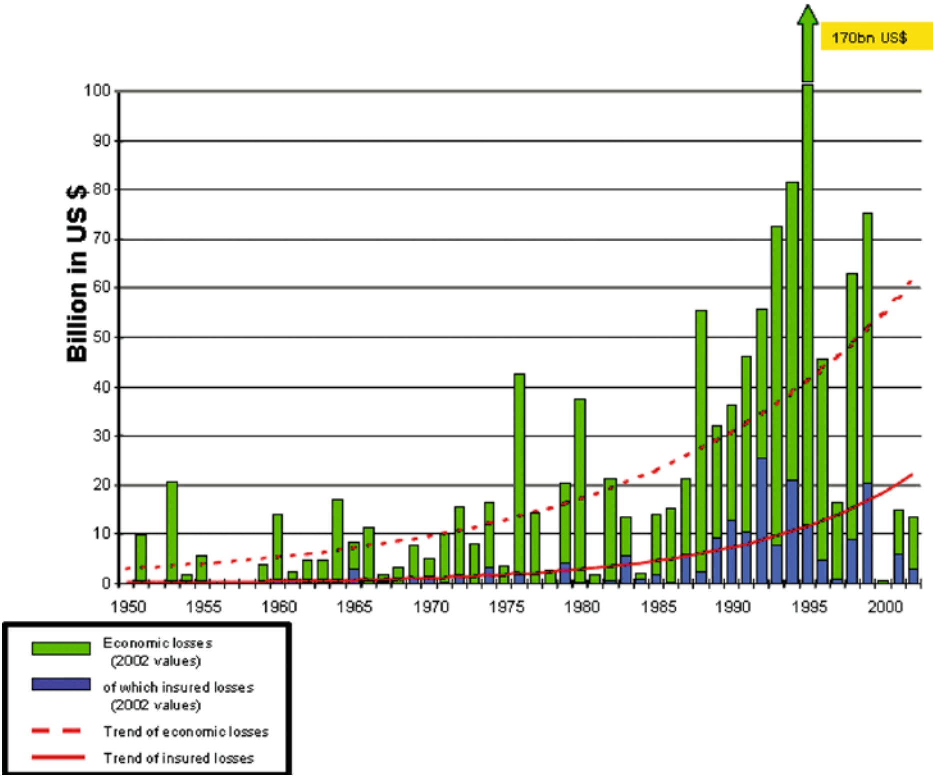

Figure 2. Global trend of economic and insured losses, 1950–2000 Source: Munich Re. 2002.

(INDDR) declared that, through the work in the 1990s, the costs would be reduced by 50% by the year 2000. While no clear pattern of increasing NTEE has been recognized in all atmospheric and geophysical areas, the loss due to increased hazards (physical event and human vulnerability) is clearly showing an incremental trend over time (Figure 2).

Some recent explanations of increasing trends of cost (economic and human) due to NTEE have focused more on the human/social variables as opposed to dominant science and technology oriented approaches which emphasize the geophysical aspects of risk and hazards. It is worth noting some of them here. Etkin (1999) asserts that “though more frequent extreme events in nature may play a role – a large part of the answer [regarding the increasing global cost] certainly lies in the realm of increased social vulnerability” (p. 69). This assertion was strongly supported by a more recent, detailed study of weather extremes in the United States (Changnon 2003).

Changnon (2003) states that the trends in various extreme weather events (not their losses) over the past century exhibit a mix; one trend is upwards (heavy rains-floods), others are downwards (hail, hurricanes, tornadoes, and severe thunderstorms), and there are unchanging flat trends (winter storms and wind storms). It is argued that these trends do not fit the predictions, based on GCM simulations under a warmer world resulting from increased CO_2 levels that call for weather extremes and storms to increase in frequency and intensity (Kattenberg et al. 1996). The indepth investigations of costly weather events in the U.S. revealed that "changes in society, which has become more vulnerable to weather damages, is a primary cause, not major increase in the frequencies or intensities of most hazards" (Changnon 2003, 287).

We would like to argue that, irrespective of an established synoptic causal link between global atmospheric warming and accelerated environmental extremes, the aspects of mitigation of nature-triggered environmental extremes (NTEE), and of adaptation of our built environment (including infrastructure, transportation, housing) require immediate policy attention. Neither the smaller communities nor the countries in general can afford to bear astronomical human and economic costs and shocks. This is more critical in light of the current global economic structure and trend, which are closely linked, dynamic, and competitive.

2. Conceptualizing Mitigation and Adaptation

Natural hazards and disasters have a long history of study and debate, and policies on managing the impacts have been in existence for decades. By contrast, climate change has only recently emerged on the international and national environmental agenda. Therefore, it is not unexpected that different technical languages have developed. Prominent among the concepts and terms that cause confusion are the words adaptation and mitigation. It is therefore felt necessary to provide operational definitions of these terms so that their usage in this volume is clearly understood.

In the natural hazards community, mitigation is defined as the wide array of actions that can be taken to reduce vulnerability. In the language of the United Nations Framework Convention on Climate Change (UNFCCC), the reduction of carbon dioxide and other GHGs and carbon sequestration in soils and biomass is referred to as 'mitigation'. Also, in the climate change world, the idea of vulnerability reduction is called 'adaptation'. Such varied usage of terms makes communications between the natural hazards and climate change communities difficult. Moreover, in terms of natural systems, many are now defining adaptation as 'building resilience' and 'increasing capacity' within ecosystems to cope with change. Ecologists also define adaptation slightly differently – it is defined in the evolutionary sense – which can add to the overall confusion and demand a careful assessment of the context in which terms are used.

Where the focus is on creating safer, more resilient communities, discussions and documents routinely use such concepts as reducing risk, reducing vulnerability, natural disaster reduction, and hazard reduction without drawing distinctions and assuming understanding. Such terms and concepts expand the lexicon of risk management and can provide helpful distinctions, if they are well explained and placed in context. The purpose here is not to discuss these terms in detail, but rather to note the need for clarity in literature addressing issues related to hazards and the risks they pose to humans. Underlying all such terms is the desire to better understand human exposure and, from this knowledge, influence decisions towards achieving safer communities for all populations.

The key words in the natural hazards/climate change dialogue are almost identical in meaning, except that disaster mitigation refers to all kinds of disasters, including non-natural disasters and those natural disasters that are not climate-related, such as earthquakes, tsunamis, and other geophysical events. Such definitional differences and subtleties are an integral part of the research domain, irrespective of the subject or discipline. However, it is worth noting this anew, when we endeavor to shed light on more complex issues.

Mitigation policies and strategies concerning hazards and disasters, with a natural-trigger, of all types (geophysical, climatic, biological and others) are the thematic subject of the studies of this special issue. In the 'disaster management' context, 'preparedness' and 'response' are often considered 'mitigation'. However, 'preparedness' and 'response' actions are chiefly geared toward readiness for dealing with expected or sudden or imminent events. In contrast, 'mitigation' implies sustained, deliberate measures, implemented well in advance of the event to avoid or reduce the impact of hazards and impending disasters. The usage of the term to depict the same meaning varies from country to country or region to region. For example, the above concept is accepted by most North American institutions, whereas in Australia and Japan, 'loss-reduction' is used. In order to maintain a consistency in this issue, the above concept of mitigation was given to the authors to be used as an operational definition and individual authors were allowed to use their own terms and concepts, only if there were specific clarifications given prior to their application in the text. Adaptation generally refers to reforming, restructuring, and reorganizing for the purpose of making a phenomenon suitable for a new situation, context and need, and from this perspective, adaptation has an evolutionary connotation. Burton et al. (1993) categorized adaptation to NTEE into biological and cultural groups. In this Special Volume, the latter is principally relevant as it involves deliberate or incidental human efforts to adapt to changing environmental conditions and risks.

3. Risk, Loss Potential, Mitigation, and Adaptation

Recognizing the limits of modeling generalization, we present in Figure 3 a schematic flow diagram depicting the processes involved in the interface between natural environment and human society, within which hazards, vulnerability, and risk exist. The model is designed to offer a sequential, but not linear, determination of driving forces, features involved, outputs, iterative processes, and feedback

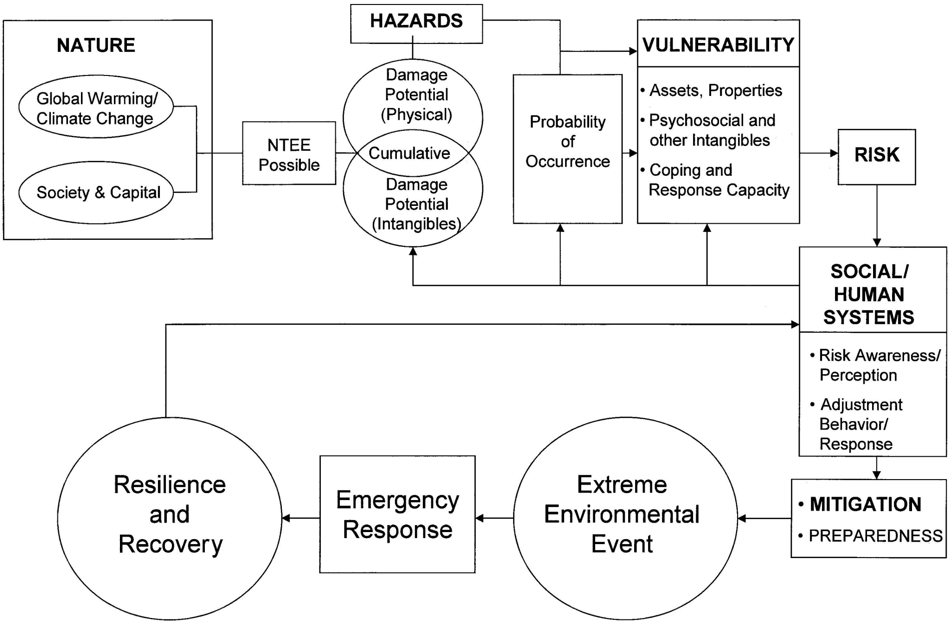

Figure 3. The process of human vulnerability to NTEEs.

loops in a generalized fashion. It is also formulated in the context of the recent trend of global warming and its associated effects upon climatic variables and all major aspects of human spheres. One of the principal objectives of this model is to delineate the place of 'mitigation' efforts as part of human coping and adaptation mechanisms to environmental risks.

A 'hazard' is generated and determined by the potential for damage, both tangible and intangible, by an extreme environmental event. Thus, it is preconditioned by the presence of the human domain. In academic and professional usage, hazards often refer to an objective feature of geophysical processes, without accounting for the damage-potential. In this context, Hewitt (1983) suggests that although "[f]ew researchers would deny that social and economic factors or habitat condition other than geophysical extremes affect risk ... [t]he direction of argument in the dominant view relegates them to a dependent position" (p. 5). We would like to stress that indirect loss as well as damage of intangible resources could surpass damage of tangible and measurable resources due to a disastrous event. In addition, although the concept of cumulative damage potential was introduced by Hewitt and Burton (1971) three decades ago, and 'cascading effects' of catastrophic events have been noticed for many years, serious attention to these aspects has been lacking.

Human risk is considered in terms of chance or probability of a particular hazard actually occurring. For example, a severe earthquake event measured at 7.0 on the Richter scale has the potential to cause damage of $20 billion of assets and property in a large city like Vancouver (Canada), and is thereby recognized as a hazard to the inhabitants of the city. However, this perspective does not reveal anything about the chance of occurrence of a severe earthquake in Vancouver. The product of impact potential (i.e., damage and loss) with probability of occurrence of an extreme event indicates the nature and magnitude of risk. Nonetheless, former dimension (damage and loss potential) requires an indepth analysis of 'vulnerability' to loss to reveal actual overall risk.

Since the early 1980s, there has been a growing acknowledgment of the significance of people and society at large and their relationships to hazards in terms of total hazard risk (Mitchell 1989; Blaikie et al. 1994; Varley 1994; Hewitt 1997; Haque 1997). Vulnerability has been generally conceptualized as a pre-existing condition or state defined by a set of negative attributes that cause people or communities' susceptibility to loss (Berry 2002). The early definition of vulnerability focused primarily on the loss-propensity (e.g., UNDRO 1982; Kates 1985; Bogard 1989), such as UNDRO (1982) has viewed vulnerability as "the degree of loss to a given element or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude". In such a concept, the hazard event is being regarded as the primary cause of loss, with people or communities characterized as 'victims', passive actors that are subordinate to the hazard (Berry 2002). Contributions to critical literature led a rapid evolution and shift in conceptualizing and usage of the term vulnerability to hazards and loss. Since the early 1990s, the focus shifted to human community and people's living conditions, social and economic resources, livelihood patterns and, more importantly, social, economic and political power. It thus embodied a consideration of resilience, and an element of empowering human agents. As Blaikie et al. (1994) have clarified:

> By vulnerability we mean the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood are put at risk by a discrete and identifiable event in nature or in society.

In order to measure vulnerability and make it operational, Ohlson (2003) categorized it into 'exposure to physical events' and 'effects on the human adaptive capacity'. The former aspect focuses on the degree of loss to a given element or set of elements at risk while the latter dimension concentrates more on societal 'band of tolerance' (Smith 1999) and human capacity to cope and adapt to environmental fluctuations and changes.

Risk can be determined by examining the probability of occurrence of the event, along with measuring asset inventory and liable resources (Figure 3). In the risk transference process, awareness (hazard identification) and perception of the environment would function as important intervening variables (Etkin 1999). Potential victims, individually or collectively, tend to determine their behavior to take into account perceived “acceptable levels of risk”. Purposeful measures may be taken to avoid or mitigate the adverse impact of extreme environmental events. Preparation to respond to impending disasters is linked more to an assumption of the onset of the event.

‘Emergency’ refers to a relative time-space conjuncture, and is largely dependent upon the state of danger, anticipation, preparedness, and more importantly, coping capacity of a system. In a broad sense, emergency is a situation or an occurrence of a serious nature, developing suddenly and/or unexpectedly and demanding immediate attention. This is generally of limited duration. Societal adjustments to disasters and emergencies function as negative feedback into the response sub-system, which takes place during and after the recovery phase. For example, following the 1997 Red River Valley flood in Manitoba (Canada), public institutions collectively have undertaken the largest mitigation in the history of the province through expanding an existing floodway system. Gulkan’s study in this volume has revealed that, in Turkey, by contrast, governments have missed an opportunity to reduce future loss by implementing a stricter building code policy following the 1999 earthquake.

It is important to point out that structural (primarily engineering) mitigation measures can only deal with the aspects of physical vulnerability of people, property and assets, and thus are inadequate to encompass the full spectrum of disaster mitigation. It is an utmost necessity to underscore the significance of the societal effects of environmental hazards and disasters, particularly the implications of disastrous events on socioeconomic recovery and ability to respond to future events.

Prehistorically, humankind has evolved with limited control over the natural forces for most parts of their evolutionary path, but with cultural and technological development such relationships changed phenomenally. Both evolutionary and dramatic discoveries, inventions, and subsequent innovations were significantly involved in influencing such changes. Since the Industrial Revolution, our capacity to manipulate natural laws and forces accumulated dramatically. As well, human impact on the environment has generated newer kinds of risks, often resulting in catastrophic disasters. In today’s postmodern society, our challenges have shifted from preparing and responding to hazards and impending disasters to undertaking deliberate actions to avoid and/or reduce their adverse effects. Public and institutional policies formulated by the concerned public and private agencies to prevent and mitigate risks and hazards, stemming from Mother Nature and its forces, have exhibited clear evidence of cost-effectiveness and net positive results. As well, it is important to formulate strategies and action and to implement plans in innovative ways in order to mitigate and adapt to emerging environmental changes and challenges.

As illustrated above, a very disturbing trend with respect to loss due to nature-triggered disasters has been depicted by several contemporary studies (Munich Re. 2003; Etkin 1999; Burton et al. 1993; Figures 1 and 2). It is evident, first, that in the developed world, despite considerable technological and organizational advancements, the economic and social loss due to NTEEs has been increasing over the last hundred years (the magnitude of loss of human lives decreased significantly). Secondly, in the capital-poor, developing countries, loss of human lives and injuries have been rising during the last century. Given this scenario, the importance and role of an exploration into diverse concepts and experience in formulating and implementing mitigation and adaptation related policies and programs in various parts of the world cannot be underestimated. Sharing of such experiential learning and futuristic policy, planning, and management ideas, in the context of similar and dissimilar geophysical, ecological, and socio-cultural and economic backgrounds, can be a very effective means for advancing our knowledge and of addressing serious issues of threats to lives, properties, and resources. It is critical in this type of exercise to generate and share ideas to develop and examine various options for avoiding, reducing, and recovering from loss due to NTEE, so that appropriate policy guidelines and measures can be formulated.

It is important to reiterate three features:

(i) According to Munich Reinsurance Company (2003), the numbers of NTEE, specifically floods and windstorms, have increased since 1976, and their associated economic losses including insured losses have more than doubled by 1995 (crossing the US $50 billion per year mark; Figure 2). Notably, 2001 experienced more than US $55 billion loss due to NTEE.

(ii) IPCC findings reaffirm the above pattern, revealing projected increased risks of floods and droughts in many regions of the world. Specifically, based on high resolution modeling studies, the Panel has indicated an increase over some areas in the peak wind and precipitation intensity of tropical cyclones.

(iii) The International Federation of Red Cross and Red Crescent Societies (IFRRCS 2003) recorded a trend of considerable increase in deaths and injuries throughout Asia, Africa, and Latin America during the recent decades, despite a rapid economic growth in many countries. Haque (2003), in his investigation of selected southeast and south Asian and Pacific island nations, registered a positive correlation between development indicators and disaster loss. One plausible explanation is the tendency of denial by elites of society of risky locations, on the one hand (Etkin 1999, p. 73–74), and increased poverty in both developing and depressed regions, on the other (Haque 1997, 2003). Globally, in 1960 the richest fifth population received 30 times the income of the poorest fifth; the ratio by 1997 rose to 60 (Brown et al. 1998; cited in Etkin 1999, p. 73). Blaikie et al.'s (1994) 'pressure and access' model explains this feature by arguing that social processes largely determine the site, location, technological and cultural tools and other tangible and aesthetic resources. Thus, the social systems "create the conditions in which hazards have a differential impact on various societies and different groups within [the] society" (p. 46). Haque (2003) further asserts that if adequate risk assessment and measures are not undertaken during resource use and decision, such as during project design and implementation, development activities will lead to increasing susceptibility because of the accumulation of infrastructural and non-monetary establishments over time.

4. Mitigation is Linked with Vulnerability and Resilience

Institutional approaches to environmental risk and hazards during the post World War II era have been dominated by efforts to modify the 'natural event systems' (i.e., geo- and bio physical variables) to minimize the physical parameters of events (Burton et al. 1999; Hewitt 1994). In cases where the scope for modifying the physical processes was limited (such as earthquakes and hurricanes), emphasis by the dominant 'technological-fix' school was placed upon appropriate land-use planning, introduction to building codes, improved weather forecasting, regulatory intervention in natural resource use, and engineering modification so that NTEE could be resisted or contained. Given the fact the scope for effective human interventions into the geo- and biophysical events to prevent so-called extremity is restricted in several areas, emerging new realities complicate the challenges further. In the context of recent global warming and possible climate change, McBean presents the case of tornado risk as an example of climatic hazards. He concludes that risk-management strategies should assume more frequent events in the future, and argues that mitigation strategies for NTEE will always be dealing with risk. With climate change bringing a new set of risks, each with its uncertainties, the risk manager, policy and decision maker have new challenges. Since NTEE like tornadoes have considerable impacts and divert resources towards mitigation and recovery, changing NTEEs are a significant factor affecting economic growth and social development.

Several studies incorporated in this volume have challenged the dominant approach to risk and hazards mitigation in which the underlying goal is to "fix" natural processes or resource use (land-use) pattern, building structures, and warning systems and communication means. Indepth research in Australia (Anderson-Berry and King), Brazil (Branco et al.) and Canada has revealed a strong association between effective hazards mitigation and addressing societal and physical (i.e., location-related) vulnerability of local communities, and taking responsibility in terms of collective and individual response-behavior. Anderson-Berry and King view mitigation strategies and measures as a disparate component of hazards as they are linked with both 'resilience' and 'vulnerability'. Based on the findings from a longitudinal, empirical investigation in the tropical cyclone-prone northern Australian communities, they assert that mitigation efforts must be built on strengths and target weaknesses and limitations. The study offers a method for measuring and ranking both vulnerability and resilience, and thus indicating community capacity to mitigate the impact of the hazard. As individuals and communities must bear the primary responsibility for their own hazard mitigation efforts through knowledge, awareness, preparation, and appropriate response-behavior, the role and focus of public and private institutions should be to assist or directly determine those strengths and weaknesses of resilience and vulnerability for ultimate elimination or mitigation purposes.

By reflecting the theoretical propositions of Anderson-Berry and King, Branco et al.s' empirical study in northeastern Brazil demonstrate that the provision of shared responsibility and a 'grass roots' approach to mitigation can strengthen community resilience and reduce vulnerability. The study attempts to spelling out the utmost significance of non-structural mitigation measures, along with other alternatives. It is recommended that although rainwater harvesting to mitigate drought hazards *per se* is a structural measure, without community participation such a labour-intensive option would not be feasible. By examining the Canadian perspectives, Pearce makes a strong case advocating for a crucial need of community involvement for risk, hazards, and disasters mitigation. In order to substantiate her arguments, Pearce presents a community case from western Canada in her paper. The study concedes that formulation of mitigation strategies and measures is preconditioned by a successful Hazards, Risk and Vulnerability (HRV) analysis. It further adds that public participation is an important element in ensuring that community and region-based HRV analysis is meaningful.

In the developed world in general, disaster mitigation traditionally has been an 'academic' concern with limited relevance to policy issues. As discussed above in detail, nonetheless, since the mid-1970s the staggering public and private (mainly insurance) cost raised new questions and interest regarding cost-effectiveness and other feasibilities (political, social, cultural and others) of risk and hazards mitigation. Research yet to be done to demonstrate, with conceptual substantiation and empirical evidence, that mitigation would make sense in many projects when realistic choices are assessed and decisions are made for net social and economic gains against human and economic investments. Through his contribution to this volume, Ganderton argues that the fundamental principles of benefit-cost analysis of disaster mitigation should guide the decision generation system. However, finally, pragmatic response decisions, with good practice in project evaluation, should be made considering a broad spectrum of choices that go beyond monetary value.

A similar message is echoed by Etkin and Stefanovic as they claim that NTEE induced losses are largely attributed to human behavior that creates vulnerable communities. Hence, in order to eliminate or reduce vulnerability and mitigate the risk of disasters, it is necessary to consider underlying values – i.e., peoples' world view and their nature of interaction with the natural domain. Rather than illustrating the natural domain as villain against human on world stage, they argue for advancing disaster mitigation through a process that will place greater emphasis on human interactions with and reliance upon the natural world, and the development of community resilience. In order to attain the goal of sustainability of all forms of life and the balance between living and non-living elements of our ecosphere, Etkin and Stefanovic provocatively suggest a paradigm change, towards an eco-ethical approach to NTEEs and their losses. Furthering a similar postulation, Mileti and

Gailus call for an adoption of interdisciplinary (i.e, interconnected and overlapping rather than cross- or trans-disciplinary) approach to risks and hazards to effectively prevent and/or minimize loss and ensure sustainable development. The findings of a team of more than 100 expert academics and practitioners, who participated in the Second Assessment of hazards research and application in the United States (terminated in 1998) have suggested that losses from hazards and the inability to comprehensively reduce losses of all types have been the result of sectoral, discipline-based development approach as well as narrow cultural premises and attitudes towards the natural environment, science, and technology. Mileti and Gailus's analysis of impact of the Second Assessment on the research and applications community is suggestive of the complementary role of knowledge-stakeholders, managers and field practitioners.

Democratic political systems, which are predominant mode of governance in North America, Europe and many other nations of other continents, are usually thought to represent and be accountable to their citizens. Accordingly, the development of risk, hazards and disasters management policies, like other policies, is often thought to be generated, although indirectly, by the public. In reality, under such system, elected representatives are responsible for initiating appropriate public action programs. Yet, while public involvement does occur in many aspects of disaster and emergency management policy in the democratic world, many quarters tend to criticize current institutional norms and practices concerning public safety, security, risk-reduction and emergency responses as 'superficial' and thereby inefficient. Due to lack of accountability of public representatives, the complexity of issues and processes, and different access to financial and technical resources enjoyed by competitive interests are just some of the barriers that discourage effective public involvement. A movement, which may partly be triggered by such criticisms, by the public institutions towards effective public participation in the development public policy is noticeable. In order to present such a case, Valeriah Hwacha reports on the processes and outcomes of the efforts of the Government of Canada, through the Department of Public Safety and Emergency Preparedness Canada in conducting consultations with provinces, territories and stakeholders to develop a national disaster mitigation strategy (NDMS). The Strategy aims at enhancing Canada's capacity to prevent as well as mitigate disasters and their associated losses before they take place and promoting the development of disaster-resilient communities. Hwacha clarifies why and how, in the NDMS process, stakeholders have recommended to create a robust national emergency management system, and agreed that a policy direction towards mitigation will be a wise investment in the country's future.

Serious shortcomings of contemporary democratic political and decision-making systems, in which regimes possess limited term of governance, in adopting long term mitigation strategy are recognized, although implicitly, by Gülkan in Turkey. Polat Gülkan has been directly involved in developing and implementing Turkey's national disaster recovery and reconstruction, and rehabilitation policies and programs, yet he reveals his frustration in influencing them to adopt an effective mitigation strategy. He argues that following a disaster, such as an earthquake or catastrophic flood, a window of opportunity is created for policy makers to undertake long term mitigation measures that would benefit individual and collective interest immensely. The experience in Turkey following the 1999 earthquake shows a disappointing characteristic – an absence of a comprehensive, unified disaster management approach embodying mitigation strategies to reduce the future toll of NTEE. The country as a whole exhibited an admirable success in reconstruction and immediate recovery from the earthquake disaster but risk from and vulnerability to future NTEE were not accounted for in the national policy decisions. The study implicitly indicates that the preoccupation of decision-makers with a goal of demonstrating immediate, visible, results of policy and program implementation is a major hindrance to the formulation and implementation of a national, sub-national or regional mitigation strategy.

A major element of concern in developing a national mitigation policy is the lack of adequate recognition of local and/or regional issues, problems, and cultural perspectives. The overriding interest and pressure groups are usually successful in designing or strongly influencing public policy development, which unfortunately would augment geographical, ethnic, racial, and other societal inequities unless they are addressed forcefully. Using northern Canada as a regional case study, Newton et al. analyze the current perspectives of NTEEs that are likely to be influenced by climate change. The study reveals that, in the societal and policy domains of the Canadian North, the place of the greenhouse gas emission is not a crucial issue. Newton et al. finally provide a rationale behind the need for more comprehensive adaptive strategies to complement the current tendency to focus on the mitigation primarily of greenhouse gases produced in the Canadian North.

5. Conclusions

To synthesize, we find that, although there is much controversy around climate change, especially whether there is a permanent shift from the expected climatic fluctuations and variability, the fact of warming of the atmospheric temperature in the last century is no longer a subject of scientific or policy debate. The agreement on the later subject has been profoundly influenced by the real-time observations, since the 1950s, of global surface temperature, notably in the Northern Hemisphere. Due to such changes in the geophysical parameters, certain types of nature-triggered environmental extreme events are likely to continue to increase. How global warming will affect regional climates and pertinent variables is not well known, which substantiates the fact that our ability to predict precisely consequential effects is limited, and poses serious constraints against straightforward policy decisions.

The trend of global average annual economic loss, both insured and uninsured, due to NTEE exhibits an alarming upward trend. While it was less than US $20 billion during the 1970s, by the year 2000 the average loss per year was more than US $70 billion. In exceptional years, for example, in 1995, it reached as high as US$167 billion. If a full-cost accounting of these phenomena is attempted, the numerical figures concerning loss due to NTEE would multiply in a compounding manner. Such a sudden colossal, economic setback is not only a threat to sustainable development and prosperity, but also hampers our societal resilience considerably. The established and dominant perspectives of disaster are deeply embedded in response and relief. The authors of this book collectively have placed a call for a shift of emphasis from response and relief (management-focus) to "preparedness, mitigation and prevention within the context of sustainable development towards reducing our collective risk and vulnerability to natural hazards" (Briceno 2004).

Research findings of the work of this volume reaffirm that human dimensions, specifically our awareness and decision-making behavior, are powerful explanatory factors of increasing disaster-losses. It has been recently recognized widely that many regions of the world are rapidly accumulating large, latent risk burdens and increasing vulnerability through the concentration of low-income population in risky areas, the loss of ecological resilience to withstand NTEEs, generation of the momentum of rapid urban and economic growth, rural-urban migration, and the loss of social safety nets. A disastrous event thus exposes cumulative tensions of risk, unleashing the levels of impact that supercedes local, regional, and national coping capacities. Disaster mitigation through addressing human, social, and physical vulnerability is one of the best means for contributing to 'climate change adaptation plans' and sustainable development goals.

Conventional disaster response approach has a historical background in civil defense and application of a 'command and control' approach to dealing with emergencies and immediate recoveries. However, recent lessons from various countries have depicted that the formulation of mitigation strategies cannot be top-down as it requires social, political, and cultural acceptance and sense of ownership. An interactive, participatory process, involving local communities, produces best expected outcomes concerning mitigation, preparedness, and recovery. An emerging consensus is that there is a need to move towards the goal of the International Strategy for Disaster Reduction. Sharing of best practices and lessons globally is certain to produce more efficiency and understanding in policy and decision making. In the words of the Director of the Inter-Agency Secretariat of the ISDR, Salvano Briceno:

> We need to harmonize our efforts towards sustainable development plans and poverty reduction initiatives to include disaster risk assessment as an integral component, increasing investment in reducing risks and vulnerabilities towards the achievement of the Millennium Development Goals and the Johannesburg Plan of Implementation for Sustainable Development. Disaster reduction is both a humanitarian and development concern that must be considered as one of the core responsibilities of the international community at large (2004, p. 3).

We find that there is a reasonable volume of literature that advocates in favor of vulnerability, hazard, and disaster reduction. At the policy level, linking disaster mitigation efforts with vulnerability and poverty reduction is still illusive. Portraying specific cases that help establish the fact that mitigation works, in economic, social and political sense, is needed to influence policy and decision makers. Such show-cases should be developed, in the first place, for convincing exhibition to the public, stakeholders, and institutional representatives.

Finally, the 'top-down' and 'command and control' approaches conceal within the assumptions that extreme environmental events are essentially the breakdown of the normal functions of our society and economy and, as crisis, are essentially a deviation from the order of the established structures (Hewitt 1983, p. 29). The restorations of order and so-called 'normal' conditions become the primary mission of crisis and disaster management, relief, and reconstruction. We would like to assert that this notion fails to determine the principal factors of disaster, that is, the impact of NTEE upon society and the economy. In addition, the efforts in prevention and mitigation of hazardous events, by modification of the geophysical processes, have dominated the policy, planning, and decision-making until the recent past. However, the serious limitations of such views were widely recognized, as such geophysical and engineering approaches failed to shift disaster loss downward. The chapters below depict that, for their effectiveness, the risk, hazard, disaster mitigation and management must embody human concerns – vulnerability, resilience, and spirit – along with geophysical processes. Without such a change, mitigation of disasters will remain a fallacy rather than a reality.

References

Balling, R.C. and Cervany, R.S.: 2003, 'Compilation and discussion of trends in severe storms in the United States: Popular perception v. climatic reality', *Natural Hazards* **29**, 103–112.

Berry, L.J.: 2002, *Community Vulnerability to Land-Falling Tropical Cyclones and Storm Surges*, Ph.D. dissertation, School of Tropical Environmental Studies and Geography, Townsville, Queensland, James Cook University.

Blaikie, P. et al.: 1994, *At Risk: Natural Hazards, People's Vulnerability and Disasters,* London, Routledge.

Bogard, W.C.: 1989, 'Bringing social theory to hazards research: Conditions and consequences of the mitigation of environmental hazards', *Sociological Perspectives* **31**, 147–168.

Briceno, S.: 2004, *Global Challenges in Disaster Reduction,* Available at http://www.ema.gov.au/ema/rwpattach.nsf/viewasattachmentPersonal/B78479D88B6C7A24CA256DB2002F1A5D/$file/DC%20Briceno%20Global%20Challenges%20in%20Disaster%20Reduction.pdf.

Burton, I., Kates, R. and White, G.F.: 1993, *The Environment as Hazard,* 2nd Edition, New York, The Guilfor Press.

Cannon, T.: 1994, 'Vulnerability analysis and the explanation of 'natural' disaster', in A. Varley (ed.), *Disasters, Development and Environment,* Chichester (UK), John Wiley, pp. 13–30.

Changnon, S.A.: 2003, 'Shifting economic impacts from weather extremes in the United States: A result of societal changes, not global warming', *Natural Hazards* **29**, 273–290.

Chase, T.N. et al.: 2003, 'Changes in global monsoon circulations since 1950', *Natural Hazards* **29**, 229–254.

Etkin, D.: 1999, 'Risk transference and related trends: Driving forces towards more mega-disasters', *Environmental Hazards* **1**, 69–75.

Fachereau, N. et al.: 2003, 'Rainfall variability and changes in southern africa during the 20th century in the global warming context', *Natural Hazards* **29**, 139–154.

Haque, C.E.: 1997, *Hazards in a Fickle Environment: Bangladesh,* Dordrecht, Kluwer Academic Publishers.

Haque, C.E.: 2003, 'Perspectives of natural disasters in East and South Asia, and the Pacific Island States: Socio-economic correlates and needs assessment', *Natural Hazards* **29**, 465–483.

Hewitt, K.: 1983, 'The idea of calamity in a technocratic age', in K. Hewitt (ed.), *Interpretations of Calamity: From the Viewpoint of Human Ecology,* Boston, Allen and Unwin Inc., pp. 3–32.

Hewitt, K.: 1997, *Regions of Risk: A Geographical Introduction to Disasters,* London, Longman Harlow.

Hewitt, K. and Burton, I.: 1971, *The Hazardousness of a Place: A Regional Ecology of Damaging Events,* Toronto, Department of Geography, University of Toronto.

IFRCRC (International Federation of Red Cross and Red Crescent Societies): 1997, *World Disaster Report 1997*, Geneva, Oxford University Press.

IFRCRC (International Federation of Red Cross and Red Crescent Societies): 1998, *World Disaster Report 1998*, Geneva, Oxford University Press.

IFRCRC (International Federation of Red Cross and Red Crescent Societies): 2003, *World Disaster Report 2003*, Geneva, Oxford University Press.

IPCC (Intergovernmental Panel on Climate Change): 2001, *Climate Change 2001: Synthesis Report – Summary for Policy Makers,* IPCC Plenary XVIII, Wembley (U.K.).

Kates, R.W.: 1985, 'The interaction of climate and society', in R.W. Kates et al. (eds.), *Climate Impact Assessment,* SCOPE 27, New York, Wiley.

Kattenberg et al.: 1996, 'Climate models-projections of future climate', in *Climate Change 1995. The Science of Climate Change: Contributions of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge, Cambridge University Press.

Lawson, B.D.: 2003, 'Trends in blizzards at selected location on the Canadian prairies', *Natural Hazards* **29**, 123–138.

Khandekar, M.L. and Gönnert, G.: 2003, 'Special issue on global warming and extreme weather: An assessment', *Natural Hazards* **19**(2).

Khandekar, M.L. and Murty, T.S.: 2003, 'Guest editorial', *Natural Hazards* **29**, 101.

Mitchell, J.K.: 1989, 'Hazards research', in G.L. Galle and C.J. Willmott (eds.), *Geography of America,* Columbus, O H Merrill, pp. 410–424.

Munich Reinsurance Company: 2003, *Topics (Annual Review: Natural Catastrophes 2002),* Draft Version, Munich.

Ohlson, D.: 2003, 'A Risk-based approach to climate change adaptation in the forest management sector', in the Canadian climate impact and adaptation research network (CCIARN) (ed.), *Climate Change and Forests: Making Adaptation a Reality*, A report of the CCIARN workshop on climate change and forests, Winnipeg, November 18–19, pp. 39–50.

Robinson, P.J.: 2003, Atmospheric circulation and inland flooding in twentieth century North Carolina, USA: Implications for climate change impacts', *Natural Hazards* **29**, 155–172.

Shabbar, A. and Bonsal, B.: 2003, 'An assessment of changes in winter cold and warm spell over canada', *Natural Hazards* **29**, 173–188.

Smith, K.: 1999, *Environmental Hazards: Assessing Risk and Reducing disaster,* 2nd Edition, London, Routledge.

UNDRO (United Nations Disaster Relief Organization): 1982, *Natural Disasters and Vulnerability Analysis,* Geneva, Office of the United Nations Disasters Relief Coordinator.

Valrley, A. (ed.): 1994, *Disasters, Development and the Environment,* Chichester, John Wiley.

SECTION 1: VULNERABILITY, MITIGATION AND RESPONSE TO ATMOSPHERIC AND HYDRO-CLIMATIC HAZARDS

RISK MITIGATION STRATEGIES FOR TORNADOES IN THE CONTEXT OF CLIMATE CHANGE AND DEVELOPMENT

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(Received 18 December 2003; accepted in final form 2 March 2004)

Abstract. Mitigation strategies for natural hazards will always be dealing with risk. With climate change bringing a new set of risks, each with its uncertainties, the risk manager has new challenges. Since natural hazards like tornadoes have large impacts and divert resources towards mitigation and recovery, changing natural hazards are a factor affecting development. In this paper, an analysis of tornado risk in Canada in the context of a changing climate is given which leads to the conclusion that risk-management strategies should assume more frequent events in the future.

Keywords: climate change, development, natural hazards, risk management, tornadoes

1. Introduction

In the broad scope of public-policy discussions with respect to the environment and people, two issues are most frequently at the forefront: sustainable development and climate change. The two issues are intrinsically linked as noted, for example, by Runnalls (2003), President of the International Institute for Sustainable Development in Canada, "... climate change, [is] the greatest problem facing sustainable development today."

This connection was also recognized in the United Nations Framework Convention on Climate Change, which states the following objective:

> ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure food production is not threatened and to enable *economic development to proceed in a sustainable manner* (UNFCCC 1992, emphasis added).

It is clear that climate change, however, is just one of the stressors on societies, ecosystems and, hence, sustainable development. Watson (2000) states: "One of the major challenges facing humankind is to provide an equitable standard of living for this and future generations: adequate food, water and energy, safe shelter and a healthy environment (e.g., clean air and water). Unfortunately, human-induced climate change, as well as other global environmental issues such as land degradation, loss of biological diversity and stratospheric ozone depletion, threatens our ability to meet these basic human needs."

The concept of sustainable development brings together social, environmental and economic considerations. Perhaps the most succinct definition of sustainable development is, "to ensure that [humanity] meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). In practice it means that societies need to look to the future and make investments now that will allow future generations to have health and well-being consistent with present generations.

Natural disasters can have large impacts on human development and some events have reversed years of progress (Mileti 1999). Handmer (2003) notes that the poorer the country the greater the impact on the economy and on development progress, citing, for example, that Hurricane Mitch in 1998 caused an impact on the Honduras' economy of about 75% of its gross domestic product. Development is then not sustainable. Part of sustainable development needs to be the consideration of decisions being made now, including decisions to invest or not, and how they will alter exposure of society to the risk and occurrence of natural hazards.

Policies and strategies addressing all natural hazards result in sustained, deliberate measures, implemented well in advance of the event to avoid or reduce the impact of hazards. There are different approaches to disaster management:

- Mitigation (sometimes called adaptation) is the adoption and implementation of standards and codes to protect infrastructure, people, etc., from extreme events based on an analysis of probabilities of events and the costs of implementation. It should be noted that 'mitigation' in the climate-change community means reducing emissions to reduce the hazard, a very different approach than climate-change adaptation (which is essentially hazard mitigation). For example, building codes can be modified to account for the increased likelihood of tornadoes, winter storms and coastal storm surges. In addition to modifying building codes, communities should prepare response strategies.
- Another complementary approach is anticipation of natural hazards through warnings, forecasts and scenarios. Warnings advise people about impending events (e.g., tornado or flood). Forecasts or scenarios identify anticipated climate events such as seasonal drought or long-term climate changes, respectively. Appropriate response strategies can then be identified. The response strategy will vary with the event. For example, in the case of a tornado within the next 10 min, the response is to seek safe cover. If the warning is given for a river crest within the next 5 days, the response can be preparations for evacuation and implementation of emergency actions. If a forecast or scenario predicts more tornadoes over the next year, decade or century, responses can include changing of building codes, introducing more educational programs and improving warning systems.

In a disaster-management context, emphasis must be on damage prevention and human safety through mitigation-adaptation and anticipation (early warnings), rather than recovery. Recovery is an unavoidable reaction for most governments. However, it has been shown (Mileti 1999) that investments in mitigation-adaptation can greatly reduce or eliminate costs of responses and recovery at a later date. At present, many governments have sustainable development strategies in place. For example, the Government of Canada requires each of its ministries to develop a sustainable development strategy (Treasury Board Secretariat 2004). These strategies mostly focus on impact of the ministry's operations or activities on the environment (Environment Canada 2001). A common approach is to "green" their activities by reducing emissions of pollutants and reducing waste. They seldom include recognition that natural hazards impact on Canadians and their activities and that these impacts can reverse development. There are some exceptions such as the Department of Fisheries and Oceans having a goal "to ensure safer navigation in Canadian waterways" and Health Canada "protecting health from environmental hazards." In other words, it is important as part of a sustainable development strategy to look at the impacts of the environment (either natural or human-changed) on economic and social systems. Governments need to develop and implement policy and strategic options concerning hazards and disaster mitigation that will reduce human suffering and socio-economic cost and contribute to sustaining the environment. Another part of sustainable development involves developing resilient communities. Resiliency is achieved through analysis of risks from natural hazards and formulation of policies and strategies to minimize risks and damage. Since we will always have imperfect knowledge of the state of our present and future environments and the potential for disasters, building resilience prepares us for a range of situations.

2. Natural Hazards in Canada

Year 2003 was one in which Canadians were continuously reminded of their vulnerability to hazards. There has rarely been a year with such a variety of weather disasters month-after-month and from coast-to-coast (Meteorological Service of Canada 2003a). Avalanches killed 28 people in western mountains, wildfires burned in Alberta and British Columbia, flash floods occurred in Quebec, BC, and Newfoundland, hydrologic drought persisted in the southern Prairies and damaging winds and hailstorms hit Alberta. Hurricane Juan struck Atlantic Canada. Insured property losses and other disaster costs made it one of the most expensive years ever for Canada. Two weather events alone – the wildfires in British Columbia and Hurricane Juan in the Maritimes – racked up costs of almost $ 1 billion (Meteorological Service of Canada 2003a). Dore (2003) has analyzed information from the Office of Critical Infrastructure Protection and Emergency Preparedness (2003) and concluded that hydrometeorological disasters (hailstorms, ice storms, droughts, ice storms and others) and injuries due to extreme weather events are both increasing with time. Deaths due to extreme weather events vary with the decades since 1900 but have increased from the 1970s to the 1990s. In comparison, the number of geophysical disasters (avalanches, earthquakes, landslides, tsunamis) is unchanged over time.

Recent tragedies have included the eastern Canada ice storm of 1998 with a cost of over $ 5 billion (Canadian dollars) and about 28 deaths, the Saguenay flood of 1996, with economic impacts of $ 1 billion, ten deaths and 150 000 displaced people, and the Red River flood of 1997, with about $ 1 billion in damages, four deaths and 25 000 evacuees (OCIPEP 2003).

The growing costs of natural hazards have prompted Canada's (and other countries') insurance companies to become more proactive. With support of the member companies of the Insurance Bureau of Canada (IBC), the Institute for Catastrophic Loss Reduction (ICLR) was created initially within the IBC and later as a research institute at the University of Western Ontario. The ICLR mission is to reduce loss of life and property caused by severe weather, weather-related events and earthquakes through identification and support of sustained actions that improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. The focus is on prevention of devastating losses from natural hazards. This paper discusses the tornado hazard in Canada. While Canada has a lower tornado risk than the United States, destructive and deadly tornadoes have occurred here in the past.

3. Tornadoes: Extreme Events With Major Impacts

Tornadoes have generated major impacts in Canada and in other countries, particularly the United States. Some recent Canadian tornadoes include Edmonton, Alberta, in 1987, with 27 deaths; Barrie, Ontario, in 1985, with 12 deaths; and Pine Lake, Alberta, in 2000 with 12 deaths. In the historical record, the distribution of tornado events causing deaths and the number of deaths are greatest in Saskatchewan and Ontario (OCIPEP 2003). Mitigation of tornado impacts is a major strategic consideration for different levels of government, including the weather services, municipal planners, emergency response organizations and relief agencies.

Most Canadian tornadoes have been classified as weak on the Fujita scale (Glickman 2000; NOAA 2003; Meteorological Service of Canada 2003a), which varies from F0 to F6 (see http://www.spc.noaa.gov/faq/tornado/f-scale.html). An F1 tornado is referred to as a moderate tornado resulting in cars being overturned, trees uprooted and carports destroyed and with winds estimated to be in the range of 117–180 km/h. The majority of Canadian recorded tornadoes between 1980 and 1997 fell in the F0 to F1 range (Meteorological Service of Canada 2003b). Only 7% of the average 80 tornadoes per year across Canada during this period were F2, and about 1%, F3. In the United States there are 800 to 1000 tornadoes per year and about 15% are of F2 intensity (The Tornado Project 2002). An F3 tornado results in houses torn apart, trains overturned and forests and farmland flattened with winds estimated in the range of 253–330 km/h. In the historical records of the

Meteorological Service of Canada only nine tornadoes have been classified as F4. No F5 tornado has ever been recorded in Canada, although there have been several reported in the United States. Statistics concerning tornado intensity may, however, be imprecise due to the difficulty of measuring tornado damage. In fact, nearly 43% of Canadian tornadoes are officially unclassified. Confirming and classifying tornado touchdowns is a particular problem in sparsely populated areas, when little damage is visible and few people witness the tornadoes. For example, a powerful tornado may travel through open fields, causing minimal damage and thus rank low on the F-scale. In contrast, a weaker tornado may pass through a populated area and receive a higher F-scale ranking because it caused more visible damage.

An average F0 tornado track is about 40 metres wide and 1.7 kilometres long. An average F4 track is about 400 metres wide and 36 kilometres long (OCIPEP 2004). Tornado impacts are often very localized but warning must be issued for a larger area because of uncertainty in predicting actual paths and the size of forecast regions. For example, Barrie, Ontario, was impacted by a tornado in 1985. This was a multiple outbreak event that took 12 lives and caused about $ 200 million (Canadian) in damages. The tornado watch area, as issued by the Meteorological Service of Canada, covered an area of about 10 000 km^2, while the area with significant damage was less than 100 km^2. So most of those who were in the area of the tornado watch would not have been impacted; the risk of being impacted was less than 1/100.

Another tornado example is the Pine Lake, Alberta, event of July 2000, which caused 12 deaths. Following the Pine Lake event, the ICLR undertook a study, comparing the communities of Pine Lake and North Dumfries, Ontario, and their perceptions of the tornado hazard. These communities are similar demographically and have comparable statistical tornado risk. However, North Dumfries has not seen a tornado in over 50 years while Pine Lake experienced the recent devastating event. In both communities, a survey showed, with little difference between the communities, that most people believed a tornado warning was a serious enough threat to alter their plans (76%) and that the science of tornado warning and predictions is somewhat or quite accurate (84%). However, in Pine Lake, 61% knew that the length of time to take shelter when a warning is heard is only 10 min, whereas in North Dumfries, only 26% knew, apparently as a result of their recent experience. Further analysis of these surveys will be reported later. The results do indicate significant differences between communities' perceptions of risk and their understanding of response strategies.

4. Climate Change

The IPCC (2001a, pp. 12, 13) has recognized that human-induced climate change will very likely create changes in the frequency of occurrence of extreme events. "The frequency and magnitude of these type of events: heat waves, floods, droughts, fires and extreme weather events leading to significant economic losses and loss of life, are predicted to increase in a warmer world” (Watson 2000). This was recognized in the Ministerial Declaration of the 8th Conference of the Parties (Delhi 2001; cited in UNFCCC 2003), which, in reference to climate change and sustainable development, called on countries to, “... promote sustainable development...” including “adaptation to the adverse effects of climate change is of high priority for all countries.”

The IPCC (2001a, p. 14) has projected a global mean temperature change between about 1 °C to almost 6 °C, depending on various emissions scenarios and accounting for model sensitivities. One of the identified reasons for concern is the increasing risk from extreme climate events. Even for the smallest likely increase in temperature, the IPCC assessment was an increase in risks from extreme climate events and, as the global mean temperature change increases, that risk becomes larger. Although there are uncertainties in these predictions, Zwiers (2002) has pointed out that confidence can be placed on the 20-year forecasts.

Various extreme climate events can change in intensity and frequency with a changing climate. The IPCC has provided historical analyses and projections with confidence levels of changes for extreme events. For example, the IPCC (2001a, p. 15) has reported more intense precipitation events over the northern hemisphere mid- to high-latitude land areas, at a confidence level of 66–90% during the latter half of the 20th century. They project with a 90–99% confidence level more intense precipitation events over many areas during the twenty-first century. The scientific consensus on changes in extreme precipitation events is strong compared to other extreme events.

Canadian tornadoes are related to daytime heating and most occur in the spring and summer when daytime high temperatures exceed 20 °C (see Figure 1). The IPCC concluded with 90–99% confidence that increases in the number of hot days over nearly all land areas would occur with climate change. Karin and Zwiers (2000) projected increases in the number of hot days (defined as a day with maximum temperature greater than 30 °C) in southern Ontario, Alberta and Manitoba by a factor of about six by the period 2080–2100. Since tornadoes depend on factors beyond just the degree of “hotness,” it is not justified to directly translate this into a change in either tornado frequency or intensity. Raddatz (2003), for example, has postulated that increased CO_2 could result in more benign summer severe weather seasons. The IPCC noted that, “... confidence in models and understanding is inadequate to make firm projections. In particular, very small-scale phenomena such as thunderstorms, tornadoes, hail, and lightning are not simulated in global models” (IPCC 2001b).

5. Risk Analysis

In the decades to come, the climate will continue to change, but changes in the frequency of occurrence of extreme events like tornadoes are difficult to scientifically

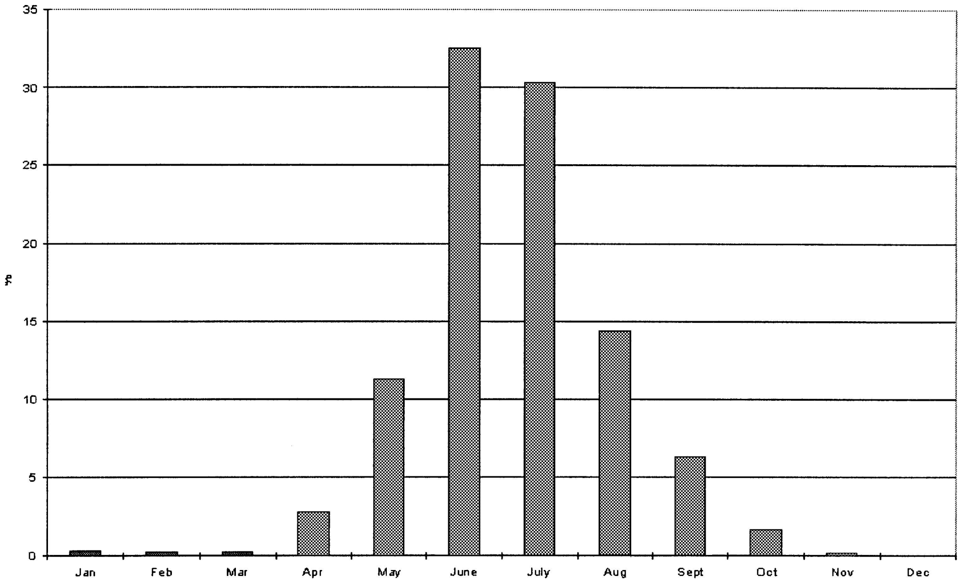

Figure 1. Canadian tornado occurrence as a percentage by month (Tornado 2003).

project. The consensus for increasing frequencies of intense precipitation events and number of hot days is fairly strong, while that for increases in tornadoes frequencies is not clear.

Present-day tornado risk is higher in the Midwest of the United States just south of Canada. Further, the percentage of higher intensity tornadoes is twice as high in the United States (14% of F2, compared to 7% presently in Canada). Modeling simulations have shown an increase in the number of hot days, hence a longer tornado season (the period when daytime maximum temperatures exceed 20 °C) is more probable.

Extreme events result in significant costs. These funds are often diverted from other societal investments that contribute to sustainable development. Societies already make investments to reduce the impacts of extreme events with mitigation investments found in structural and/or non-structural approaches. A fundamental issue for governments and societies is the management of risk in face of uncertainties of whether and how extreme events will increase with a changing climate.

In developing a risk mitigation strategy incorporating climate change, it is important to note that there is no evidence that the number of extreme events, including tornadoes, will decrease in the future. As such, governments should be at least maintaining their current level of investments. Since infrastructure is becoming more expensive, the costs associated with similar numbers of tornadoes will also increase, so it makes sense to make larger investments today towards reducing future costs. For comparative judgment on investments, increasing baseline investments is required in the future. The key risk-management question is: should society base its future investments in damage prevention (mitigation, warnings) to protect people and their activities and infrastructures on the assumption of an increase in tornadoes?

Many countries have adopted the precautionary principle through the United Nations Framework Convention on Climate Change (Article 3 – principles, UNFCCC 1992), which enunciated that nations agree to "protect the climate system" through "their common but differentiated responsibilities" and to take "precautionary measures" recognizing that the "lack of full scientific certainty should not be used as a reason for postponing actions." The precautionary principle supports making further mitigative investments.

A parallel analysis, following McBean (2004) and Leiss (2001), invokes the rationale of Pascal's wager. If the risk manager poses the following question: "should there be additional investments ($\$_{\text{invest}}$), beyond the baseline?" then an analysis of the costs of the expected increased impacts ($\$_{\text{impacts}}$) is needed. Mileti (1999) and others indicate that there can be substantial benefit-cost savings in terms of appropriate investment in disaster mitigation then $\$_{\text{impacts}} >> \$_{\text{invest}}$ (where both are in absolute economic units such as dollars). Pascal's wager poses the risk-decision in terms of consequences, depending on what actually happens, in the form of a decision matrix with four possible outcomes:

A. Tornadoes do increase in the future	B. Tornadoes do NOT increase in the future
A1. If we believe this and act accordingly (i.e., make additional investments, $\$_{\text{invest}}$), we will avoid some of the serious impacts of tornadoes in the future.	B1. If we believe this and act accordingly (i.e., no additional investments, $\$_{\text{invest}} = 0$), we will save ourselves any economic costs of additional investments.
A2. If we do not believe this and do not act (i.e., no additional investments, $\$_{\text{invest}} = 0$), we will have greater impacts from tornadoes in the future.	B2. If we do not believe this, and act accordingly (i.e., we make additional investments, $\$_{\text{invest}}$), we will waste the cost of the additional investments.

Pascal's Wager suggests that only downside risks be considered and the upside ones ignored. The downside risks, the bad things that may happen as a result of our choices, are represented by outcomes A2 (greater impacts) and B2 (waste resources). Since our assumption, based on the literature, has lead to the conclusion that the magnitude of the costs of additional impacts ($+\$_{\text{impacts}}$, A2) far exceeds the cost of wasted investments ($-\$_{\text{invest}}$, B2), it makes sense to avoid option A2. Hence, risk analysis indicates that we should take action on the basis of the projection that the number of tornadoes will likely increase in the future. The main action would be to make investments in reducing vulnerability, the same conclusion that arises from the precautionary principle.

6. Summary and Conclusions

Approaches to mitigating impacts from natural hazards will always require consideration of uncertainty and risk. When the impacts of a natural hazard can be particularly devastating it is appropriate to undertake stronger mitigative-adaptive actions. Climate change has now added an increased uncertainty to disaster risk management. Responding to the risks of natural hazards now must include attention to probable and possible future hazards. Tornadoes can be a devastating hazard and their characteristics could change with a changing climate. However, at this time, the scientific knowledge is weak for projecting potential changes in tornado frequencies. Regardless of the limited knowledge for changes in the tornado hazard in Canada, it is argued in this paper, on the basis of risk analysis that it is appropriate for Canadian disaster-management strategies to be altered to account for greater threat of tornado impacts in the future.

Acknowledgments

This research was supported by the Institute for Catastrophic Loss Reduction, which is funded by the Ontario R&D Challenge Fund and the member companies of the Insurance Bureau of Canada. The author has benefited from discussions with D. Henstra, L. Falkiner and P. Kovacs and the comments of an anonymous reviewer.

References

Dore, M.H.I.: 2003, 'Forecasting the conditional probabilities of natural disasters in Canada as a guide for disaster preparedness', *Natural Hazards* **28**, 249–263.

Environment Canada: 2001, *Highlights of Updated Sustainable Development Strategies.* See www.ec.gc.ca/press/2001/010214_b_e.htm.

Glickman, T.S.: 2000, *Glossary of Meteorology*, 2nd edn., American Meteorological Society, pp. 855.

Handmer, J.: 2003, 'Adaptive capacity: what does it mean in the context of natural hazards', in J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*, Imperial College Press, pp. 51–70.

Intergovernmental Panel on Climate Change: 2001a, *Summary for Policy Makers, Report of Working Group I.* See www.ipcc.ch.

Intergovernmental Panel on Climate Change: 2001b, *Working Group I, Technical Summary*, p. 53. See www.ipcc.ch.

Leiss, W.: 2001, *Understanding Risk Controversies*, Montreal, McGill-Queen's University Press, p. 388.

McBean, G.A.: 2004, 'Climate change and extreme weather: A basis for action', *Natural Hazards* **31**(1), 177–190.

Meteorological Service of Canada: 2003a, *The Top Ten Weather Stories For 2003*. See www.msc.ec.gc.ca/media/top10/2003_e.html.

Meteorological Service of Canada: 2003b, *Thunderstorms and Tornadoes*. See www.qc.ec.gc.ca/meteo/Documentation/Orage_e.html.

Mileti, D.S. (ed.): 1999, *Disasters by Design*, Washington, Joseph Henry Press, p. 351.

NOAA (US National Oceanic and Atmospheric Administration): 2003, See www.spc.noaa.gov/faq/tornado/f-scale.html.

Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP): 2003, *Canadian Disaster Database*. See www.ocipep.gc.ca/disaster/default.asp.

Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP): 2004, *Tornado Information*. See www.ocipep.gc.ca/info_pro/posters/naturalhazards/tornadoes_e.asp.

Raddatz, R.L.: 2003, 'Agriculture and tornadoes on the Canadian prairies: potential impact of increasing atmospheric CO_2 on summer severe weather', *Natural Hazards* **29**, 113–122.

Runnalls, D.: 2003, *Sustainable Development and Nuclear Waste*, NWMO background papers. See www.nwmo.ca.

The Tornado Project: 2002, See www.tornadoproject.com/.

Treasury Board Secretariat: 2004, *Sustainable Development Strategies*. See www.tbs-sct.gc.ca/rma/dpr/00-01/Guidance/Templates/sustainable-durable-e.asp.

Watson, R.: 2000, *Presentation of Robert T. Watson Chair Intergovernmental Panel on Climate Change at the Sixth Conference of Parties to the United Nations Framework Convention on Climate Change*, November 13, 2000. See www.ipcc.ch.

World Commission on Environment and Development: 1987, *Our Common Future*, Oxford, Oxford University Press, p. 400.

UNFCCC: 1992, *The United Nations Framework Convention on Climate Change*. See www.unfccc.int.

UNFCCC: 2003, Documents for COP 8. See www.unfccc.int.

Zwiers, F.W.: 2002, 'The 20-year forecast', *Nature* **416**, 690–691.

MITIGATION OF THE IMPACT OF TROPICAL CYCLONES IN NORTHERN AUSTRALIA THROUGH COMMUNITY CAPACITY ENHANCEMENT

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(Received 31 January 2003; accepted in final form 4 February 2004)

Abstract. Community mitigation of hazard impact requires hazard knowledge and preparedness on the part of the members of diverse and complex communities. Longitudinal research in the tropical cyclone prone north of Australia has gathered extensive datasets on community awareness, preparedness and knowledge, in order to contribute to education campaigns and mitigation strategies. Data have been used to identify issues of vulnerability to cyclones and capacity to deal with the hazard. This has been developed as a community vulnerability and capacity model that may be applied to diverse communities in order to assess levels of capability to mitigate and deal with the cyclone hazard. The model is presented here in a simplified form as its development is evolving and ongoing.

Keywords: capacity, community, resilience, tropical cyclone, vulnerability

1. Introduction

The cost of the impact of natural hazard events in communities in Australia (and in other developed countries) is spiraling and potentially becoming ‘unaffordable’ (Bureau of Transport Economics 2001). Government agencies and various industries are becoming increasingly aware of this and are searching for means of reducing vulnerability and minimizing (or shifting) these losses and/or costs. The insurance and re-insurance industries that have traditionally borne much of the cost of disasters are increasingly concerned at their level of ‘exposure’, and are now relying less on historical records to estimate and determine ‘risk’ (and thus the extent of their exposure) and more on sophisticated ‘forecasting’ tools, in order to understand (and presumably attempt to minimize) future potential losses (Meyer 1997).

Northern Australia has experienced a boom in its population and economy during the last three to four decades, concentrating people and increasingly complex infrastructure and buildings into the tropical cyclone prone coastal strip. The greatest concentration has been along the eastern coast of Queensland.

Before this recent period of growth, Northern Australia was still the pioneer fringe of Australia, where isolated communities are expected to rely on their own resources and knowledge of local conditions. Mitigation of the impact of tropical cyclones was very much a personal and community responsibility.

Physical mitigation works, such as levees and coastal defenses, were not constructed in the sparsely populated lands of the north. Many roads were, and in remote areas still are, cut off for large parts of the wet season. As the population and economy have developed in the north, roads and residential areas of towns have been made slightly more flood proof and buildings more wind resistant. During 2003 the state of Queensland introduced a state hazard planning policy into legislation with the intention of enforcing some physical mitigation measures such as raised house pads and stormwater drainage easements, or development controls in hazard-prone areas. However, it is not likely that the planning policy will significantly reduce vulnerability to hazards in the short to medium term, as it will be some years before these begin to be a significant part of the urban landscape.

The principal responsibility for hazard mitigation still remains firmly with individuals, families and communities to prepare for predictable hazards such as cyclones, storm surges and floods, and to take appropriate mitigation actions. This presupposes knowledge and awareness amongst the population. National, state and local government institutions are expected to play an active role in aiding that awareness and by providing warnings and direct intervention in such events as evacuation and recovery. Thus the awareness, preparedness, vulnerability and resilience of communities are crucial aspects of hazard mitigation. If community vulnerability is to be effectively reduced it is essential to first understand the type and dimensions of the 'risk' that residents face, how they perceive and understand this risk, how they make decisions about what levels of risk are 'acceptable' and what actions or behaviors they decide to undertake to minimize their risk exposure. The very fact that individuals or families have the power to reduce or increase their vulnerability by their decisions and actions defines it as a dynamic process rather than a static state. Vulnerability and capacity must therefore be examined within this framework. Unfortunately, community vulnerability has rarely been considered as a dynamic process within the context of a specific hazard and a specific community.

2. Community Vulnerability to Land-Falling Tropical Cyclones and Storm Surges

The term community is generally used to describe groups of people that share common attributes. It implies some sort of sense of belonging and connection that bonds people into meaningful supportive social groups. Newby (1987, p. 43) defines community as, "a local social system... a set of social relationships which takes place wholly or mostly within a locality." Max Weber conceptualized community in terms of belonging together – sharing a common culture, interaction and institutionalization of central activities (cited Ilf 1995). Emergency managers have traditionally considered a community to comprise a group of people that share the same geographically defined area, with the underlying assumption being that the group is relatively homogeneous and socially cohesive. For political decision-making processes and administrative convenience community boundaries are often based on local government or administrative areas. In reality the occupants of a spatially defined area are rarely homogeneous. They are likely to belong to a mosaic of communities that are inter- related and overlapping, as well as to a number of unrelated communities. Each community will be defined by a common interest, which may be more important than the spatial unit itself (Ilf 1995). The concept of 'community' implies a sense of belonging and active commitment. This is not a passive, never-changing concept but rather a process that takes time to develop. Communities evolve and dissolve.

Effective emergency management requires that decision-makers understand and respond to the diversity of communities. Different groups may be exposed to different types of losses, and even within groups individuals may be exposed to different magnitudes of loss. Unique community characteristics and vulnerabilities need to be identified and evaluated, and appropriate management strategies applied. As hazard impact is generally geographically defined it presents a real challenge for emergency managers if 'communities' are not also geographically defined. For emergency management purposes it is important there is at least some sense of community, in terms of some kind of meaningful relationships between neighbors, at a geographical level – in addition to whatever other 'communities' may exist.

The impact of a natural hazard on a community may not always be unexpected but is almost certainly unwanted. As direct impacts are relatively uncommon, community residents are often poorly prepared – both physically and mentally. Views that describe, explain and predict community interaction following the impact of a natural hazard generally support one of two theories – either that disasters enhance community cohesion[1] or that disasters contribute to increased social disorganization.

A commonly accepted myth that disasters bring communities closer together is often reinforced in the media during times of hazard impact, with stories and televised images of communities rallying together and local heroes helping to rescue neighbors and their belongings. Much of the earlier disaster literature supports the notion that in the face of a common leveling disaster experience communities are characterized by the disappearance or reduction of social barriers between individuals or groups, greater social solidarity, reduced conflict and general feelings of goodwill and helpfulness towards others. Feelings of enhanced community cohesion are often described as a direct consequence of the disaster (Barton 1969; Fritz 1961; Mileti et al. 1975; Mileti 1999).

There is some evidence to indicate that disasters reinforce and intensify existing social and societal conditions. Furthermore, evidence shows that post-impact, communities in decline will continue to decline while strongly developing communities will continue to thrive (Bates et al. 1963; Haas et al. 1977; Geipel 1982; Davis 1986). On a regional scale, disasters are not generally shown to have any long-term economic impact – losses in one sector or area are often balanced by gains in others.

Within a local area, however, economic impact is likely to be unequal, with poorer sections of the community experiencing greater losses and being less able to fully recover than those with more economic resources (Rossi et al. 1978; Friesma et al. 1979; Bolin 1994). Small businesses are likely to be more greatly impacted than larger corporations (Tierney and Dahlhamer 1997).

It seems likely that post-disaster community interaction is reflective of pre-disaster community solidarity. Kaniasty and Norris (1999) found that while supportive community cohesion may have developed following a disaster, access to newly forming community networks varied according to pre-existing social values and mores, which included a combination of ascribed individual characteristics, such as ethnicity; achieved individual characteristics, such as education; location of social networks; and exposure to the disaster, notably the amount of loss. Socially marginalized groups appeared to retain their marginal status throughout the disaster and post-disaster periods. In the long-term disaster recovery process, community social stratification, economic viability, political motivation and structural features most often return to pre-disaster conditions. Turner and Killian (1987) demonstrate that new social norms that emerge following a disaster-related community disruption do not persist. Taylor (1972) and Sweet (1998) establish that new 'helping roles' are temporary. Alway et al. (1998) showed that changes in gender roles are common in the immediate post-disaster period, but these tend to be "slight and fleeting." It is, therefore, imprudent to conclude from emergent behavioral norms in the early post-disaster period that norms as well as social structure will be equally pliable throughout the longer-term reconstruction and recovery phases of disaster (Passerini 2000).

Following a disaster, communities usually return to pre-existing social structures, often rebuilding pre-existing biases and inequalities with help from neighboring communities, insurance and both government and non-government aid (Walters 1978; Aysan and Oliver 1987; Mileti and Passerini 1996). The post-disaster reconstruction period presents an opportunity to build in mechanisms that will strengthen communities and infrastructure against future losses. Unfortunately, a lack of clear recovery goals at all government levels, the complexity of working with multiple administrative and service entities and an absence of institutional capacity frequently constrains any opportunity to change (Mileti 1999). The reconstruction process is, therefore, more likely to benefit the socially and economically powerful sectors of the impacted community at the expense of the less powerful than to redress pre-disaster societal inequalities (Dynes 1989).

3. Vulnerability, Resilience and Capacity

Since the early 1980s and most particularly throughout the 1990s (the International Decade for Natural Disaster Reduction), there has been a growing recognition of the significance of people and their relationship to hazards in terms of the total hazard risk. This has been reflected in the growth of literature that attempts to define, measure and explain people's (individual and collective) vulnerability to hazards (Blaikie et al. 1994; Varley 1994; Hewitt 1997; Mitchell 1989). Natural disasters are broadly understood to be consequences of the interface of a natural hazard and a vulnerable human community. Total risk is then defined as the product of all potential hazard events and the vulnerability of the exposed elements at risk; that is, the risk equation as modified by Granger et al. (1999):

$$\text{Total risk} = \text{Hazard} \times \text{Elements at risk} \times \text{Vulnerability}.$$

De-constructing and understanding vulnerability is therefore central to understanding and ultimately managing total hazard risk and thus mitigating against hazards.

Vulnerability is broadly defined throughout the disaster literature as the susceptibility to harm. At its simplest, it has been conceptualized as a pre-existing condition or state defined by a set of attributes that make people or communities more, or less, susceptible to loss. Definitions all broadly describe vulnerability as the potential for loss, and most, either directly or indirectly, suggest the possibility of avoiding some of that loss (Blaikie et al. 1994). An appreciation of vulnerability is therefore central to risk management and to the development of hazard mitigation strategies.

Blaikie's et al. 1994 definition is useful in that it describes vulnerability in terms of people's capacity to avoid, cope with and recover from hazard impact. This clearly illustrates two trends in explaining vulnerability. Firstly, there is the shift in focus away from the hazard event being the primary cause of loss (with people characterized as victims or passive onlookers that are subordinate to the hazard), towards a focus on the human community and people's living conditions, social and economic resources, livelihood patterns and social power. Secondly, it includes a consideration of resilience, which is a more positive (empowering) concept. In the Australian emergency management context, vulnerability is defined as, "the degree of susceptibility and resilience of the community and environment to hazards. The degree of loss to a given element at risk or set of such elements resulting from the occurrence of a phenomenon of a given magnitude and expressed on a scale of 0 (no damage) to 1 (total loss)" (EMA 2000).

'At-risk' groups in developed countries also tend to be based on social and societal inequalities which influence key aspects such as location, and hence proximity to a hazard's sphere of influence. Australian, European and North American studies typically identify low-income households, women, the very young, the elderly, the unemployed, the disabled, large families, single parent households, newcomers to the community and migrants, ethnic minorities and female-headed households as being more 'vulnerable' and likely to suffer disproportionately higher levels of loss in the event of hazard impact than those at relatively greater social and economic advantage with easier access to resources (Bolin 1994; Peacock et al. 1997; Blaikie et al. 1994; Wisner 1993; Davis 1998; Fothergill 1996; Bolin and Stanford 1998;

Enarson and Fordham 2000; Fothergill et al. 1999; Stehlik et al. 2000; Keys 1991; Salter 1995; Granger 1993, 1997). While a single identifying characteristic broadly defines a ‘vulnerable’ group – such as being from an ethnic minority or being unemployed – it is not that characteristic that creates the vulnerability, but rather its societal context and how that context limits access to resources. Vulnerability factors are not mutually exclusive as they tend to occur in combination; for individuals, households or communities that identify with more than one ‘vulnerable’ group, vulnerability is increased exponentially (Morrow 1998). In terms of hazard-related total loss, the wealthy are likely to lose more, but they are more likely to be able to access resources to assist in recovery. Proportionally the poor are likely to lose more in terms of their material assets, have more difficulty in recovering and suffer more lasting negative effects (Bolin 1994). Cannon (1994) concluded that, “. . . a given household’s vulnerability (or resilience) in the face of environmental hazards will be a result of a cluster of factors (class, race, gender, age etc.) that affect their coping capacities in the context of varying levels of social protection against hazards.” It must be said though that vulnerability is very much hazard-specific. Everyone will be vulnerable to suffering loss in various situations and under various conditions.

4. Longitudinal Research on Community Vulnerability and Capacity in Cairns, Far North Queensland

In just over 100 years the region of Far North Queensland between Innisfail and Cape York has experienced 47 Severe Tropical Cyclones resulting in 393 recorded deaths and many millions of dollars of property loss. Between 1956 and 1990 there were no serious tropical cyclone impacts at Cairns although winds associated with Cyclone Winifred (Innisfail, February 1, 1986) caused some property and vegetation damage in the Cairns region. Over the past 130 years (on average) the Cairns area has experienced a noticeable impact from a tropical cyclone every 2.2 years (most of which have not been in the severe category). These cyclones have approached close enough to Cairns to produce wind or sea damage every 4.2 years and Cairns has suffered a significant impact every 12.5 years (Callaghan 1998). Return periods are irregular, but it is estimated that a Severe Tropical Cyclone may impact any given area of the regional coastline about once every twenty to thirty years (Wadley and King 1993).

In 1996 the Bureau of Meteorology (responsible for the delivery of cyclone advice messages and warnings), the Queensland Department of Emergency Services (responsible for providing the legislative framework for emergency and risk management and preparing public hazard awareness education) and Cairns City Council (responsible for preparing the Cairns community for hazard risks and preparation and delivery of counter disaster activities) were collectively concerned that Cairns community residents were not aware of, or adequately prepared for, the risk of land-falling tropical cyclones. It was feared that residents would not respond appropriately to cyclone warnings and were not likely to take actions that would minimize their losses.

The implications of this for the Bureau of Meteorology, Queensland Department of Emergency Services and Cairns City Council were that effective emergency management in times of cyclone impact would be compromised, community residents would suffer unacceptable levels of loss and the recovery process would be jeopardized. A longitudinal study of the people of Cairns and Far North Queensland to a specific hazard – land-falling tropical cyclones and storm surges – included both pre- and post- impact studies. The study examined the tangible and intangible characteristics and attributes of a defined community and identified, measured and attempted to explain changes in the community vulnerability through the progression of time and experience. This study provides an excellent opportunity to improve our understanding of the dynamics of community vulnerability to natural hazard impact and hence to develop community mitigation measures.

The research project was initiated by the Centre for Disaster Studies – through the IDNDR funded national program of the Tropical Cyclone Coastal Impacts Program – to determine and evaluate any individual and collective characteristics of Far North Queensland residents that contribute to their vulnerability to tropical cyclones and associated storm surges. Over a period of more than four years the research outcomes would contribute to the construction of a theoretical framework for understanding how residents in the Cairns cyclone-prone region perceive the cyclone risk and how they respond to the cyclone threat. Understanding of this community has contributed to mitigation through education, improving awareness and preparedness, and directing behavioral change throughout the cyclone-prone regions of Northern Australia. The focus of this crucial aspect of mitigation has been the improved awareness and preparedness of the general population, in order that they may better cope with the impact of a natural hazard. This is not a substitute for the more traditional hazard mitigation roles of emergency managers and local councils, but rather it is intended to complement and add to the ability of people to deal with disaster.

Nine coastal and near coastal townships to the north of Cairns city centre, collectively known as the Cairns Northern Beaches, provided the case study area. The area extends from the highly vulnerable Machans Beach, situated on the delta of the Barron River in the south to Palm Cove, with its prestigious tourist facilities in the north. The area is similar to other cyclone prone North and Far North Queensland (and indeed northern Australian) coastal communities, particularly those with expanding tourist industries. In 1996 the collective population of the townships was estimated to be 19,228; this has increased at an estimated annual rate of 4.2% (ABS 1998). The nine communities are for the most part not interlinked. In time of flood, which is most often cyclone related, several of the townships become isolated when low points on single access roads from the highway are submerged.

Data for the study were collected between 1996 and 2000, using questionnaire-based surveys. In-depth interviews were also conducted with key informants and stakeholders throughout the study period. The initial survey was administered to households in early 1996. A final drop-off/pick-up questionnaire was administered to the same population sample in early 2000. During the period of the study the community was exposed to intensified cyclone awareness campaigns that were prepared and delivered cooperatively by the Bureau of Meteorology, the Queensland Department of Emergency Services and the Cairns City Council using a combination of television advertisements, pamphlets, radio and newspaper features, public meetings and mail outs. The findings and recommendations of each of these studies were considered and incorporated into successive cyclone awareness education campaigns. When designing the research strategy it was decided that the same sample population would be surveyed following any real cyclone threat to the area. This included both warnings and any land-falling tropical cyclones. During the data collection period two land-falling tropical cyclones directly impacted the Northern Beaches case study area. Post-impact surveys designed to determine and measure the effect of the experience on community household residents' perceptions, attitudes and behaviors were administered. The region's school students were also invited to participate in the study. Age-appropriate questionnaire-based surveys were administered to one group of primary school Year 5 students and one group of secondary school Year 9 students in October 1996. The school surveys were not part of the three main household surveys, but were used to complement the main surveys and to explore opportunities for school-based educational cyclone awareness campaigns. By March 2000 data had been collected from five separate, but related, questionnaire-based surveys:

- Community Vulnerability to Tropical Cyclone and Storm Surge Disasters – Household Survey Questionnaire for Cairns Northern Beaches Communities February – March 1996 – before the occurrence of any specific cyclone.
- Cyclone and Storm Surge Awareness Survey – Cairns region Year 9 Students aged 14 years) – October 1996.
- Cyclone and Storm Surge Awareness Survey – Cairns region Year 5 Students (aged 10 years) – October 1996.
- Household Survey Questionnaire for the Cairns Northern Beaches Region following Cyclone Justin on Saturday, March 22, 1997.
- Household Survey Questionnaire for the Cairns Northern Beaches Region following Cyclone Steve on Sunday, February 27, 2000.

Other post-disaster and community vulnerability studies carried out by the Centre for Disaster Studies were used to complement the findings of the Cairns study (King 2002).

The selected unit of analysis in the community surveys administered in the case study area was the 'household', most often a nuclear family. The individual student was the unit of analysis in the school student surveys, as was the individual respondent in the in-depth interviews. The community studies were both cohort and panel studies. The sample selected for the 1996 survey would be revisited – by address – in all subsequent surveys in the case study area (the same cohort). It was recognized that there would be some movement of population throughout the four-year study period (the 2001 census indicated that 55% of the Northern Beaches population had lived at a different address five years earlier, including moves from other parts of the same city), but it was expected that a significant proportion of respondents would participate in all community studies (the same panel).

Data collected from the Cairns region students supported a cross-sectional research method. Data were collected only once and explored phenomena as they existed at that point in time. This approach did not allow identification of any causal relationships or change in phenomena over time. It did, however, allow a cross-sectional comparison of some selected elements between the two student cohorts, and also between the Year 9 students and community household residents in 1996.

The community household study was both cross-sectional and longitudinal. The first survey in 1996 provided data that described the pre-cyclone impact community. This approach enabled causal relationships and changes over time to be identified and measured. Progressive community household surveys therefore produced a longitudinal study and three cross-sectional studies.

Both quantitative and qualitative data were collected. Quantitative analysis was used to measure variables and phenomena that could be directly observed and easily counted. This approach also enabled temporal changes in such data to be measured in percentage terms. It also made direct comparisons between similar survey and census data possible. For phenomena that could not be quantified a qualitative approach was used. Qualitative data were generally collected in the form of extended responses to open survey questions. The combination of approaches resulted in the accumulation of a comprehensive set of data.

Survey questionnaires drew on previous post-disaster studies (Raggatt et al. 1993; Smithson 1993). As the surveys were applied research supported by industry and input from stakeholder groups[2] was invited and encouraged. The aim of the school-based studies was to identify and evaluate evidence of students' cyclone awareness and general attitudes towards the cyclone hazard. As it was appreciated that some 10–11-year-olds may have difficulty communicating their understanding in writing, this cohort was given the opportunity to express their awareness with a drawing of a 'cyclone scene'.

Households were selected using a systematic random sampling technique. It could therefore be safely assumed that the sample should contain the same variations as the total population and be truly representative. The stratification implicit in this process ensured proportionally equal representation across all Northern Beaches townships and in all three storm surge zones.[3] The same population sample was used in all subsequent community surveys associated with the project, with surveys mailed or hand delivered to the same 700 households[4] that had initially been selected.

A combination of qualitative and quantitative data was collected throughout the survey process. Children's drawings also provided valuable insights. Changes in attitudes and awareness from one survey to the next were measured in percentage terms. Simple testing for significance and correlation were carried out primarily with '*t*' tests and *chi square* tests. An understanding of phenomena was achieved through an analysis of the verbal and written explanations of respondents. This qualitative data was evaluated in terms of commonalities and consistencies in responses; identifying trends; the explanatory power and scope of responses; and the heuristic worth. As there were 100 questions in the initial community survey and over 70 in each of the post cyclone studies (primarily the same questions), only a small selection is presented here as an example of the sort of comparative data that were generated.

5. Findings

The results of the Cairns Northern Beaches surveys were used to identify issues of vulnerability that have subsequently been incorporated into the model of community vulnerability and indicators.

There are high levels of misunderstanding of terms such as storm surge and categories of cyclones. As a consequence of the experience of two tropical cyclones directly impacting the area, there is almost universal understanding that Category 5 is the most severe cyclone and Category 1 the least. It is disappointing that 30% of the community residents are still uncertain of which categories indicate a Severe Tropical Cyclone. The most common mistake continues to be the inclusion of Category 2 with Severe Cyclone Categories 3 – 5. It is likely that this has arisen because of the media persistently referring to Cyclone Steve as a 'severe' Category 2 cyclone.

Most residents stayed secure in their own homes with their families and pets during the period that Cyclone Steve posed a significant threat to coastal communities. Power outages were widespread so most kept updated with warnings using battery operated radio. Approximately a third of the households plotted the track of the cyclone using a cyclone-tracking map. Many respondents indicated that they had kept track of the cyclone on the television or the Internet until the power went out.

Throughout the study period residents described their perceptions of the cyclone and storm surge risks. In 1996 the community had been relatively inexperienced and often poorly informed about the cyclone hazard and their stated perception of risk was high. During the study period the direct impact of two land-falling cyclones was experienced, and the Cairns residential community was exposed to an intensified public education effort to raise cyclone awareness. As frequent contact or familiarity with a known hazard is supposed to reduce perceived risk of the hazard, it could be expected that residents stated perception of the risk would, by the end of the study period, be reduced. Following Cyclone Steve residents estimated their perception of the risk of both cyclone and storm surge, again using a semantic differential scale of one to six (where one represented no threat and six extreme threat). Following the impact of Cyclone Steve community household residents continued to perceive the risk of both cyclone and storm surge to be high.

The experience of two land-falling tropical cyclones directly impacting the study area appears to have gone some way towards debunking the myth that the area is in some way naturally protected. Data show that the proportion of the population confident that the mountains and/or the reef prevent a direct cyclone 'hit' has reduced by more than 20% throughout the study period.

Residents had been confident that they had coped well with Cyclone Justin, and again they were satisfied with the performance of their households during Cyclone Steve. People generally felt secure in the area; they considered that with their 'adequate' preparations they were also secure in their homes. Data confirms this widespread confidence, with very few indicating any intention or desire to relocate as a result of their 'cyclone experience(s)'.

When responding to questions relating to household insurance in the two previous community surveys, residents frequently indicated that their responses reflected what they believed to be true, but that they intended to check their policies. Uncertainty about the extent of insurance coverage was common. In 1996 it was demonstrated that a substantial proportion of the community believed their insurance covered loss arising from storm surge, erosion, landslide and flooding. Some may have been covered for flood loss, but no one was insured against storm surge, erosion and landslide. Data confirm that, despite efforts on the part of various insurance companies to explain, 'in plain language[5]', the details of the extent of insurance cover, many remain poorly understood.

The greatest confusion appears to be related to flood insurance. Residents frequently indicated that they assumed 'flood' was included in 'storm and tempest' insurance. Flood insurance is available for some residential properties as an optional extra to some household insurance policies.

6. Assessing Vulnerability

The set of surveys from Cairns Northern Beaches provided an extensive range of individual and household demographic and socio-economic characteristics, hazard awareness and perceptions, and reported behavior, both before and after the occurrence of tropical cyclones. Additional data available locally, from the census and the city council, provided information on aspects of the communities, the suburbs and the actual physical infrastructure. Thus a wide range of information about the people, community and the locality was available for making an assessment of the relative vulnerability and resilience by progressively quantifying, combining and ranking characteristics.

6.1. The Community Vulnerability and Capacity Model

Vulnerability to hazard impact is widely understood to be a problem that applies to all human populations throughout the world. The IDNDR focused world attention on the problems of community hazard vulnerability; it encouraged and supported research and investigation that recognized that the problem was not simply one of a need to acquire a better understanding of the dynamics of natural hazards, but rather one of a need to better understand how the hazard and the impacted community interact. Focus was clearly on gaining an understanding of what it is that makes a natural hazard event become a disaster, and then, based on this understanding, developing strategies that will mitigate against the disaster potential.

The Cairns Northern Beaches Community study is unique in that it was specifically designed to identify the vulnerability of a selected case-study population based on characteristics identified in a pre-impact (or baseline) study. In each of the two post-impact studies changes in community cyclone preparedness, adaptive responses and risk perceptions could be identified and then described in relation to the pre-impact study. Following the second cyclone impact, changes between impacts could be identified and, in many instances, measured.

With rigorous field investigation (and the 'good' fortune of two tropical cyclones making land-fall directly over the case-study area) this study has provided a unique opportunity to observe, experience, record and explain the (hazard-promoted) growth and changes in the Cairns Northern Beaches community over a four-year period.

The outcomes of the project are expected to provide emergency managers and policy-makers with information about the community that will support sound decision-making and ultimately enhance community safety through mitigation. To assist in this process and provide community decision-makers with a useful 'tool', a simple vulnerability model has been designed to support an evaluation of a range of identified individual, community and societal characteristics and attributes that contribute to the Cairns community's cyclone 'vulnerability'. The development of this model is an evolving and ongoing process.

The Cairns Community Vulnerability and Capacity model has been developed by drawing on the content and method of previous models, particularly Cannon (2000) and Granger (1997; Granger et al. 1999). The schematic in Figure 2 is similar to Crichton's (1999) 'Risk Triangle' in that it considers the 'whole' (Cairns community vulnerability) in terms of the relationships between three sets of component characteristics. The inside area of the schematic triangle describes the product of these relationships. While simplistic, this schematic provides a clear visual demonstration of the impact of all contributors to vulnerability, and hopefully will prove to be a useful and powerful 'tool' for emergency managers and policy makers in their planning processes.

One side of the triangle represents the individual's contribution to the total community vulnerability. It includes those characteristics and traits that contribute to

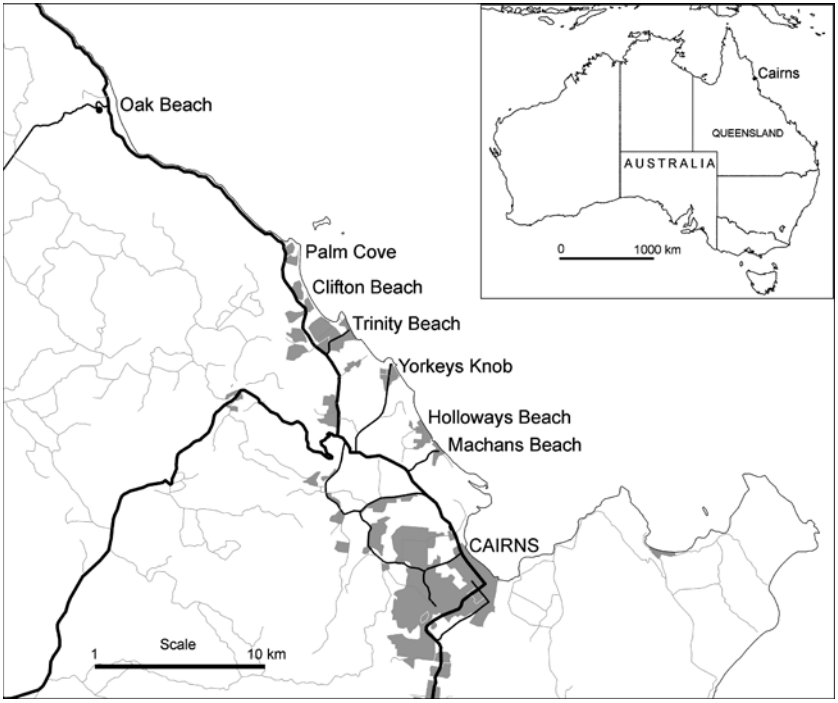

Figure 1. Cairns beaches on eastern coast of Queensland, northern Australia.

Figure 2. Community Vulnerability and Capacity – Schematic. (Source: Anderson-Berry 2002).

the individual's perception of cyclone risk. People will decide how to prepare for the cyclone threat and how they will respond to warnings. Another side represents the community characteristics that contribute to the community's social capital and capacities. It includes the social resources available within the Cairns communities that are a consequence of networks of mutual support, reciprocity, trust and obligation. These are the intangible social structures that provide social cohesion and enhance the community's ability to withstand and recover from hazard impact.

The final side represents the societal infrastructure that, in a tangible way, supports the community. It includes the physical infrastructure and the legislative and administrative framework that determines the level of societal support available to the community. The detailed variables selected from the surveys and community datasets are expanded in Figure 3, which is otherwise a development of Figure 2.

The effective application of the model exposes and demonstrates the synergies and (inter- and intra-) relationships that increase the potential for communities to become more or less susceptible to loss and more or less resilient in the event of cyclone impact. Tropical cyclones are the most likely (and the most prepared for) natural hazard that Cairns residents will face; they are to a degree predictable, they can be forecast, identified and monitored with increasing accuracy and certainty by the Bureau of Meteorology. Importantly, they characteristically offer some warning time. They are also a multi-faceted hazard. In addition to extreme wind effects a storm surge is associated with all land-falling tropical cyclones, and while this

Figure 3. Model of Community Indicators of Vulnerability and Resilience. (Source Anderson-Berry 2002).

may or may not be 'disastrous' the destructive potential must also be considered. Other hazards frequently associated with land-falling tropical cyclones include land-based flooding and land-slip. Appropriate and timely defensive actions, both preparatory and adaptive, can substantially minimize economic loss and loss of life and livelihood.

6.2. INDIVIDUAL CONTRIBUTORS TO COMMUNITY VULNERABILITY

An examination of the characteristics of individuals (see Figure 3) and the variables that contribute to the individual's perception of the cyclone risk, the degree of risk considered to be acceptable and demonstrated actions taken to minimize this risk indicates that in this respect the Cairns resident community is relatively robust. Residents are generally well-resourced and relatively self-reliant. Average income throughout the area was found to be moderate, and while some households almost certainly suffered some financial difficulties there was no evidence of identifiable poverty. It could be expected therefore that residents would be able to access resources to prepare for and respond to land-falling tropical cyclones adequately. In neither the census nor the community surveys are there any apparent concentrations of very elderly or very young residents; it may be considered unlikely that the spread and degree of responsibility and dependence some individuals have for (and upon) others would contribute significantly to community vulnerability. Virtually all residents were mobile, had access to independent transport and very few were found to have severely limiting disabilities.

Most residents were aware that the area is cyclone prone when they moved to their current residences and could demonstrate a sound general knowledge of cyclones. Fewer were aware of, or knew much about, storm surge. Understanding of both hazards was, however, limited. This is significant, as residents will base their perception of the cyclone risk on these understandings, and it is on these perceptions that they will decide what level of risk is acceptable and how to respond appropriately. Perception of risk was consistently found to be biased towards the optimistic. Hazard-awareness education was usually readily available, although very little had been designed to meet demonstrated community needs, and had therefore not been well absorbed by those who accessed it. Media coverage of tropical cyclones and other hazards generally, and local land-falling tropical cyclones specifically, is usually sensationalized and sometimes inaccurate, often informing poorly and sending 'mixed messages' to residents. Media personalities, however, consistently provided a vital and often trusted link between the authorities, particularly those relaying warnings to the public. At the beginning of the study period most residents did not have direct personal experience of land-falling tropical cyclones. By the end of the study most had, although those who had acquired their experience with Cyclones Justin and Steve still have not experienced a Severe Tropical Cyclone.

Individual residents at the household level demonstrated a confidence in their own ability to control the consequences of cyclones and storm surges in terms of the way they both prepared for and responded to the cyclone threat. Adaptive response activities (preparations carried out during the warning period) were carried out with increasing efficiency as residents became more experienced. However, seasonal and longer-term preparations were less well attended to or understood, including household insurance. Residents were confident that they understood both warning advice messages and recommended defensive actions, but this was not always shown to be true as illustrated in Tables I and II. The community social norms of independence and privacy appeared to be strong. Individuals tended to form strong cohesive relationships within households but did not usually interact well with neighbors. Many were, therefore, relatively isolated and relied on their own judgments and actions to ensure household safety. Trust in the authorities to inform the community honestly and adequately, and to take action so as to ensure community safety, was consistently (and increasingly) low. Physical, tangible characteristics of individuals were not shown to be major contributors to community

TABLE I
Understanding of storm surge

Stage during a cyclone when residents would usually expect a storm surge to occur					
	Post Steve ($N = 416$)		Post Justin ($N = 361$)		Community
Survey		% change from 1996		% change from 1996	($N = 572$)
Correct	15.1	+10.4	14.7	+10%	4.7
Partially correct	22.1	−50.1	31.0	−41.2	72.2
Incorrect	28.6	+26.0	35.5	+32.9	2.6
Don't know	13.2	–	13	–	13.1
No response	20.9	+13.2	5.8	+1.9	7.7

TABLE II
Knowledge of cyclone categories

	Steve ($N = 416$)		Justin ($N = 361$)		Community
Survey		% change since 1996		% change since 1996	($N = 572$)
Most dangerous cyclone (Category 1 or 5)					
Correct	95.0	+8.8	94.7	+8.5	86.2
Incorrect	1.9	−7.9	1.7	−8.1	9.8
No response	3.1	−0.9	3.6	−0.4	4.0
Severe cyclone categories					
Correct	43.0	+1.9	57.9	+19.8	41.1
Partially correct	30.5	+6.4	29.4	+5.3	24.1
Incorrect	4.3	−6.5	3.6	−7.2	10.8
No response	22.1	−1.9	9.1	−14.9	24

TABLE III
Use of tracking maps

	Steve		Justin		% (yes)
$N = 416$	Yes	No	Yes	No	Change
Residents that stayed in their own homes while cyclone Steve impacted the Cairns area on Sunday February 27.	91.6	7.9	91.3	8.4	+0.3
Residents that had a cyclone-tracking map when the Cyclone Steve advice messages began.	57.9	41.3	53.7	42.7	+4.2
Residents that tracked Cyclone Steve using a cyclone-tracking map?	34.6	64.4	43.8	56.2	−9.2
Residents with pets	70.7	28.6	72.2	27.8	−1.5

vulnerability to land-falling tropical cyclones. More significant were the less tangible attributes. Perception of risk was initially found to be biased and, despite direct cyclone experience, remained biased as illustrated in Table V. Consequently, decisions relating to what defensive response actions are to be appropriate may not be sound and the confidence with which residents act upon these decisions may not be well founded.

Each contributing characteristic can be assigned a value according to the significance of its contribution to total vulnerability in the context of a specific impact scenario. One (1) indicates that the contribution (in this instance) is extremely low and five (5) indicates that the contribution is extremely high. For example, in the Cairns Northern Beaches ethnicity is not a community characteristic that increases vulnerability because of the tiny size of minority households; hence, it is given the lowest value (in a developing country, or in a larger Australian city, with a significant migrant population, ethnicity would rate much more highly). This process is not entirely subjective, as it is based on knowledge arising from both qualitative and quantitative community data, and is a process that is available to emergency managers (in the field). The methodology is a ranking of characteristics that is developed from the Cairns multi-hazard assessment of Granger et al. (1999).

While these characteristics are ranked on the basis of survey responses, they can, for the purpose of displaying them meaningfully on the model triangle, be grouped according to their relative contribution to vulnerability. They can then be represented along the side of the triangle according to their relative contribution; the length of the side will be determined by the significance of the aggregated characteristics (with each individually having a value of between one and five units). Given the number of community characteristics and attributes of individuals identified within the Cairns community, the maximum number of ‘units’ that contribute to the length of the side is 80 units; based on the community analysis the actual contribution is 29 units, which is 36.25% of the possible maximum.

TABLE IV
Changes in perceptions of risk

	Steve ($N = 407$)		Justin ($N = 353$)		Community ($N = 543$)
		% change since 1996		% change since 1996	
Perceived cyclone risk					
– None – 1	1.0	+0.4	1.4	+0.8	0.6
2	3.2	+0.1	2.5	−0.6	3.1
3	13.8	−5.9	16.4	−3.3	19.7
4	20.4	−7.8	27.2	−1.0	28.2
5	24.1	+12.5	13.0	+1.4	11.6
Very great – 6	37.6	−0.8	39.4	+2.6	36.8
Mean	4.76	+0.18	4.66	+0.08	4.58
Median	5	–	5	–	4
Mode	6	–	6	–	4
Perceived storm surge risk					
– None – 1	2.0	+0.3	1.7	–	1.7
2	4.8	+1.6	3.1	−0.1	3.2
3	15.0	−1.6	14.2	−2.2	16.4
4	21.6	−1.1	22.2	−0.5	22.7
5	21.3	+7.6	14.0	+0.3	13.7
Very great – 6	35.3	−6.9	44.7	+2.5	42.2
Mean	4.61	−0.09	4.78	+0.08	4.70
Median	5	–	5	–	5
Mode	6	–	6	–	6

TABLE V
Residents' beliefs that Cairns is, to some degree protected from a direct cyclone hit

What residents believe may protect the region (if anything)	Steve ($N = 416$)		Justin ($N = 361$)		Community ($N = 572$)
		% change since 1996		% change since 1996	
Yes mountains	8.7	−17.2	18.0	−7.9	25.9
Yes, reef	3.6	+0.8	1.4	−1.4	2.8
Yes, reef and mountains	2.4	−2.1	3.3	−1.2	4.5
Yes other	2.6	−1.2	4.4	+0.6	3.8
Don't know	1.7	−0.7	0.8	−1.6	2.4
No	79.3	+26.5	69.8	+17	52.8
No response	1.7	−6.0	7.7	−6.9	7.7

6.3. Community characteristics and social capital

The second group of characteristics that influence the vulnerability and coping capacity of the people of Cairns to land-falling tropical cyclones and storm surges are those that contribute to the social capacity of the residential community. These characteristics include the often less tangible social resources available within communities that result from networks of mutual support, reciprocity, trust and obligation. Furthermore, they provide social cohesion and enhance the community's ability to withstand and recover from hazard impact (Winter 2000). They are the characteristics that are left largely uncovered in Granger's consideration of community vulnerability (Granger 1997; Granger et al. 1999), but are included in Cannon's model (Cannon 2000). They are difficult to quantify, and are not likely to exist as readily available data in the local community. However, they may be quantified through the use of attitudinal surveys.

In terms of social capital, the Cairns Northern Beaches 'communities' must surely be considered deficient. Data relating to community networks and social structures indicates that community social networks of mutual support based on reciprocity, trust, and obligation are weak and their community structures are generally poorly defined. The strongest level of social aggregation is the individual household, which is most often a nuclear family unit. While these units are generally cohesive and supportive of individual members, they are often separated from the extended family networks that strengthen family ties and facilitate the sharing of family knowledge, experience and history. Social interaction between households within neighborhoods is often limited, making it quite possible for households to be isolated within neighborhoods. This was clearly illustrated with evidence that almost half the community households have no regular or usual contact with neighbors. In 'normal' times this may promote feelings of loneliness, but in times of hazard impact, when contact with neighbors was shown to be even more limited, this could leave some residents in the community totally without support. There appears to be little social cohesion or strength in spatially defined communities in the Cairns Northern Beaches townships, and other communities of mutual interest tend to be fragmented. There is limited evidence of strong neighborhood social networks and levels of participation in both formal and informal community organizations are low. A notable exception is found in the most physically vulnerable township of Machans Beach, which is also the oldest of the Northern Beaches suburbs and the closest to Cairns city.

Public involvement and engagement in civic and political processes is infrequent and tends to be individual rather than group activism. The expressed level of trust in local government processes is generally low and individuals frequently expressed feelings of powerlessness and exclusion from decision-making (political) processes. Political agitation has had some success (notably the Cairns city council's back-down on the policy to withhold evacuation centre location details and the subsequent release of these details to the public), but this has usually been the result of the sum of individual pressure, rather than organized group activity. Collective community trust in Emergency Management authorities and the Bureau of Meteorology was demonstrated throughout the study period to be cautious, but increasing. With regard to communications relating to tropical cyclones, the community's relationship with media was variable. On the one hand, there was suspicion that reports were sensationalized, but on the other hand the media, particularly the radio, provided an essential and generally trusted communication link between the emergency service providers and the community. Radio personalities were frequently shown to provide a vital human link between the hazard and the community.

Groups within the various communities were rarely shown to be cohesive and generally displayed low levels of tolerance of diversity (except perhaps when a net benefit is perceived, as with tourists). An individual and collective sense of belonging and commitment to the area was shown to vary but was clearly much stronger in communities where social networks are stronger, such as Machans Beach, and is unlikely to be related to home ownership or financial commitment to the area. It is likely that individual and household units within the community share similar values and goals, but it is unlikely that they collectively share a common world view. While enthusiastic involvement in community social activities was limited, people generally demonstrated a willing readiness to be supportive during times of crisis. Community social structures that support social cohesion in times of need are not necessarily strong enough to support long-term social relationships.

Table VIII ranks the impact of each community characteristic to vulnerability and capacity, using the same method as for individual characteristics. The community characteristics (like the 'individual' characteristics) are subjectively ranked, but they can, for the purpose of displaying them meaningfully on the model triangle, be grouped according to their relative contribution to vulnerability. They can then be represented along the second side of the triangle according to their relative contribution. The number of community characteristics as a percent of attributes of 'community' was 62.5% of the possible maximum of vulnerability. The three

TABLE VI

Residents intentions following Cyclone Steve

	Steve			Justin		
($N = 416$)	Yes	No	No response	Yes	No	% Yes change
Households where any members would *like* to move away from the Cairns area following their experience of cyclone Steve.	6.3	93.1	1.7	3.3	94.5	+3.3
Households where any members *intend* to move away from the *Cairns* area following their experience of cyclone Steve.	3.1	95.9	1.0	2.5	96.1	+0.6

TABLE VII
Residents perceived extent of their insurance cover

	Steve ($N = 416$)		Justin ($N = 361$)		Community ($N = 572$)
		% change since 1996		% change since 1996	
Storm surge	15.6	−1.4	16.1	−0.9	17.0
Erosion	9.9	+0.8	7.2	−1.9	9.1
Landslide	10.1	+1.2	6.9	−2	8.9
Flood	19.0	+0.8	19.1	−0.9	18.2

highest ranked items are those indicating greatest vulnerability, while the lower ranks are those where the community may be considered to be most resilient, with the greatest capacity for community-generated mitigation. However, as lower vulnerability does not necessarily imply greater resilience, it is safest to conclude that the lower ranks simply indicate less vulnerability.

6.4. Societal infrastructure

The third set of characteristics that contribute to the vulnerability of Cairns community residents represent the societal infrastructure (and structures) that support the resident community in a tangible way, and provide the physical framework within which the residents live, work and carry on their livelihood activities. This set of characteristics is described by the physical infrastructure and the legislative and administrative framework that determines the level of tangible physical societal support available to the Cairns community generally. This includes many of the characteristics included in Granger's discussion and analysis of community vulnerability under the categories of 'sustenance', 'shelter' and 'security' (Granger 1997; Granger et al. 1999), and in Cannon's consideration of social and societal protection (Cannon 2000). The characteristics that contribute to societal infrastructure are discussed in terms of a (not improbable) scenario of a three-meter (above AHD, Australian Height Datum, or average sea level) storm surge associated with a Category 3 land-falling tropical cyclone. Data discussed in this section are drawn primarily from the Cairns building database that was collected in support of the AGSO Cities Project Cairns Study. The information is readily available from Cairns city council.

A significant number of key facilities and the services they support are likely to lose function and be inaccessible to community residents throughout the area in the event of a land-falling tropical cyclone, particularly if there is an associated significant storm surge or flooding. Data presented throughout the discussion of the societal contributors to community vulnerability indicates that the impact of a (moderate) storm surge would completely cripple the city and temporarily wipe out its economic base. Business and industry would be severely impacted and the ability

TABLE VIII

Characteristics and attributes of individuals, society and communities that contribute to community vulnerability in the Cairns Northern Beaches. Grouped in ranked order from 1 (low) to 5 (high importance)

Characteristics and attributes of individuals	Rank
Trust in authorities	4
Proximity to hazard	3
Hazard education and information	3
Specific hazard knowledge	3
Level of cyclone awareness	2
Previous experience	2
Perception of controllability	2
Access to media	2
Age	1
Income	1
Household structure	1
Gender	1
Ethnicity	1
Education	1
Social norms values belief systems	1
Initial well being	1
Characteristics and attributes of society	
Hospitals and medical facilities	4
The physical environment	3
Buildings and dwellings	3
Transport infrastructure	3
Power	3
Logistics	3
Business commerce and industry	3
Community facilities	3
Emergency services	3
High risk & hazardous facilities	3
Communications	2
Water supply	2
Sewage	2
Fuel and gas	2
Emergency plans, warnings mitigation	2
Characteristics and attributes of communities	
Social networks and support structures	4
Social and community participation	4
Trust in people and social institutions	4
Civic and political involvement / empowerment	3
Altruism, volunteerism	3
Collective sense of community belonging and place	3
Tolerance of diversity	2
Sense of common future	2

*Values are assigned in a non-severe cyclone (Catagory 1–2) context – in a scenario based on a severe tropical Cyclone the values would need to be reconsidered.

of emergency services to respond effectively would be severely compromised. Essential services, such as power and telecommunications, would be limited and logistics that feed and sustain community residents would be largely unavailable. Regardless of where people live throughout the area, they are vulnerable to loss in the event of a land-falling tropical cyclone because of the effect on the societal structures that support all community functions. While community residents may, for the most part, be physically safe in their own properties, it is unlikely that community life could be sustained without significant external support. Cyclone Steve, at the upper end of Category 2, disrupted rather than crippled the city, but a relatively small increase in severity would have resulted in a much severer impact.

To present meaningfully the information relating to the societal characteristics and attributes that contribute to a greater or lesser degree to the Cairns community cyclone vulnerability, it too must be applied to the model. Drawing on the above discussion, a relative value (again between one and five) can be assigned to each of the contributing characteristics that reflects the dimension of its possible contribution to the total vulnerability.

In Table VIII, characteristics have been grouped according to their relative contribution to vulnerability and capacity. They can then be represented along the side of the triangle according to their relative contribution. Given the number of community characteristics and attributes of individual identified within the Cairns community, the maximum length of the side is 75 units; based on the community analysis, the actual length is 41 units, or 54.6% of the possible maximum.

Access to medical facilities is the most critical vulnerability, while characteristics with the lowest rank contribute more directly to enhanced community capacity for hazard mitigation. At the level of the storm surge scenario associated with a Category 2 or 3 cyclone, communications such as radio and telephone may continue to be accessible. Water supply, being mostly gravity fed, would probably continue uninterrupted as all sources are well outside storm-surge zones, but sewerage is dependent upon power. For this reason, and the speed with which sewerage disruption becomes a public health disaster, there are many backup procedures, including emergency power, under the control of the council.

7. Conclusions

Analysis of vulnerability shows us where mitigation efforts need most to be targeted. It shows the weakest lifelines, the areas where society needs strengthening and the groups and characteristics of individuals to target in education and information campaigns. Vulnerability is not the opposite of resilience. Resilience is a set of strengths that run parallel to those of vulnerability. Mitigation efforts must build on strengths and target weaknesses and limitations. The model that has been developed from detailed studies and analyses of the Cairns Northern Beaches population outlines a method for measuring and ranking both vulnerability and resilience, and thus indicates community capacity to mitigate the impact of the hazard. As individuals and communities must bear the primary responsibility for their own hazard mitigation through knowledge, awareness, preparation and appropriate behavior during a hazard event, the role of authorities and emergency managers must be to identify those strengths and weaknesses of resilience and vulnerability in order to contribute to knowledge and awareness.

Acknowledgements

Funding for the research projects was provided by the Bureau of Meteorology, Cairns City Council, Emergency Management Australia, Queensland Department of Emergency Services and the Tropical Cyclone Coastal Impacts Program.

Notes

1. Term 'social cohesion' follows Durkheim's (1964) concept of social solidarity and refers to the degree to which people are connected with one another within the social system
2. Bureau of Meteorology, Queensland Department of Emergency Services and Cairns City Council
3. The Cairns city council has zoned, for planning purposes, the area between sea level and 4.5 m into three 'storm surge zones' 0–1.5 m, 1.5–3.0 m and 3.0–4.5 m.
4. Households were identified by address – not by occupant.
5. The Insurance Council of Australia together with many individual insurance companies have produced pamphlets that explain the extent of various levels of insurance cover in 'plain language' – that is – simple, direct and free of legalistic jargon.

References

ABS: 1998, *CData 96 (Final Release)*, CD-ROM databases from the 1996 National Census, Australian Bureau of Statistics, Canberra.

Alway, J., Belgrave, L.L. and Smith, K.L.: 1998, 'Back to normal: Gender and disaster', *Symbolic Interaction* **21**(2), 175–195.

Anderson-Berry, L.: 2002, *Community Vulnerability to Landfalling Tropical Cyclones and Storm Surge.* PhD Thesis, James Cook University at Townsville/Cairns.

Aysan, Y. and Oliver, P.: 1987, *Housing and Culture After Earthquakes*, Oxford, UK, Oxford Polytechnic.

Barton, A.H.: 1969, *Communities in Disaster: A Sociological Analysis of Collective Stress Situations*, Garden City, NJ, Doubleday.

Bates, F., Fogelman, C.W., Parenton, B., Pittman, R. and Tracy, G.: 1963, 'The social and psychological consequences of a natural disaster', *NRC Disaster Study*, Vol. 18, Washington, DC, National Academy of Sciences.

Blakie, P., Cannon, T., Davis, I. and Wisner, B.: 1994, *At Risk – Natural Hazards, People's Vulnerability, and Disasters,* London, Routledge.

Bolin, R.: 1994, 'Post-disaster Shelter and Housing: Social Processes in Response and Recovery', in R. Dynes and K. Tierney (eds.), *Disaster, Collective Behaviour and Social Organisation*, Newark, University of Delaware Press, pp. 115–127.

Bolin, R. and Stanford, L.: 1998, *The Northridge Earthquake: Vulnerability and Disaster*, London, Routledge.

Bureau of Transport Economics: 2001, *Economic Costs of Natural Disasters in Australia*, Report No. 103, Canberra, Bureau of Transport Economics.

Callaghan, J.: 1998, *Tropical Cyclone Impacts Along the Australian East Coast from November to April 1867 to 1997*, unpublished working document, Brisbane, Bureau of Meteorology.

Cannon, T.: 1994, 'Vulnerability analysis and the explanation of "Natural Disasters", in A. Varley (ed.), *Disasters, Development and the Environment*, Chichester, John Wiley.

Cannon, T.: 2000, 'Vulnerability analysis and disasters', in D.J. Parker (ed.), *Floods* Vols 1 & 2, London, Routledge.

Crichton, D.: 1999, 'The risk triangle', in J. Ingleton (ed.), *Natural Disaster Management,* London, Tudor Rose.

Davis, N.Y.: 1986, 'Earthquake, tsunami resettlement and survival in two north Pacific Alaskan native villages: Natural disasters and cultural responses', *Studies in Third World Societies*, Vol. 36, Williamsburg, VA, College of William and Mary.

Davis, M.: 1998, *The Ecology of Fear,* New York, Metropolitan.

Durkheim, E.: 1964, *The Division of Labour in Society*, New York, Free Press.

Dynes, R.: 1989, 'Reconstruction in the context of recovery: Thoughts on the Alaskan earthquake', *Proceedings NCEER Conference* Buffalo, New York, National Earthquake Resource Center.

Emergency Management Australia: 2000, *Emergency Risk Management: Applications Guide,* Canberra, Australia, Emergency Management.

Enarson, E. and Fordham, M.: 2000, 'Lines that divide, ties that bind: Race, class and gender in women's flood recovery in the US and UK', *The Australian Journal of Emergency Management* **15**(4), 43–52.

Fothergill, A.: 1996, 'Gender, risk and disaster', *International Journal of Mass Emergencies and Disasters,* November 1998, **14**(1), 33–56.

Fothergill, A., Maestas, E. and Darlington, J.: 1999, 'Race, ethnicity and disasters in the United States: A review of the literature', *Disasters* **23**(2), 156–173.

Friesma, P., Caporoso, J., Goldstein, G., Lineberry, R. and McLeary, R.: 1979, *Aftermath: Communities after Natural Disasters*, Beverly Hills, CA, Sage.

Fritz, C.: 1961, 'Disasters', *Contemporary Social Problems,* in R. Merton and R. Nisbit (eds.), New York, Hardcourt, pp. 651–694.

Geipel, R.: 1982, *Disaster and Reconstruction*, London, George Allen and Unwuin.

Granger, K.: 1993, 'Understanding Queensland's storm tide hazard', *Presentation Paper from AURISA 21st Annual International Conference*, Adelaide, Australia, 23–26 November, 1993.

Granger, K.J.: 1997, 'Lifelines and the AGSO cities project', *The Australian Journal of Emergency Management* **12**(1), 16–18.

Granger, K., Jones, T., Leiba, M. and Scott, G.: 1999, *Community Risk in Cairns: A Multi Hazard Risk Assessment,* Canberra, Australian, Australian Geological Survey Organisation.

Haas, E., Kates, R. and Bowden, M. (eds.): 1977, *Reconstruction Following Disaster* Cambridge, Mass, MIT Press.

Hewitt, K.: 1997, *Regions of Risk: A Geographical Introduction to Disasters*, Essex, UK, Longman.

Ilf, J.: 1995, *Community Development. Creating Community Alternatives – Vision Analysis and Practice*, South Melbourne, Longman, pp. 1–3, 14–17, 89–94.

Kaniasty, K. and Norris, F.H.: 1999, 'The experience of disaster: Individuals and communities sharing trauma', in R. Gist, R. Lubin and B. Lubin (eds.), *Response to Disaster*, Philadelphia, PA, Taylor and Francis.

Keys, C.: 1991, 'Community analysis, some considerations for disaster preparedness and response', *The Macedon Digest,* June, **6**(2), 13–16.

King, D.: 2002, 'Post Disaster Surveys: Experience and methodology', *Australian Journal of Emergency Management* **17**(3).

Meyer, P.: 1997, *Tropical Cyclones,* Zurich, Swiss Reinsurance Co.

Mileti, D.S., Drabek, T.E. and Haas, J.E.: 1975, *Human Systems in Extreme Environments: A Sociological Perspective*, Colorado, USA, Institute of Behavioral Science.

Mileti, D. and Passerini, E.: 1996, 'A social explanation of urban relocation after earthquakes', *International Journal of Mass Emergencies* **14**(1), 97–110.

Mileti, D.: 1999, *Disasters by design: A reassessment of natural hazards in the United States*, Washington, DC, Joseph Henry Press.

Mitchell, J.K.: 1989, 'Hazards research', in G. L. Galle and C. J. Willmott (eds.), *Geography in America*, Columbus, OH, Merrill, pp. 410–24.

Morrow, B.H. and Phillips, P. (eds.): 1998, 'Women and disasters', *International Journal of Mass Emergencies and Disasters*, Special Issue, **17,** 5–130.

Neuman, W.L.: 1997, *Social Research Methods: Qualitative and Quantitative Approaches*, Boston, Allyn and Bacon.

Newby, H.: 1987, 'Community and urban life', in P. Worsley (ed.), *The New Introducing Society*, London, Penguin.

Passerini, E.: 2000, 'Disasters as agents of social change in recovery and reconstruction', *Natural Hazards Review* **1**(2), 67–72.

Peacock, W., Morrow, B. and Gladwin, H.: 1997, *Hurricane Andrew: Ethnicity, Gender and the Sociology of Disaster,* London, Routledge.

Raggatt, P., Butterworth, E. and Morrissey, S.: 1993, 'Issues in natural disaster management: Community response to the threat of tropical cyclones in Australia', *Disaster Prevention and Management* **2**(3), 12–21.

Rossi, P., Wright, J., Wright, S. and Weber-Burdin, E.: 1978, 'Are there long term effects of American natural disasters?', *Mass Emergencies* **3**, 117–132.

Salter, J.: 1995, 'Disasters as manifestations of vulnerability', *The Australian Journal of Emergency Management* **10**, 9–10.

Smithson, P.: 1993, 'Tropical cyclones and their changing impact', *Geography* **339**(78), pt. 2, 170–174.

Stehlik, D., Lawrence, G. and Gray, S.: 2000, 'Gender and drought: Experiences of Australian women in the drought of the 1990's', *Disasters* **24**(1), 38–53.

Sweet, S.: 1998, 'The effect of a natural disaster on social cohesion: A longitudinal study', *International Journal of Mass Emergencies and Disasters* **6**(3), 321–331.

Taylor, J.B.: 1972, 'An approach to the analysis of emergent phenomena', *Proceedings Japan – United States Disaster Residential Seminar: Organizational and Community Responses to Disasters,* Columbus, Ohio, Disaster Research Center, pp. 110–129.

Tierney, K. and Dahlhamer, J.: 1997, 'Business disruption preparedness and recovery', *Lessons from the Northridge Earthquake,* Preliminary Paper No. 257, Newark, Delaware, Disaster Research Centre.

Turner, R. and Killien, L.: 1987, *Collective Behaviour*, 3rd edn, Englewood Cliffs, NJ, Prentice Hall.

Varley, A. (ed.): 1994, *Disasters Development and the Environment*, Chichester, John Wiley.

Wadley, D. and King, W. (eds.): 1993, *Reef, Range and Red Dust,* Brisbane, Queensland, Department of Lands.

Walters, K.J.: 1978, 'The reconstruction of Darwin after cyclone tracy', *Disasters* **2**(1), 59–68.

Winter, I.: 2000, 'Major themes and debates in the social capital literature: The Australian connection', in I. Winter, (ed.), *Social Capital and Public Policy in Australia*, Melbourne, AIFS.

Wisner, B.: 1993, 'Disaster vulnerability: Scale power and daily life', *Geographical Journal* **30**(2), 127–140.

IMPROVING ACCESS TO WATER RESOURCES THROUGH RAINWATER HARVESTING AS A MITIGATION MEASURE: THE CASE OF THE BRAZILIAN SEMI-ARID REGION

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(Received 30 July 2003; accepted in final form 1 April 2004)

Abstract. This paper focuses on the importance of rainwater harvesting to mitigate the scarcity of water in the semi-arid region of Brazil. It is a case study about the Million Cisterns Project, an initiative developed by NGOs with the support of Brazilian Federal Government Institutions and international funding organizations. The project is innovative in a series of ways when compared to mitigation measures previously implemented by the government. Instead of focussing on short-term, top-down, palliative measures based on the construction of dams and wells, it focuses on low cost, bottom-up, long-term measures and, most importantly, it involves an educational component. Thus, the provision of water is closely related to the empowerment of the most destitute population and this leads to the sustainability of the actions. The case study serves to illustrate the relevance of the partnership between grassroots organizations and governmental institutions in the context of mitigation.

Keywords: Brazil, grassroots participation, mitigation, rainwater harvest, sustainability

1. Introduction

Access to fresh water has been a preoccupation shared by many nations throughout the world. This resource is scarce and yet crucial for the survival of human beings. In various regions around the world, especially the arid and semi-arid zones, the absence of water resources or the limited access to it is aggravated during drought periods. In those cases, mitigation measures toward the drought are usually implemented to mitigate problems related to the lack of water. Therefore, in face of the intimate relationship between the droughts and the scarcity of water resources, various actions devoted to mitigate one of these problems have repercussions on the other.

Although Brazil can be considered one of the countries of the world which has amongst the largest water reserves, mostly due to the water available in the Amazon basin, the country faces many problems related to the scarcity of water. Most of the northeastern portion of the country and parts of the southeast are characterized by a semi-arid environment and are severely affected by water shortages. In such a scenario, there is an unequal relationship between the most destitute and the elite in regards to access and control over water resources. The northeast is experiencing the problems of privatization of water that occur in several other countries (Branco et al. 2003a). The scarcity of water resources has been designated as one of the most serious limitations to the development of the Brazilian semi-arid region. Water is thus viewed as a precious resource and access to it is intimately related to socio-economic and political power.

The water-related problems of the Brazilian semi-arid region are expressed in the Water and Climate Dialogue Research Report (United Nations Environment Program 2003). According to this report, the availability of water is expected to decrease gradually over the years. This includes the variability in the flow of the São Francisco River, the most important river in the region. This can be seen as a result of global warming, high evaporation rates and the deforestation of the Amazon rainforest (Gnadlinger 2003).

The mitigation measures implemented by the government, for many years, were ineffective and ignored the real needs of the poor. These measures were based on a top-down approach and were mostly of a technical and emergency nature. They either focussed on the construction of large dams and wells or on the provision of work, water and food for the poor population. These mitigation measures were palliative in nature and failed to implement long-term solutions to the situation experienced by the affected population. Furthermore, there was no participation of those suffering the effects of the scarcity of water in the planning of these actions. As a result of the aggravation of the problems and the pressure of civil society organizations over the government, this scenario has changed. There has been a shift from focussing on large-scale, short-term, technical solutions, mostly palliative in nature, to small-scale, long-term measures which address the needs of the most destitute.

The local NGOs have played a very important role in showing the importance of focussing on the needs of the poor and have succeeded in calling the attention of governmental organizations to that. This has partly been done through the presentation of the results of their work on the ground. Among the actions implemented is the reliance on rainwater harvesting through the Million Cisterns Project (P1MC), which has been coordinated by the Semi-Arid Articulation (ASA), a consortium of NGOs. This initiative has received the support of the federal government through the National Water Agency (AWA) and is being implemented not only in the semi-arid region. Beyond providing water to the poorer sector of the population, the project also involves the education of the beneficiaries in regards to the management of water in the semi-arid environment as well as raises their consciousness to issues such as the rights and obligations of every citizen. The appropriateness of rainwater harvesting as a viable and inexpensive alternative to fulfill the needs of the poor around the world was discussed in the Third-World Water Forum, which took place in Kyoto, Japan, in March 2003 (Gnadlinger 2003).

The main goal of this paper is to analyse the importance of the Million Cisterns Project as a mitigation measure toward the scarcity of water in the Brazilian semi-arid region. The analysis will provide an insight about the impact and usefulness of a mitigation measure initially proposed by civil society and then supported by governmental institutions. This calls attention to the relevance of the partnership between governments and grassroots organizations in regards to the development and implementation of effective mitigation measures. In order to understand the importance and the impact of such an initiative, a brief historical overview of previous mitigation measures will be presented. It is important to mention that since the project is in its implementation phase, there are some constraints in regards to the data being presented, as the results are partial up to this stage.

1.1. THE SEMI-ARID REGION AND ITS CHARACTERISTICS IN THE CONTEXT OF THE SCARCITY OF WATER

Brazil is a vast country which occupies 8 511 996.3 km^2 of land and has a population of 169 799 170 (IBGE 2000). It is characterized by a great regional diversity not only in socio-economic development, but in cultural and demographic terms as well. While the south and the southeast, the more developed regions where political power is concentrated, are characterized by the presence of Europeans and Asians, particularly, Italians, Germans and Japanese, the north is characterized by a massive indigenous population and the northeast by the presence of Europeans, Africans and, to a lesser extent, indigenous peoples (Wagley 1963; Andrade 1986; Freyre 1975, cited in Branco 2000). In light of the discussion of internal colonialism, the northern and northeastern regions, being less developed and exploited by the southern and southeastern regions, occupy the place of the periphery (Cardoso and Faletto 1976, cited in Branco 2000).

The northeast of Brazil occupies 1 539 32 km^2, which comprises the states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia and occupies 18.2% of the nation's territory. The most recent figures indicate that the population of the region is 28.12% of the national population, or 47 741 711 inhabitants. The northeast is therefore one of the most populated regions of the country, with a population density of 31.01 inhabitants per km^2 (IBGE 2000). All of the northeastern states have part of their land characterized by a semi-arid portion except for the state of Maranhão, which is located further north. Besides occupying most of the northeast, the Brazilian semi-arid also covers parts of the Minas Gerais and Espírito Santo states, which are located in the southeast (see Figure 1). The semi-arid region is characterized by the occurrence of periodic droughts and is the poorest region of the country. Income and wealth are very unequally distributed and the quality of life of the majority of the population is very low.

The region is characterized by the *caatinga* type of vegetation. The climate is hot and dry. The area receives direct influence of various air trends (Atlantic Equatorial, Continental Equatorial, Polar, among others), which in some way interfere in the climate. However, as these trends reach the interior of the northeast region, they

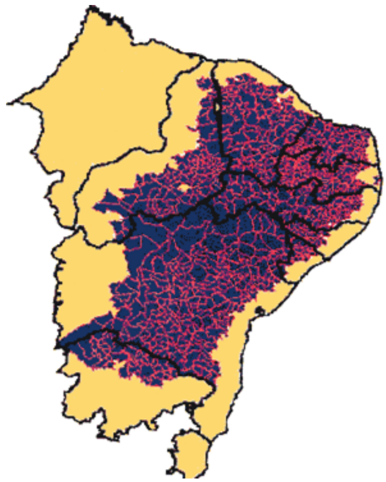

Figure 1. Map of the Brazilian semi-arid area (Source: ANA/P1MC online).

contribute to a variation not only in the volume of rain that falls, but in the intervals between the rainfalls (Suassuna 2000).

Annual precipitation varies between 500 and 800 mm in most of the region, with a few areas receiving 400 mm. The rainfall is not well distributed over the year. There are short periods of time when it seldom rains. The main characteristic of the scarcity of water is, therefore, not the low volume of rainfall but its distribution in time. The climate of the Brazilian northeast is also influenced by other phenomena such as the *El Niño*. The *El Niño* interferes especially by preventing the cold fronts moving from the southern portion of the country. The proximity to the equator is another natural factor which has a strong influence in the climatic characteristics of the northeast. The low latitudes are responsible for the high temperatures (26°C on average), a high number of sunlight hours (approximately 3000 a year) and a high index of evapotranspiration. The semi-arid region evapotranspirates on average around 2000 mm/year and in some areas can reach around 7 mm/day (Suassuna 2002).

In economic terms, subsistence agriculture plays a secondary role. However, it is the most important activity for the most vulnerable and most affected population, i.e., the small landholders who are unable to pursue cattle-raising due to the costs involved; instead, they raise other animals, such as goats, that are adapted to the semi-arid nature of the environment (Branco and Vainsencher 2001). Among the poorest population, who are either small landholders or sharecroppers, subsistence crops such as beans, corn and manioc are the most important crops. They sell the surplus of these crops only in times of need, preferring to keep it for household consumption. During severe drought years, when the scarcity of water achieves extreme proportions, small food producers are unable to realize a harvest. In normal drought periods, when the absence of rainfall occurs in the non-rainy season, when the yield is high, low local market prices make it difficult to sell the crops produced. The latter situation occurs due to the absence of an effective policy to assure commercialization of the cultivated crops (Branco 2000).

As can be seen, the population of the region is exposed to an economic vulnerability either in the rainy or in the dry period. It is hoped that adequate policies to assure the commercialization of the crops are implemented, as they would benefit the population tremendously. The Million Cisterns Project was designed to supply rainwater harvesting for both household and agriculture and thus can reduce the vulnerability of the small food producers. In this paper, however, attention will be mostly devoted to household water supply.

A large portion of the rural landholdings in the semi-arid region faces the scarcity of water on a permanent basis. Even when the area receives normal rainfall, the reservoirs are usually empty 2 months after the rainy season is over, with no other water available. Those periods are usually referred to as the "green drought" because the vegetation remains green although there is no water available to fulfil the basic needs of the population. In periods of "green drought" the government provides water to the population. Trucks carrying water in large tanks (*carros-pipas*) are seen throughout the semi-arid interior – i.e., s*ertão*, as it is referred to. This measure creates a dependency for the population (Portella et al. 1999; Branco 2000) as the provision of water through those tanks is closely related to political favors and, as a result, strengthens patron-client types of relationships. The water is also of poor quality and causes a series of illnesses to those who drink it (Branco et al. 2003a). The reliance on rainwater harvesting has contributed to an improvement in the health of many people throughout the world, including Australia, as it was pointed out at the Third World Water Forum (Gnadlinger 2003).

The small landholders who are usually those that depend on subsistence agriculture for their survival constitute the most vulnerable population not only in economic, but in political terms. Therefore, long-term measures such as the Million Cisterns Project appear to be appropriate to fulfil the water needs of the local population. In order to understand the importance of the project, it is important to have a historical perspective on the mitigation measures implemented prior to the Million Cisterns Project.

2. Mitigation and Adjustment Experience

2.1. A HISTORICAL PERSPECTIVE ON MITIGATION MEASURES

For years the government responded to the scarcity of water by creating several institutions and giving priority to infrastructural and physical factors as well as to short-term assistance efforts. This had taken place since the beginning of the century, when the first institution, the Department of Works to Overcome Drought (*Inspetoria de Obras Contra as*) was created. In 1954, this institution was substituted by DNOCS (The National Department of Works to Overcome Drought), which continued focussing mainly on the physical characteristics of the scarcity of water. SUDENE (Superintendency of Northeast Development) and the Department of Natural Resources were also created in the 1950s. Both institutions also focussed on the physical aspects of the problem (SUDENE 1981).

The main mitigation measure implemented by the government was the construction of dams and wells. Most of them were constructed in private properties and served only private interests. In this case, the majority of the regional population, the small landholders, could not benefit (Branco 2000).

Beyond the policies and programs focussing on the physical and hydrological aspects of the scarcity of water through the construction of dams and reservoirs, government initiatives also included "emergency" measures, which were generally palliative in nature (Pessoa et al. 1983; Branco 2000). The emergency measures were undertaken to fulfil the immediate needs of the affected population during the crisis period and, to a certain extent, helped mitigate drought effects. In explaining the character of institutionalization of emergency measures, Pessoa noted that, "referring to government intervention as an 'emergency' conveyed the idea of urgency that led to the abuse and corruption known as 'drought industry'" (Pessoa 1987, p. 478, cited in Haque and Branco, 1998, p. 17; Branco 2000). The emergency work fronts (*Programas de Frentes de Emergência*) undertaken by the government were devoted to minimize drought severity by creating employment for the affected population particularly through construction of dams and wells. Although the plan was designed to serve both physical and social needs, it was never very effective.

Several works have pointed to the inefficiency of the "work front" measure with limited benefits to the population (Pessoa 1987; Branco 2000). One of the major problems of the "work fronts" was its top-down approach. According to Pessoa (1987), since project formulation, decision-making, control and execution were not shared with the workers, the work front programs eventually benefited the large landowners. The work fronts provided only short-term relief in times of severe drought crisis; they did not mitigate the effects of the drought nor provided a long-term solution to the problem of the scarcity of water, a problem embedded in the regional development process.

During the 1989–1993 drought, the government implemented some changes in the "emergency work fronts." They came to be referred to as "productive work fronts" (*Frentes Produtivas de Trabalho*), in response to lack of success with previous "emergency work fronts" and pressure from the local population as well as grassroots organizations working in the area to support the needs of the local population. In many areas, civil society organizations were involved, such as the Rural Labourers Union Movement (MSTR), ecumenical grassroots organizations and local NGOs (CAATINGA 1994).

The number of persons who applied for the work available through these work fronts was higher each year and the number of jobs available was not enough to absorb all of those in need. This reflected a worsening of the problem year after year.

In spite of the changes instituted, these governmental measures were of a palliative nature, actually increasing the vulnerability of the population. The government had not implemented mitigation measures for long-term solutions based on education and active participation of the population in decision-making.

In 1998–1999, there was again a major period of scarcity of water. During that time, productive work fronts were introduced again and civil society organizations took part in the committees responsible for the program management. However, such as in previous years, this measure was palliative and focussed only on short-term solutions. These were certainly not enough positions to fulfill the needs of all of the population (Branco et al. 1999) as many people were excluded from benefiting.

As it can be seen, the mitigation measures implemented prior to the Million Cisterns Project did not efficiently promote improvement in the quality of life of the population nor did they contribute to sustainable development. As a result of that, the population adopted mitigation measures, such as migrating to large urban centers, and therefore faced severe hardships (Branco and Vainsencher 1999; Branco 2000). This type of response cannot be seen as an effective mitigation measure and has actually increased people's vulnerability.

In the last few years, a number of NGOs pressured the government to shift attention from emergency short-term solutions to focus on a long-term project devoted to the provision of water to the most destitute. This initiative involves the reliance on rainwater harvesting for both household consumption and agriculture.

2.2. The Million Cisterns Project

The P1MC, as it is referred to, is distinct from the various mitigation measures implemented before, not only for focussing on the needs of the poor, but for stressing the importance of education as the basis for all its actions. The project can be seen as the broadening of the experiences of civil society organizations throughout the years. Those NGOs had been working closely with local communities in a search of solutions to the problems of the scarcity of water. The harvesting of rainwater appears to be a very promising experience not only due to the possibility of harvesting water for critical drought periods, but especially for allowing and facilitating the introduction of an effective and permanent process of social organization and mobilization for water management.

The actions have been implemented not only in the semi-arid region of the nine northeastern states, which comprise 86.48% of the northeastern area, but in the semi-arid portion of the southeastern state of Minas Gerais (11.01% of the state) and of Espírito Santo (2.5% of the state). The total area covered by the project is 974 752 km^2.

The main goal of the project is to contribute, through an educational process, to a social transformation in the region. Through the provision of water and the empowerment of the most vulnerable population, the project expects to introduce new patterns of social relations distinct from the old patron-client relations between the poor and the wealthy, which have characterized the semi-arid region for a long time. The project thus considers the preservation, access to and management of water as a right and an obligation of every citizen.

In such a context, the project broadens the understanding and the practice of "dealing" with the problems posed by the semi-arid ecosystem in a sustainable way. Considering these factors, it can be said that this is a program based on long-term mitigation measures, which gives priority to educational actions rather than to technical ones. In this sense, it is distinct from the previous mitigation measures.

The P1MC is being implemented in 1021 municipalities and aims at benefiting a total of 8 300 000 people. It was initiated in August 2001 and expects to construct a million cisterns in a 5-year period (ASA 2002). The first stage was planned to be finalized by July 2003, with the construction of 12 400 cisterns. For the second stage, ANA is using funds from the *Proágua* semi-arid project, which is funded by the World Bank. These funds will be used for the construction of over 63 000 cisterns (ANA/P1MC 2004) (see Table I). Besides the support from NGOs, governmental institutions such as ANA, the National Water Agency, which is part of the Ministry of the Environment and international institutions such as UNICEF, the project is counting on support from the Hunger Zero and Thirst Zero Programs, recently implemented by the federal government.

Local NGOs researched the most appropriate type of cisterns for several years. The cylindrical cistern was found to be the most adequate type (see Figure 2). In technical terms, this type of cistern is adaptable to the kinds of soils found in the Brazilian semi-arid region. Furthermore, they are very simple to be constructed and the transfer of this technology is also simple. Beyond that, these cisterns last for a long time. There are some that have been in use for over 40 years. The cost is also very low when compared to the benefits they bring to the user. The necessary material for constructing a cistern costs approximately US$ 250.00 and the members of the beneficiary families participate in the construction process.

Along with the construction of cisterns, the project has several specific objectives. One of the most important of them is the implementation of an educational process to the beneficiary population. This is based on the idea that the inhabitants

TABLE I

Spatial distribution and chronogram for the implementation of rural cisterns per states

Year	Total number of cisterns	Units	AL	BA	CE	ES	MG	PB	PE	PI	RN	SE
1	45,000	47	1,100	9,500	6,600	600	1,200	7,800	6,700	4,000	6,400	1,100
2	138,500	54	6,000	30,000	18,000	1,500	3,000	24,000	24,000	10,000	16,000	6,000
3	275,400	64	9,700	83,800	53,000	1,500	6,000	38,700	38,700	15,000	24,000	5,000
4	299,100	64	9,700	109,200	53,000	2,000	6,700	39,700	39,700	19,000	15,400	4,700
5	242,000	64	13,400	104,500	44,400	2,000	5,300	4,800	36,900	14,000	12,000	4,700
Total	1,000,000		39,900	337,000	75,000	7,600	22,200	115,000	146,000	62,000	73,800	21,500

(Source: ANA/P1MC online)

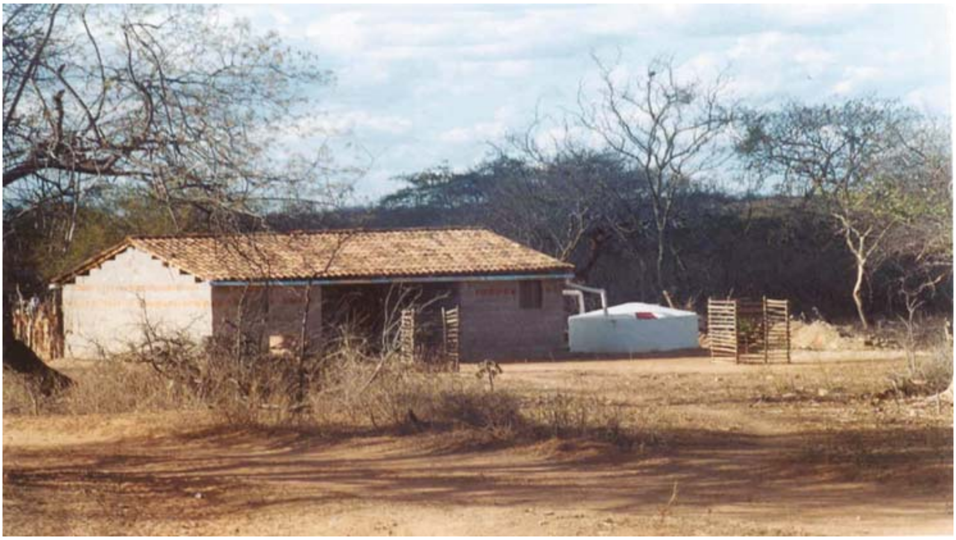

Figure 2. A typical rainwater harvesting cistern (Source: ANA/P1MC online).

of the semi-arid region need to be exposed to new ways and alternatives about how to better deal with the scarcity of water and the other limitations imposed by the environmental conditions of the region. Once this is achieved, it is expected that the local population will be able to participate and influence the planning and the implementation of public policies devoted to promote the sustainable development of the region. A series of workshops are offered. These workshops focus on raising the consciousness of the population in regards to their rights as citizens. This appears to be the most adequate way for the local population to contribute to the formulation of public policies and therefore fulfill their needs as well as benefit from a sustainable development.

The workshops are offered to beneficiary families, health workers and teachers from rural communities. The objective is to encourage their mobilization, their motivation, their comprehension and their knowledge about the issues mentioned above. The project therefore provides means of empowerment for the population as the provision of water and the training about water management is accompanied by a political consciousness that can be a very powerful instrument for change.

Another relevant aspect of the project is the fact that it aims at providing a decentralized access to water for human consumption to one million families. As it can be observed, the family, not the head of the household, is the beneficiary unit and receives attention from the program. In this regard, participation in the workshops is not limited to the male head of the household and this benefits women to a great extent.

Furthermore, the project aims at providing a correct understanding of the semi-arid region in the large context of the Brazilian society. This was never systematically done through any other program or project implemented in the region. Through its actions, the P1MC attempts to demystify the idea that the semi-arid region is a burden to the nation and the notion that the population of the more developed south and southeast regions work to supply the needs of the hungry semi-arid dwellers.

Rainwater harvesting seems to be an appropriate technology because rain is relatively abundant in the region despite the fact that it is not well distributed over time. Even in years when rain is less abundant, it rains approximately 250 mm in the region. When rain is adequately harvested, it is sufficient to fulfill the needs of households during critical periods. A cistern with the capacity to hold 16 000 l of water can provide water for the consumption of a family with five individuals during a period of 10–12 months (ASA 2002). The availability of water through the cistern frees women and children from walking long distances to fetch water as they are usually the ones responsible for this task (ASA 2002; Branco et al. 2003b).

Furthermore, access to harvested water protects the family members against illnesses related to the consumption of contaminated water. By having access to this resource, the poor population is also free from the dependency on the local elite, who have historically controlled water. During election times, for example, the politicians rendered favor to the poor in exchange for votes (Branco and Vainsencher 2001). The provision of water, along with the consciousness-raising process involved in this project, is a very important step to stop that dependency.

Besides raising the consciousness of the population towards their right to water, this project allows people to learn ways to manage scarce water resources and understand their rights as citizens. In addition, the project also involves the training of the family members about how to construct their cisterns. This not only gives a sense of fulfillment to the beneficiary population, who are engaged in the construction of a cistern that will benefit them (the population engaged in the emergency work fronts never had that pleasure as most of the dams and wells which they constructed were located on private properties), but can also provide them with a new source of income. Moreover, the training is provided for both women and men. Six women were trained in a rural community found in the state of Pernambuco in 2003, two of whom were heads of their households. After the training, three of those women adopted rainwater harvesting as an income-generating activity. This is important, particularly due to the fact that the availability of wage labor is very limited, especially for women (Branco et al. 2003b).

Lastly, from the ecological point of view, rainwater harvesting cisterns do not pose any threat to the environment. In this case, they can contribute to the sustainability of regional development

2.3. A THEORETICAL REFLECTION ON DISASTER MITIGATION

Natural hazards such as the scarcity of water which leads to droughts cannot be treated as the result of natural and physical forces solely, but should be seen as the result of a combination of socio-economic and political forces (Cuny 1983; Maskrey 1989, 1993; Rogge 1992; Branco 2000; Wilches-Chaux 1993; Wiest et al. 1994). This is clearly apparent in the fact that this problem does not equally affect a population as a whole, but rather tends to affect more profoundly the most vulnerable. Vulnerability is the factor which determines the impact of any disaster (Rogge 1992). According to Wilches-Chaux, vulnerability is the lack of capacity of a population to cope with the effects of a certain change in its environment (Wilches-Chaux 1993).

It has been shown that attention to the physical aspects of vulnerability leads only to a limited understanding of disaster phenomena. A thorough understanding, therefore, cannot be reached unless attention is given to a wider historical analysis of the evolving relationship between people and the forms, means and relations of production (Maskrey 1989, p. 34). This is clearly seen through the ineffectiveness of the physical mitigation measures, i.e., the construction of dams and wells in response to the scarcity of water in northeastern Brazil.

Vulnerability is the result of a combination of social, political and economic factors (Wilches-Chaux 1993). The most vulnerable segment of the population in the context of northeastern Brazil consists of those who have limited or no access to or control over the means of production and are therefore marginalized by social relations of production which perpetuate dependency and inequality.

Several studies have indicated that the goal of mitigation is to reduce vulnerability (e.g., Wilches-Chaux 1993, p. 39). According to Maskrey:

> . . . mitigation refers to measures which can be taken to minimize the destructive and disruptive effects of hazards and thus lessen the magnitude of a disaster. Mitigation measures can be of different kinds, ranging from physical measures such as flood defences or safe building design to legislation, training and public awareness. Mitigation is an activity which can take place at any time: before a disaster occurs, during an emergency, or after disaster, during the recovery and reconstruction (Maskrey 1989, p. 39).

Rogge suggests that it is worth drawing attention to the need that there be a more universally acceptable definition of the term "mitigation", and especially one that more readily and clearly distinguishes between "mitigation" and "preparedness" (Rogge 1992, p. 39). He points out that

> The concept of mitigation, as widely used in disaster studies, is not always a clear one. To some it implies all risk-reduction and preparedness actions taken prior to an onset of a hazard event. To others, it has a much more specific meaning, such as activities undertaken specifically to lessen the human and socio-economic impact of a hazard; engineering and technocrats, on the other hand, may use the term to refer solely to technological and/or structural interventions aimed at containing the physical impacts of particular hazards (Rogge 1992, p. 29).

Both Maskrey (1989) and Rogge (1992) contribute to the understanding of the concept of mitigation. Mitigation can be formal, i.e., governmental or popular. Formal mitigation measures are usually top down in approach whereas popular or community-based mitigation measures are undertaken by the affected population at the grassroots level (Maskrey 1989). In a critique to formal mitigation measures, Maskrey recognizes that this type of mitigation is associated with professional and high technology, while local know-how is distrusted; he states, "(governmental) programmes are inherently uneconomic because they exclude the principal resources available for mitigation in most contexts: people themselves, their local knowledge, skills and organization" (Maskrey 1989, p. 86).

Formal mitigation measures have therefore not only failed to include the needs of the affected population but also hindered the participation of the affected population and their view about the hazard itself. In order to be effective, mitigation measures have to involve long-term objectives and goals. Thus, measures which are addressed to fulfill the immediate needs of a population are not effective. The engagement of the affected population in mitigation is, in many cases, successful because the population affected by disasters is usually aware of its needs. This is the case particularly when the population is conscious of the root of the problems underlying the disaster. Therefore, the process of consciousness-raising, as proposed by Paulo Freire, meaning an educational process that transforms those involved in the sense of politically empowering themselves (Freire 1980), is of great importance for the development of effective mitigation measures.

Popular or community mitigation measures, therefore, imply the importance of political mobilization and consciousness of people's needs and rights. The introduction of these measures calls for participatory action of those affected by disaster. Another important aspect of community-based mitigation is that it does not exclude the government. Instead, its purpose is to pressure the government to change policies and to engage in negotiations for effective support (Maskrey 1989, pp. 88–89).

The level of attention to disaster mitigation by governments, donors, other agencies and local populations is invariably related to prevailing or perceived levels of risk (Rogge 1992, p. 29). Mitigation is, therefore, closely related to risk perception by governments, donors, other agencies and the local populations. Although formal or government sponsored mitigation programs are supposedly designed to mitigate disasters, in the majority of the cases, these programs involve short-term solutions. These measures are usually top-down approaches that, instead of decreasing people's vulnerabilities, actually aggravate them by increasing dependence (Maskrey 1989). One of the problems with formal mitigation measures is that they usually deal with the physical and material aspects of vulnerability, not the socio-historical conditions.

An example can be seen through the measures implemented by the government in northeastern Brazil prior to the implementation of the Million Cisterns Project. During critical periods of water scarcity the government provided some temporary wage-earning activities, i.e., emergency work fronts for the affected population to engage in work in the construction of wells and dams, along with distribution of food and water. Those actions then focussed on the physical/material vulnerability instead of dealing with the historical roots of the problem such as the unequal distribution of land and the lack of educational programs designed to deal with the scarcity of water in times of drought crisis.

Furthermore, wells and dams were usually constructed on private properties and thus benefited only a few, the majority of whom were large landowners (Andrade 1985; Coelho 1985). Under these circumstances these measures did not reduce the vulnerability of the affected population who was in the great majority poor. It usually satisfied the interests of the political and economic elite (Branco 2000).

Although the scarcity of water as a disaster is part of the ineffective development of the region and can actually be seen as a problem embedded in the development process requiring long-term solutions (Wijkman and Timberlake 1984; Maskrey 1989; Branco 2000), the programs implemented by the government did not have long-term goals. Instead of dealing with the causes of the problem and attempting to decrease the population's vulnerability, these measures were not incorporated into regional development planning (Coelho 1985). They therefore served to maintain the status quo as the government was unwilling to introduce the necessary structural changes involved in a long-term planned mitigation, such as changes in the land tenure system, along with effective extension programs to inform and educate the rural population about adequate measures to cope with the problem (Andrade 1985; Coelho 1985; Pessoa 1987; Branco 2000).

After wasting a great amount of funds in the implementation of ineffective and palliative top-down mitigation measures, the affected population was able to pressure the government to implement less costly and more appropriate measures devoted to the most vulnerable sector of the population. This has been done through the excellent work of NGOs, which work closely with the poor population of the region. After years of work, NGOs elaborated the Million Cisterns Project, which is based on the utilization of rainwater harvesting to fulfill the needs of the most vulnerable sector of the population. Besides the provision of water to the population, through an economical alternative, the project involves an educational component designed to raise the consciousness of the local women and men towards their rights as citizens. Besides aggregating the appropriate technological alternatives, focussing on the needy population and raising their consciousness, the project brings together civil society and the government in the attempt to mitigate the problem. Such an approach is found to be the most appropriate way ever implemented to mitigate the scarcity of water in the semi-arid region of Brazil and to promote sustainable development.

Through the implementation of this project, the Brazilian northeast is getting close to solve the problems of the scarcity of water and consequently the recurrent drought crises. By adopting this approach, the poor population is not the only one who benefits, but the region and the country as a whole. Once people have the means to stay in the rural areas, they stop migrating to large urban centers and joining the unemployed masses (Branco 2000).

The harvesting of water has proven to be not only an economical means but an effective measure for the population to mitigate problems related to climate changes, such as droughts. According to a historical study in India, abrupt climate fluctuations heightened human efforts for construction of rainwater harvesting structures across regions (Pandey et al. 2003). This type of mitigation measure was found to be an efficient way to prevent people from migrating. Such an adaptation to climate fluctuations may provide insights on potential responses of modern societies to future climate changes that has a bearing on water resources, food production and management of natural systems (Pandey et al. 2003).

The reliance on rainwater harvesting can also be considered as very appropriate because of its low costs. According to S. Halls, the Director of the International Centre of Environmental Technology at the United Nations Environment Program (UNEP), if rainwater harvesting is introduced on a large-scale, it could increase the existing provision of water based on a relatively low cost. He adds that the rural communities themselves could be responsible for its management. According to Halls, "no individual rainwater harvesting project in a certain community is enough, but if it is collectively practiced in many areas, it will certainly be sufficient" (cited in Gnadlinger 2003). In the case of northeastern Brazil, the project is having a great impact as the reliance on rainwater harvesting is not taking place on an individual basis, but on a larger-scale and, most importantly, with governmental support as well as that of international funding institutions.

Beyond all of the factors previously stated, this project has a very important educational component which has been brought up in various theoretical contributions on disaster mitigation. The Million Cisterns Project trains the beneficiaries through workshops not only about rainwater harvesting and management, but about issues related to rights and obligations of citizens and, in this sense, the project is an important tool to raise the consciousness of the population about the importance of political mobilization to achieve goals, including those related to the fulfillment of their immediate needs. This is a very important means to struggle against the old cultural model of patron-client types of relationships and to free the poor population of those ties. This project is certainly an important step toward the implementation of a sustainable development in the region.

3. Conclusion

As it has been shown, Brazil has certainly moved a long way towards the direction of efficient and sustainable mitigation measures. Although the Million Cisterns Project is at its beginning stages, it is a very promising measure if it continues to be implemented and eventually reaches all or the majority of the needy households in the semi-arid region. In order for that to be accomplished, it is necessary that the government and the civil society work together in the struggle to solve the problems of the scarcity of water and promote regional sustainable development.

As it has been pointed out by many, the mitigation measures developed by the grassroots are usually the most efficient ones since the affected population really knows what is needed. However, these measures are limited and tend to be isolated as the grassroots lack the means and resources to implement them on a larger-scale. In the case of the P1MC, the grassroots initiative has received the support of the government; this partnership is crucial to the solution of the problem.

One of the most important aspects of the project is the combination of educational and technical components. The scarcity of water and the droughts that have affected the region for a long time cannot be considered the result of physical and natural forces solely as the socio-economic and political implications of the problems are clearly seen. Therefore, in order to properly mitigate the scarcity of water, the social implications have to be addressed and the consciousness-raising of the population is the only way through which this can be done. The educational component of the project is thus the basis for any needed social transformation of the area.

The adoption of rainwater harvesting has proven to be very appropriate, especially if it is done on a large-scale. Not only does this involve low-cost projects, but calls for the participation of the beneficiary population. The beneficiary population can act as managers and prevent a series of water-borne illnesses. As it has been pointed out, if adopted properly, this measure can bring a viable solution to the scarcity of water on a world-wide basis.

Hopefully Brazil will continue to follow the path which is being initiated with this project. Despite the importance of this initiative, close attention has to be focused on the monitoring of the actions. It is important, at this stage, to assess the impact of the project on the quality of life of the beneficiary population. Another important aspect of the monitoring is to avoid the political manipulation of the construction of cisterns by local politicians. Since a "political culture" has historically been very strong in the region, the civil society organizations as well as the governmental organs involved have to account for that as they monitor the construction of cisterns to make sure those who benefit are indeed the ones with the greatest need.

References

ANA National Water Agency: 2003, Retrieved December, 2003, from http://www.ana.gov.br/GestaoRecHidricos/UsosMultiplos/arqs/P1MC.doc.

Andrade, M.C.: 1985, *A Seca: Realidade e Mito*, Pernambuco, Editora Asa.

Andrade, M.C.: 1986, *A Terra e o Homem no Nordeste: Contribuição ao Estudo da Questão Agrária no Nordeste*, 5th edn., São Paulo, Editora Atlas, S.A.

ASA Semi-Arid Articulation: 2002, *Projeto Um Milhão de Cisternas*, Rev. edn., Mimeo.

Branco, A.M., Fischer, M.I.R. and Albuquerque, L.M.: 1999, *A Seca Nordestina de 1998: Condições e Características Sócio-Econômicas*, Recife, Fundação Joaquim Nabuco/Relatório de Pesquisa.

Branco, A.M. and Vainsencher, S.A.: 1999, 'Abençoado veneno? Trabalhadoras e agrotóxicos no nordeste Brasileiro', Paper presented at the IInd International Congress Women, Work and Health, Rio de Janeiro, September, 1999.

Branco, A.M.: 2000, *Women of the Drought: Struggle and Visibility in Face of a Disaster Situation*, João Pessoa, Editora Universitária.

Branco, A.M. and Vainsencher, S.A.: 2001, 'Trabalhadoras e agrotóxicos no submédio São Francisco', *Cadernos de Estudos Sociais* **17**(1).

Branco, A.M., Coutinho, S.F.S., Suassuna, J. and Maurice, Y.: 2003a, 'Gender relations and empowerment of women in the context of water: The case of Proasne in Pernambuco, Northeastern Brazil', Paper presented at the Poster Session of the Day of the Americas of the 3rd World Water Forum, Kyoto, Japan, March, 2003.

Branco, A.M., Suassuna, J. and Picchioni, S.A.: 2003b, 'A importância de gênero no contexto da captação da água de chuva: Uma breve reflexão', Paper presented at the 4th Symposium on Rainwater harvesting and management, Juazeiro da Bahia, Brazil, July, 2003.

CAATINGA: 1994, 'Relatório da Assembleia: Oito de Março – Dia Internacional da Mulher', Ouricuri.

Cardoso, F.H. and Faletto, E.: 1976, *Dependência e Desenvolvimento na América Latina: Ensaio de Interpretação Sociológica*, 2nd edn., Rio de Janeiro, Zahar Editores.

Coelho, J.: 1985, *As Secas do Nordeste e a Industria das Secas*, Petropolis, Editora Vozes.

Cunny, F.: 1983, *Disasters and Development*, New York, Oxford University Press.

Freire, P.: 1980, *Conscientização: Teoria e Prática da Libertação Uma Introdução ao Pensamento de Paulo Freire*, São Paulo, Editora Moraes Ltda.

Freyre, G.: 1975, *Casa Grande & Senzala*, 17th edn., Rio de Janeiro, José Olympio Editora.

Gnadlinger, J.: 2003, *Relatório sobre a participação no 3. Fórum Mundial da Água (FMA)*, Juazeiro, IRPAA.

Haque, E.C. and Branco, A.M.: 1998, 'Vulnerabilidad a desastres y respuesta; Analisis comparativo de estrategias de mitigacion de Sequias', *Desastres y Sociedad* **6**(9), 34–57.

IBGE (Instituto Brasileiro de Geografia e Estatística): 2000, *Censo Populacional*, Rio de Janeiro, IBGE.

Maskrey, A. (ed.): 1993, *Los Desastres no Son Naturales*, Lima, La Red/ITDG.

Maskrey, A.: 1989, *Disaster Mitigation: A Community Based Approach*, Oxford, Oxfam.

Pandey, D.N., Gupta, A.K. and Anderson, D.M.: 2003, 'Rainwater harvesting as an adaptation to climate change', *Current Science* **85**(1).

Pessoa, D., Cavalcanti, C., Pandolfi, M.L. and Guimarães, L.: 1983, *A Seca Nordestina I – Visão Geral*, Recife, FUNDAJ, Instituto de Pesquisas Sociais.

Pessoa, D.: 1987, 'Drought in Northeastern Brazil: Impact and government responses', in D.A. Wilhite, W.E. Easterling and D.A. Woods (eds.), *Planning for Drought: Toward a Reduction of Societal Vulnerability*, Boulder, Westview Press.

Portella, T., Aamot, D., Suassuna, D., Portela, I. and Castello B.T.: 1999, *Viúvas da Seca/Widows of the Drought*, Recife, Edições Rebento/SUDENE/Tarciana Portella Produções.

Rogge, J.: 1992, A *Research Agenda for Disaster and Emergency Management*, Disaster Research Institute, University of Manitoba.

Suassuna, J.: 2002, 'Água – um fator limitante para o desenvolvimento do Nordeste?', in W. Hofmeister (ed.), *Água e Desenvolvimento Sustentável no Semi-Árido*, Fortaleza, Konrad Adenauer Stiftung.

Suassuna, J.: 2000, *Contribuição ao Estudo Hidrológico do Semi-Árido Nordestino*, Recife, FJN/Massangana.

SUDENE: 1981, *As Secas do Nordeste: Uma Abordagem Histórica de Causas e Efeitos*, Recife, MINTER.

United Nations Environment Programme: 2003, *Water and Climate Dialogue Research Report*.

Wagley, C.: 1963, *An Introduction to Brazil*, New York, Columbia University Press.
Wiest, R., Mocellin, J. and Motsisi, T.: 1994, *The Needs of Women in Disaster and Emergencies*, Disaster Research Institute, University of Manitoba.
Wijkman, A. and Timberlake, L.: 1984, *Natural Disaster: Acts of God or Acts of Man?*, Washington, Earthscan.
Wilches-Chaux, G.: 1993, 'La vulnerabilidad global', in A. Maskrey (ed.), *Los Desastres no Son Naturales*, Lima, La Red/ITDG.

THE VALUE OF PUBLIC PARTICIPATION DURING A HAZARD, IMPACT, RISK AND VULNERABILITY (HIRV) ANALYSIS

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(Received 22 August 2003; accepted in final form 31 March 2004)

Abstract. The first part of this paper discusses the links between hazard, risk and vulnerability (HRV) analysis and the development of mitigative strategies. The second part discusses the need to include public participation when completing an HRV analysis. Two current HRV models are used to illustrate the general failure of HRV analysis to include public participation. The third part of this paper provides a brief overview of the Hazard, Impact, Risk and Vulnerability (HIRV) model and its use of public participation. The paper concludes by offering a synopsis of a case study in the town and regional area surrounding Barriere, British Columbia, Canada. This case study demonstrates a positive outcome when public participation is incorporated into an HIRV analysis.

Keywords: case study, disaster management, hazard, risk and vulnerability analysis, public participation, sustainable hazard mitigation

What follows is a discussion of the importance of completing a community- and regionally-based hazard, risk and vulnerability (HRV) analysis in order to set priorities for mitigation; a brief overview of the Hazard, Impact, Risk and Vulnerability (HIRV) model and how it incorporates public participation; and a discussion of the value of public participation as demonstrated in a case study based in and around the community of Barriere, British Columbia, Canada.

1. The Importance of Completing an HRV Analysis

Without completing an adequate HRV analysis, mitigation projects may fail to reduce the risk of a disaster and its consequences. There are numerous examples of situations in which a community has embarked on a mitigation project of considerable size only to find that, when the disastrous event occurs, the project was of little or no value. In some cases, not only do the mitigative activities not provide any positive service but they also give citizens a false sense of security and impede other, more suitable, activities. The 1996 closing of the Castaic Elementary School in California provides a good example of what may occur when an adequate HRV analysis is not completed.

The Field Act was passed in California following the 1933 Long Beach earthquake, in which numerous school buildings were damaged. This act required that all new school buildings incorporate a seismic design. School boards were required to ensure that schools met the high requirements of the building code. Many school boards spent a great deal of money ensuring that schools met the code for seismic risk, but they did not take into account other hazards and vulnerabilities. For example, it was not until 1994 that the Castaic Union School District in California examined the potential hazards facing its elementary and middle schools. They discovered that not only were the schools in the area vulnerable to the ground-shaking effects of an earthquake but that they also faced a risk from the possible collapse of the Castaic Dam and a fire or explosion from the nearby 1925 gas-welded pipeline (FEMA 1997). Their assessment indicated that the risks were too high, and so, with the aid of a FEMA grant and a school bond, in 1996 the school board condemned the older buildings and rebuilt the schools in a less hazard-prone area.

Flooding situations provide another excellent example. During the 1993 Mississippi flood numerous communities found that their extensive dyking was of no value because they had failed to take into account the vulnerability of those communities that had not completed dyking projects. When the floodwaters inundated undyked communities they simply continued across the land, flowing in behind the existing dykes of so-called "protected" communities. When floodwaters finally started to retreat they were trapped behind the dykes, and residents had to endure yet longer periods of inundation (Mairson 1994; FEMA 1997).

In Honduras the 1998 Hurricane Mitch resulted in thousands of people being killed and over 800,000 being evacuated (United Nations Office for the Coordination of Humanitarian Affairs 1998). Many communities were completely cut off, as mudslides and floods damaged much of the national road network and infrastructure. One of the contributing factors to the devastating losses was local initiatives that involved harvesting existing forests and replacing them with agricultural crops. The denuded hillsides were not capable of absorbing the heavy rains that accompanied Hurricane Mitch, and the highly saturated soil caused numerous mudslides, effectively cutting off transportation throughout most of the country. Had an HRV analysis been completed and the vulnerabilities understood mitigative measures could have been undertaken to counteract the results of logging activities.

These examples, and many other well-known case studies such as the 1984 Bhopal Disaster, the 1987 Edmonton Tornado, and the 1995 Mid-Western Heat Wave support the need for adequate HRV analyses. While researchers agree that HRV analysis is an important part of the disaster management process, they often do not agree on the particulars. Hays (1991, p. 8) makes the point that HRV analysis is only the first step of the disaster management process: an HRV analysis is not an end in itself; it is the means towards an end (i.e., the mitigation of the risks and consequences of disasters). In other words, Hays believes that HRV analysis is the cornerstone of mitigation. However, he and others (Maskrey 1989; Godschalk 1991; Scanlon 1991) are less clear about the direct relevance of HRV analysis to mitigation. For example, Godschalk (1991) gives a number of reasons why the results of HRV analysis are important for disaster management planning, but they are presented in theoretical terms rather than in practical examples. In addition, Godschalk says that an HRV analysis should "justify management decisions for altering program and staffing assignments that may vary from the previous norm" (1991, p. 145). This leaves the reader uncertain as to the direct contribution of HRV analysis to the development of mitigative strategies.

It is important to understand the role of HRV analysis in the development of mitigative strategies within the disaster management process. Fischhoff et al. (1978) state that, since hazards are divided into events and consequences, one has the following options: (1) prevent the event from occurring; (2) prevent the potential consequences of the event from occurring; or (3) lessen the harmful consequences of the event. It is apparent that without adequate HRV analyses communities may neglect to plan for likely hazards. This is because, without understanding extant hazards and vulnerabilities, it would be impossible for them to adequately follow any of the foregoing options. Consequently, they would not be able to achieve "sustainable hazard mitigation" (Mileti 1999, p. 215).

Drabek (1986, p. 21) defines mitigation as "purposive acts designed toward the elimination of, reduction in probability of, or reduction of the effects of potential disasters." There is, however, a blurring of the timing of mitigation, as Quarantelli (1986, p. 4) classifies prevention activities as those geared to preventing the occurrence of an event, while he classifies mitigation activities as those geared to lessening the impacts of an event. It would seem appropriate to choose to define mitigation as representing those pre-, during, and post-disaster activities that reduce the risk and consequences of any given disaster. Thus, mitigation is interpreted in the broadest possible sense and includes both pre-disaster projects (such as structural retrofitting, adopting non-structural mitigation measures [e.g., strapping a hot-water tank to a wall], supporting neighbourhood emergency plans, and developing warning messages) and post-disaster activities (e.g., setting up counselling services for vulnerable populations, improving building codes, making zoning changes, and instituting debris management policies).

Current research defines the concept of mitigation as central to the success of disaster management. In the mid-1990s many of the United States' top hazards experts met and collaborated on the 1998 Reassessment of Natural Hazards in the United States (Mileti 1999). Based on an extensive literature review and the findings of the Reassessment, Mileti concluded that a shift in the field of disaster management must take place so that it would be possible to focus on "sustainable hazard mitigation" (1999, p. 2). Mileti argues that there are six objectives that must simultaneously be reached in order to mitigate hazards in a sustainable way: (1) maintaining and enhancing environmental quality (i.e., human activities should not reduce the carrying capacity of the ecosystem), (2) maintaining and enhancing people's quality of life, (3) fostering local resilience and responsibility, (4) recognizing that vibrant local economies are essential, (5) ensuring inter- and intra-generational equity (i.e., not precluding a future generation's opportunity for satisfying lives by exhausting resources in the present generation), and (6) adopting local consensus building.

The importance of mitigation is recognized in the Federal Emergency Management Agency's major initiative, "Project Impact"[1] (FEMA 2000), which was developed as a partnership between communities, government, and businesses in order to build disaster-resistant communities. Sustainable hazard mitigation warrants an inter-disciplinary approach that encompasses environmental, social and economic considerations as well as technical analysis in order to determine hazards, risks and vulnerabilities. This being the case, it is clear that an adequate HRV analysis is critical to the success of sustainable hazard mitigation. It can also be argued that, if sustainable hazard mitigation requires an inter-disciplinary approach, then so does completing an HRV analysis.

2. The HRV Process

The difficulty has been in finding a model for HRV analysis that embraces an inter-disciplinary approach and that integrates public participation. For example, one current HRV model is known as the "Community Vulnerability Assessment Tool: New Hanover County, North Carolina" (NOAA 1999) and is produced by the National Oceanic and Atmospheric Administration (NOAA). I refer to this as the NOAA model. It includes eight crucial steps, is geared towards opportunities for mitigation and is regionally based, focusing on New Hanover County, North Carolina. The NOAA model purports to be "an informational aid" designed to assist communities to develop effective hazard mitigation strategies. However, this model, as outlined on its CD-ROM, is devoid of any mention of the overall HRV process.

In the section of the NOAA CD-ROM that includes the New Hanover case study, reference is made to the New Hanover County Project Impact Risk Assessment and Hazard Identification Sub-Committee. There are only six members of this committee, and include representatives from (1) the National Weather Service, (2) the New Hanover County schools, (3) the Occidental Chemical Corporation, (4) the US Army Corps of Engineers, (5) the City of Wilmington engineer, and (6) the US Coast Guard. It is interesting to note that, even though this is a regionally and community-based HRV model, half of the members on this sub-committee are from nationally, not locally, based organizations. In addition to the members of this New Hanover County sub-committee, ten "data providers" are listed, and all, with the exception of the New Hanover County schools, are nationally or state-based. Nowhere does the material suggest the need for community- or county-based stakeholders to participate in the HRV process.

Similarly, from a United Nations perspective, a coordinating group is central to the United Nations Awareness and Preparedness for Emergencies at Local Level (APELL) model. The APELL model and involves "fire and rescue services, hospital and health services, civil defence, industry, environmental authorities and building authorities" (UNEP 1992, p. 18), but there is no mention of laypersons or residents being included in the HRV process. While experts are highly trained to understand various hazards, they may not have an understanding of local conditions. In the area of disaster management, appointing an "average citizen," especially a long-time resident, is important. Wynne (1992) argues that, in many cases, it is local residents rather than scientists and experts who are truly knowledgeable about the local environment. Thus, it is the partnership of expertise and local knowledge which will assist in dealing with (1) the potential lack of quantitative and qualitative data *vis-à-vis* hazards, risks and their impacts; (2) the uncertainty that is part of dealing with potential disasters; and (3) the inability of the scientific and expert community to accurately predict potential hazardous events.

As many have argued (Berke and French 1994; Salter, cited in Disaster Preparedness Resources Centre 1998; Godschalk et al. 1998; Pearce 2003), if our approach to sustainable hazard mitigation is to be effective, then it must ensure that it incorporates public awareness and participation. Indeed, the need for public participation was one of the driving factors in the development of the Hazard, Impact, Risk and Vulnerability (HIRV) model.

3. The HIRV Model (An Overview)

3.1. The HIRV process

The HIRV model is community- and region-based: it is first and foremost a tool for local communities and regional governments. It is based upon local knowledge supplemented by experts, and it is to be used by both large and small communities. Given the great differences between large metropolitan areas and small communities, an HRV model must be adaptable. The HIRV model can be used to analyze neighbourhoods within a community and/or within a regional district. With respect to HRV analysis, the goal of the HIRV model is to assist any given community to develop sustainable mitigative strategies *vis-à-vis* hazards.

There are, of course, many ways in which public participation can be incorporated into the HRV process (e.g., public meetings, surveys, advisory committees, citizen contacts, and so on [Thomas 1995]). Thomas presents a number of ways of involving the public in the decision-making process, and, depending upon the degree of public involvement, different implementation methods (e.g., public meetings, surveys, etc.) will be appropriate. Although it is not always possible, many communities find the use of an advisory committee to be a useful exercise. According to Thomas, the advisory committee can be composed of "representatives from interested groups, including business, labor unions, and agency staff as well as citizen groups" (1995, p. 125). The committee typically holds a series of meetings and hearings involving experts and policy makers on the one hand, and selected members of the public and interest groups on the other (Keeney et al. 1990, p. 1,013).

Thomas's findings suggest that the use of an advisory committee has several advantages: (1) when there are multi-stakeholders involved, it may be easier to reach consensus through an advisory committee than through a public meeting; (2) the honour, or responsibility, of membership encourages participants to think on behalf of the entire community rather than on behalf of their own special interest group; and (3) it can serve as an important vehicle for building public acceptance. While the use of an advisory committee may be appropriate for communities that contain a number of interested individuals and groups, it may not be appropriate for very small communities where there is little public interest in disaster management. In yet other communities, particularly those that have recently had a disaster, there may be large numbers of stakeholders who have an interest in participating in the HIRV process. In this case, additional implementation methods (e.g., public hearings) may be required to supplement the advisory committee.

Potentially, all of a community's residents have an interest in the findings of a comprehensive HRV analysis, yet clearly everyone cannot participate on an advisory committee and not every interested group can sit at the table. Thomas (1995, p. 122) suggests that, while some managers attempt to deal with this problem by appointing an "average citizen" with no particular bias or interest, the evidence indicates that the leaders of established organizations make the best committee members. Not only are these leaders more likely to be accepted as legitimate representatives, but they are also "most likely to display the type of broad orientation conducive to effective decision making" (Cole, cited in Thomas 1995, p. 122). As Thomas and others have shown, the greatest risk to an advisory committee's success has to do with how well its members represent the public (see Pearce 2003 for a review of various approaches to public participation and a more extensive discussion on Thomas's model). One must be very careful when (1) choosing the size of the committee, (2) choosing the members of the committee, and (3) choosing how to implement the committee.

3.1.1. *The Size of the HIRV Committee*

Much of organizational behaviour literature focuses on determining the appropriate size of work groups. There are both advantages and disadvantages to having larger rather than smaller groups. A group having fewer than five members results in (1) fewer people to share task responsibilities, (2) more personal discussions, and (3) more participation (Callahan et al. 1986, p. 215).

Efficiency differs according to size of group. Robbins (1998, p. 260) states that smaller groups are faster at completing tasks than are larger ones; however, he points out that large groups do better if engaged in problem solving. Robbins also contends that groups having over a dozen members are excellent at gaining diverse input and fact finding, while groups having seven members are better at taking action. Similarly, Senge (1990) argues that the potential of collaborative learning is that it allows us to be more insightful and more intelligent than we can possibly be on our own (i.e., individually).

Since a key role of the advisory committee is to gain diverse input and to engage in fact finding, for the most part a larger rather than a smaller committee would be most appropriate. Thomas (1995, p. 121) suggests that the optimal size for an advisory committee is no more than 15 people – "large enough to represent a variety of interests, small enough for everyone to be involved without decision making dragging on interminably."

Very small communities are unlikely to have the diversity and expertise of large communities. While the core committee membership in very small communities may be much smaller than fifteen, use of ad hoc members (brought in from nearby communities, regional governments, or provincial or federal agencies) may supplement the group's lack of diversity and proficiency. Another strategy may involve having a small steering committee as opposed to a large advisory committee. The public could be kept informed of the progress of the steering committee through newsletters, open houses and public meetings (Integrated Resource Planning Committee 1993).

When there are large numbers of interested stakeholders – more than could be efficiently involved in an advisory committee – a number of strategies may be employed. One strategy is to request the selection of a group representative (IRPC 1993, p. 13). For example, the Chamber of Commerce could nominate a businessperson to represent its interests. Another strategy is to hold a public meeting or workshop prior to the actual implementation of the HIRV process. The Integrated Resource Planning Committee suggests a number of functions that may be carried out at these preliminary sessions: (1) develop a registration system for preparing a mailing list; (2) describe the public participation options; (3) provide public comment forms or questionnaires; and (4) request suggestions for participants, facilitators, meeting times, and so on (IRPC 1993, pp. 14–15). Breaking the large group into smaller working groups or holding special workshops during the HIRV process may also facilitate the handling of large groups of interested parties.

3.1.2. *Composition of the HIRV Committee*

The Committee on Risk Characterization, which was struck by the Commission on Behavioral and Social Sciences and Education (National Research Council 1996, p. 2), argues that "coping with a risk situation requires a broad understanding of the relevant losses, harms, or consequences to the interested and affected parties." The committee also indicates that "the risk characterization process must have an appropriately diverse participation or representation of the spectrum of interested and affected parties, of decision makers, and of specialists in risk analysis, at each step" (1996, p. 3). Diversity is an important factor as Robbins's (1998) findings indicate that heterogeneous groups, due to their having access to more information and different perspectives, tend to be more effective than homogeneous groups. The former may be less expedient and have more conflicts, but it performs more effectively than does the latter. Robbins also found that, while culturally dissimilar groups initially have greater difficulty than do culturally similar groups, these difficulties tend to disappear after about 3 months.

As there are a number of persons whose day-to-day roles would strengthen the capabilities of the HIRV committee, it is important to determine the process by which participants are selected. The Land Use Coordination Office of British Columbia has published a set of guidelines relating to public participation; these provide useful information with regard to determining the membership of a HIRV committee (IRPC 1993). The IRPC (1993) identifies a number of steps that, if followed, should ensure the identification of all potential public participants. These steps can be summarized as follows:

1. Make a preliminary list of interest groups and individuals who may wish to be involved in the process;
2. Set up informal, low-key meetings with these groups and other parties;
3. Request the selection of a group representative to participate in an initial joint meeting of all the groups;
4. Ask these interested parties if they know of others who should be involved in the process;
5. and Look for missing interests.

The following are some of the representatives who may enhance the effectiveness of the HIRV committee (Pearce 2001):

• Disaster or emergency manager	• Community planner	• Local resident	• Business representative
• Industry representative	• Land developer	• Environmentalist	• Engineer
• Insurer	• Utilities representative	• Hazards expert	• Representative from the third sector[2]
• Media representative	• Public relations officer	• Elected official	

The disaster or emergency manager brings expertise *vis-à-vis* disasters, and the community planner, who benefits by gaining an awareness of where hazards, risks and vulnerabilities are located, brings the ability to make informed decisions regarding future land use. As mentioned previously, a local resident can contribute local knowledge and may provide a rich oral history regarding previous disasters. A number of researchers (Burby 1998; Aspen Global Institute 1996) emphasize a strong need for the private business community to participate in developing strategic planning proponents. In addition Burby (1998) advocates for the participation of representatives from land development agencies and real estate agencies.

Given the high concern with the environment and with potential chemical hazards, it is not surprising that several researchers suggest that representatives of industry should participate on committees concerned with potentially hazardous materials (United Nations Environment Programme Industry and Environment Program Activity Centre 1992; Thomas 1995; Burton 1996). Almost at the other end of the spectrum are representatives from environmentalist organizations. Developing policies that deal with hazards involves "creat[ing] constituencies that advocate attention to issues of sustainability and hazard mitigation" (May 1997, p. 36). Policy makers and planners have found that agencies that advocate environmental sustainability support hazard reduction (Paterson 1998).

Paterson (1998) argues that a representative from scientific, technical, and professional associations should be involved in implementing mitigation strategies – a view supported by numerous researchers (Alesch and Petak, Berke and Beatley, Dynes, and May, cited in Paterson 1998, p. 220). A member of the Professional Engineers Association might well fill this role on the HIRV committee.

Faced with rising costs following a disaster, insurers have devoted considerable resources that are conducive to mitigation, and their role in hazard mitigation, specifically, has been recognized for some time (Burton 1994; Disaster Preparedness Resources Centre 1999). In many cases, insurance and re-insurance agencies have completed extensive work on the community impact of various hazards (e.g., Insurance Bureau of Canada 1994).

Another group of stakeholders that has often been involved in calculating the community impact of disasters is made up of utility organizations as they have long been recognized as essential partners in disaster preparedness and response (Disaster Preparedness Centre 1999; Institute for Environmental Studies 1997). It is also important to have a scientist or a natural hazards expert on the committee as this person can assist in evaluating data and ensuring that scientific data are adequately "translated" for the layperson. It would be impossible to have all of the relevant experts sitting around the committee table, so it is suggested that experts be invited, as ad hoc members, to contribute information whenever appropriate. A side benefit of having a number of outside experts join the committee on an ad hoc basis is that this is one way of revitalizing an organization that may have become stagnant (Ivancevich and Matteson 1987). Given that the HIRV process is ongoing, it is clearly important to maintain the vitality of the HIRV committee.

One of the stated objectives of a successful HRV process is to empower vulnerable populations. One way to represent vulnerable populations is to include a member of the third sector on the HIRV committee. In the long run, social planners will benefit by gaining new perspectives on how, in times of disaster, social inequities result in increased vulnerability.

Still, even with a representative from the third sector, the HIRV committee has not yet ensured that it will involve and communicate with the community-at-large. "The foundation of any program to prevent and resolve public controversy must be an informed public" (Connor, cited in Thomas 1995, p. 141). In all phases of a disaster, the success of a disaster management program will depend upon getting specific information to citizens (Kasperson, cited in Burkhart 1991; Scanlon 1991).

Burkhart (1991) stresses that it is as important to provide accurate information before a disaster as it is to do so during and after a disaster. The media are essential to any warning system (Scanlon 1991; Burkhart 1991; Drabek 1986). One of the best ways of ensuring that the media will be able to fill their role during the alert and warning phases of a disaster is to make sure that they are well-informed as to potential hazards and that they develop effective warning messages (Scanlon 1991).

The media are clearly important to the disaster management system (Burkhart 1991): the difficulty is in getting them to take an active role.[3] Part of the problem is the reluctance of local governments to directly involve the media in public processes. Paradoxically, the media are perceived as being both friend and foe (Auf Der Heide 1989). However, they are expected to serve the "public interest," which means, in practice, "that mass media are the same as any other business or service industry, but carry out some essential tasks for the wider benefit of society, especially in cultural and political life" (McQuail 1996, p. 68). In addition to the media playing a watchdog role, they also "facilitat[e] self-expression, promot[e] public rationality and enabl[e] collective self-determination" (Curran 1996, p. 97).

The local media are also repositories of large collections of historical data relating to hazards and disasters. Thus, they can play a true participant role in terms of contributing to the information being collected through the HIRV approach.

Burkhart's (1991) research indicates that newspapers and television are the leading channels for passing on disaster preparedness literature and that they are the media of choice for the general public. Thus it would be a good idea to include a newspaper reporter on the HIRV committee.

Spicer (1997, p. 22) argues that "the 'best' public relations encourage and enhance consensus and community." He believes that the foremost function of public relations is to build and maintain healthy relationships by maintaining a dialogue between people and organizations, by encouraging discussion of all views, and by helping to communicate opinions. Public relations officers are all too often viewed as "product publicists" rather than as people who can provide a technical support function; that is, as people who can effectively reach target audiences (Spicer 1997).

Finally, it is important for an elected official – an experienced decision maker – to be on this committee. Although many researchers have discussed the need for elected officials to be involved in pre-disaster activities, Petak (1985, p. 5) states it most forcibly.

> It is important to note that current decision-making approaches tend to put a great deal of power in the hands of technical experts and professional administrators who are not directly accountable to the public. Elected officials must, therefore, assert their responsibility as representatives of the public and actively engage in the process of exercising value judgments which will lead to agenda setting, resource allocations, staffing, training, and, ultimately the effective implementation of a program designed to mitigate against, prepare for, respond to, and recover from disasters when and if they should occur.

By ensuring that the public participates in each step of the HRV process, the HIRV model increases the likelihood that the public will provide the political pressure needed in order to allocate resources to mitigative actions – especially given the existence of so many competing interests (e.g., recreational space, infrastructure maintenance, policing, etc.). It is important to remember that the size and composition of the committee will vary with the size of the community.

3.2. An overview of the HIRV model

The HIRV model follows the five phases outlined in Figure 1.[4]

The first phase of the HIRV model is *Hazard Identification*. During this phase, a committee composed of both laypersons and experts reviews a comprehensive list of potential hazards (which is included in the HIRV handbook [Pearce 2001]), reviews the definitions and discussions of hazards, and compiles historical data about past disasters in their given community or region.

The second phase of the HIRV model is *Risk Analysis*.[5] One of the first tasks the HIRV committee must consider is whether or not the community should be divided into neighbourhoods for the purposes of completing the HIRV analysis. This step, which is unique to the HIRV model, is critical in setting the groundwork for addressing issues of equity. The next task is to determine, for each location in the community, the probability of the occurrence of a potential hazard. This is done by using the historical data collected in the hazard identification phase as well as various factors that increase the probability of a hazard. Table I identifies some of the risk factors for wildland–urban interface fires.

TABLE I

Risk factors for wildland–urban interface fires

- Areas undergoing rapid urban growth, where pockets of suburban development infringe upon wildlands or undeveloped areas, are potentially high-risk areas for wildland–urban interface fires.
- Fine Fuel Moisture: this occurs when the moisture content of forest litter and other fine fuels drops to a low level.
- Duff Moisture: this occurs when the moisture content of organic surface soils is at a low level.
- Drought: this occurs when the moisture content of deep organic soils is low (an indication of long-term weather conditions).
- Initial Spread: this occurs when fire fuel is available and there is a potential for high winds.
- Buildup: this occurs when there is a sufficient amount of fuel available for combustion.
- Fire Weather: this occurs when weather conditions are likely to precipitate a major fire.
- Certain fuel or forest types, such as dry conifer and grasses, are more combustible than are deciduous forests.
- Lack of firefighting capacity in areas or urban and wildland interface (e.g., lack of fire hydrants, roads inaccessible to fire trucks, etc.).

Note. Participants were asked to "tick" each risk factor that applied to a particular area.

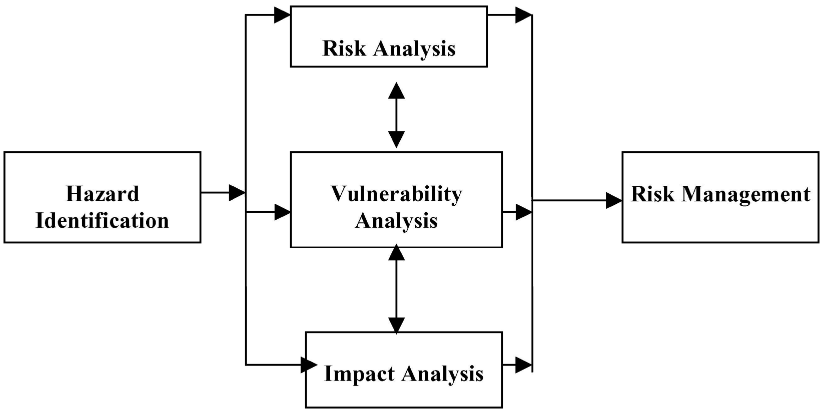

Figure 1. The five phases of the HIRV model.

Another unique feature of HIRV is that, once the assessment is complete, the participants have an opportunity to state how certain they are about the decisions they have made. Dealing with uncertainty and the inability of scientists and experts to accurately predict potential hazards is yet another unique contribution of the HIRV model. While science can, and does, provide many answers, estimating the risk of a potential disaster involves a great deal of uncertainty. The National Research Council (1996) has identified five challenges to accepting technical and scientific input regarding risk: (1) a lack of inter-disciplinary expertise, (2) an inability to integrate valuable information and knowledge from laypeople, (3) a lack of objectivity and neutrality, (4) the ability of scientists to unduly influence others due to the often highly technical information that forms part of the risk assessment, and (5) the sole reliance upon science in making risk decisions.

In many cases "the probabilities of occurrence and impact are not known with certainty; they are usually highly uncertain" (National Research Council 1996, p. 107). The NRC's findings indicate that the "most important need is to identify and focus on uncertainties that matter to understanding the risk situations and making decisions about them" (1996, p. 109). In order to deal with the issue of uncertainty and the state of scientific knowledge, the HIRV model uses the Subjective Probability Ratings (SPR) model, which was developed by Moss in 1996 as part of the Intergovernmental Panel of Climate Change (see Figure 2). This model is described in Moss and Schneider (1997). Although not specifically designed to deal with an all-hazard approach to disasters, their work is certainly useful to the HIRV committee. Their categories are as follows:

Well-Established: This category denotes wide agreement, based on multiple findings through multiple lines of investigation. A finding could be removed from this category not by a single hypothesis, observation or contention, but only by a plausible alternative hypothesis, based on empirical evidence or explicit theory, and accepted by a substantial group.

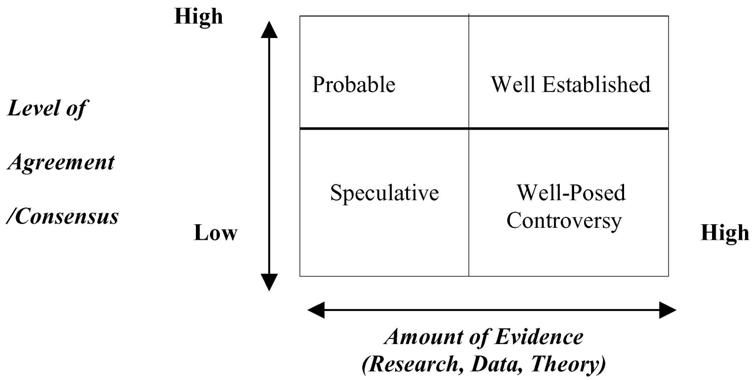

Figure 2. Subjective Probability Ratings Model (1996). *Source*: Moss and Schneider (1997, p. 121).

Well-Posed Controversy: A well-established finding becomes a well-posed controversy when there are serious competing hypotheses, each with good evidence and a number of adherents.

Probable: This category indicates that there is a consensus, but not one that has survived serious counter-attack by other views or serious efforts to "confirm" by independent evidence.

Speculative: Speculative indicates not so much "controversy" as the accumulation of conceptually plausible ideas that haven't received serious attention or attracted either serious support or serious opposition. (Moss and Schneider 1997, p. 121)

The SPR model enables the HIRV committee to determine when (1) information is well accepted and established, (2) more evidence is needed (e.g., flood plain maps, soil testing), (3) the experts or the residents disagree (e.g., regarding the likelihood of a nuclear accident), and (4) there is little evidence and consensus. In other words, the SPR model enables the HIRV committee to document degree of certainty, thus allowing the process of analysis to continue while earmarking specific areas for additional consideration. Application of the SPR model also serves to indicate areas in which additional studies or discussions need to occur.

The rationale for incorporating the SPR model into risk analysis is that it is simple and easy to understand. As Moss and Schneider (1997, p. 123) state:

> At a minimum, employing such consistency tables would force participants to think more carefully and consistently about their subjective probabilities, and help to translate words like high, medium, and low confidence into reasonably comparable probability estimates. This step would be relatively straightforward to implement, and could improve the consistency of the subjective estimates in future assessments.

This addresses the problem of uncertainty and the inability of the scientific and expert community to accurately predict potential hazardous events. A completed

TABLE II
Sample of a completed risk analysis

Name of hazard	Historical data	Risk factors	Certainty of data	Risk rating
Wildland–urban Interface fire	2 previous events in 1996 and 1998	4/9 risk factors apply	Well established	+2

TABLE III
Scale for determining the likelihood of a disaster occurring due to a specific hazard

+3	Hazard is very likely to occur	−1	Hazard has a slight chance of not occurring
+2	Hazard is likely to occur	−2	Hazard is unlikely to occur
+1	Hazard has a slight chance of occurring	−3	Hazard is very unlikely to occur

risk analysis for a wildland–urban interface fire might look like the one outlined in Table II, and Table III shows the scale to determine the likelihood of a disaster due to a specific hazard.

As indicated in Table II, in this hypothetical situation, the HIRV Committee would have determined that two previous fires had taken place and that four out of the nine risk factors listed in Table I were indicated. After considering the certainty of the data upon which the HIRV made their analysis, use of the SPR model indicated the HIRV Committee the certainty of the data was well-established. Based on this analysis, the HIRV Committee believed that a wildland–urban interface fire was likely to occur and gave it a rating of 2.

The third phase of HIRV is the *Vulnerability Analysis*. In this phase participants use the vulnerability factors that have been identified for each hazard. These factors include: people, place, preparedness, and time.[6] In some cases there may not be a great deal of research to indicate any particular vulnerability to a particular hazard. For example, Table IV lists the vulnerability factors for a wildland–urban interface fire. While it is generally known that elderly persons are more vulnerable to most hazards, there may not be any well-known research which shows a direct link between age and the risk of death or injury from wildland–urban interface fires (e.g., some elderly persons may have four-wheel drive vehicles and may be more mobile than persons who are much younger). If no specific information is known for a vulnerability factor, the section may be left blank (e.g., there is no specific day of the week which increases one's vulnerability to forest fires).

In some cases one factor may be more important than another, thus it is importance to have experts involved in the HIRV Committee to point out factors which would increase the vulnerability rating. As in the risk analysis phase, participants have an opportunity to assess how certain they are of the decisions they

TABLE IV
Vulnerability factors for wildland–urban interface fire

People	Place	Preparedness	Time
• Age For the elderly and the very young, lack of mobility to flee, inability to withstand trauma and exacerbation of underlying disease increase vulnerability.	• Buildings Wooden buildings. Buildings which are highly combustible. Buildings with wooden shingles.	• Capability to respond Inadequate emergency response plans for both urban wildfire interfaces. Lack of tested emergency response plans.	• Time of Day
• Density Generally speaking, the higher the population density, the higher the likelihood of injuries and deaths.	• Critical Facilities Wooden buildings. Buildings which are highly combustible. Buildings with wooden shingles.	• Community Education and Training Education and training programs for recreationalists. Training programs for homeowners so as to ensure that vegetation is kept away from one's home, etc. Inadequate community emergency preparedness education and training programs, including neighbourhood preparedness training.	• Day of Week
• Gender			• Time of Year Summer. Periods of high winds.

(*Continued on next page*)

TABLE IV
(*Continued*)

People	Place	Preparedness	Time
• Ethnicity Generally speaking areas with a high ethnic and cultural composition are more vulnerable due to communication issues (e.g. inability to understand warnings, read educative and training information, etc.).	• Ecological Sites	• Mitigation Program Lack of regular home inspections to ensure that homeowners are not increasing the likelihood of wildfires spreading rapidly.	• Holidays People away for long weekends and holidays and thus lack of monitoring of potential fires.
• Socio-economic Status Generally speaking those poor sectors of the population are more vulnerable to any kind of disaster – factors include poorer health, less adequate shelter, less education and lack of funds to assist in their recovery.	• Economic Sectors Forestry Sector Tourism Sector	• Warning Systems Lack of designated egress routes, posted warnings.	
	• Historical and Cultural Sites Wooden buildings. Buildings which are highly combustible. Buildings with wooden shingles.		
	• Lifelines and Infrastructure		
	• Non-structural property		
	• Recreational Land Forested areas. Treed areas with deep, long roots.		
	• Structures		

TABLE V
Sample of a completed vulnerability analysis

Name of hazard	People	Place	Preparedness	Time	Certainty of data	vulnerability rating
Wildland–urban Interface fire	2/5 factors apply	5/11 factors apply	3/4 factors apply	Summer holidays	Probable	+2

TABLE VI
Scale for determining the vulnerability to a disaster occurring from a specific hazard

+3	High degree of vulnerability	−1	Slight degree of invulnerability
+2	Moderate degree of vulnerability	−2	Moderate degree of invulnerability
+1	Slight degree of vulnerability	−3	High degree of invulnerability

have made. Continuing with the previous example, Tables V and VI provide vulnerability assessment as well as a scale to determine vulnerability to a disaster for a wildland–urban interface fire.

In this case, two out of the five factors listed under "People" were found to be relevant, as were 5 out of the 11 under "Place", and three out four under "Preparedness". In addition, the HIRV Committee found that there was an increased vulnerability during the summer and holidays. A review of the available data led the Committee members to include that their analysis was probable. A probable rating was given because there was a lack of available data for a number of factors. In conclusion, the HIRV Committee believed that there was a moderate degree of vulnerability.

The fourth phase of HIRV is *Impact Analysis*. Impacts can be viewed as being social, environmental, economic, or political. It can be argued that insofar as they will affect all of the people in a given community, all impacts are social; however, for the purposes of this analysis, impacts will be considered in terms of their primary effect. Thus, for example, a death or injury would clearly be categorized as a social impact, while damage to a commercial building would be categorized as an economic impact. Some events cross over into more than one impact area. For example, losing one's home qualifies as an economic loss, but it also qualifies as a social loss, as it has a serious impact on one's ability to continue to function within society.

The challenge for the HIRV committee is to consider hazards and vulnerabilities and to "translate" them into impacts. For example, during an earthquake, an aged population "translates" into increased deaths and injuries. Therefore, when vulnerabilities have been identified they may be used to evaluate social impacts, as indicated in Table VII. In the social impact analysis, the loss of housing, schools, and so on is not measured in terms of economic loss but in terms of societal loss.

Communities can use local experts to assist them in determining what the actual impacts would be. In many cases answers will be subject to local values. What

TABLE VII
Vulnerabilities and social impacts

Vulnerabilities	Social impacts
Age	Number of deaths
Gender	Number of injuries
Ethnic and cultural background	
Population density	
Time of day, week, year	
Buildings	Loss of housing
	Disruption of family life
	Loss of schools or educational opportunity
	Loss of a historical site
	Loss of a cultural site
	Loss of health services
	Loss of critical facilities
Recreational land	Loss of recreational opportunities

TABLE VIII
Vulnerabilities and environmental impacts

Vulnerabilities	Environmental impacts
Industrial sectors	Quality of air
Lifelines and infrastructure	Quality and quantity of water
Ecological sites	Quality and quantity of soil
Agricultural sectors	Destruction to plant life
Natural resources sector	Deaths and injuries to wildlife
	Destruction of natural resources
	Destruction of eco-systems
	Loss of bio-diversity

one community may find a high degree of impact (e.g., 10 deaths) another may consider a moderate degree of impact. As long as the evaluation is consistent across all hazards, the basis for comparison will remain valid.

The HIRV impact analysis also takes into account environmental and economic impacts. The following table illustrates how various identified vulnerabilities can be used to assess environmental impact (Table VII). So, for example, if there existed an ecological site in the community, and if this ecological site was vulnerable to the effects of a wildland–urban interface fire, then one could conclude that there would be destruction of an important ecosystem, loss of biodiversity, etc.

Table IX illustrates how various vulnerabilities can be used to determine the subsequent economic impacts following a disaster. If there are a number of buildings

TABLE IX
Vulnerabilities and economic impacts

Vulnerabilities	Economic impacts
Buildings	Structural damage
Structures	Non-structural damage
Critical facilities	
Historical and cultural sites	
Lifelines and infrastructure	
Property	
Economic sectors	Loss of jobs
Recreational land	Loss of revenue
Lifelines and infrastructure	Loss of service
	Deaths and injuries to livestock and domestic animals
	Destruction of crops

which are vulnerable to wildland–urban interface fires then it follows that there will be an economic impact in regards to the value of the building. It is important to remember that the criteria used to answer this question for the purposes of planning and mitigation need not be as stringent as the criteria used by, for example, insurance companies who are attempting to set premium rates. At its simplest, the HIRV impact analysis can be used to provide a best-guess estimate of the degree of economic impact (i.e., high, moderate, or low). If one knows that a large percentage of the buildings in a particular area will be seriously damaged, then it is not really necessary to know the exact value of that damage. An estimate that there would be significant economic damage, or that the level of economic damage in comparison to other parts of the community would be high, is sufficient for an analysis of this type.

According to Parker (1992, p. 238), "technological disasters can ... have political and career ramifications on those in public office who are in positions of trust and who do not measure up to their responsibilities." However, a standard HRV analysis does not usually measure the political impact of a disaster. That the HIRV impact analysis includes political impacts is yet another unique feature of the HIRV model. Ultimately, whether or not mitigative strategies are adopted is dependent upon the political will of the elected officials. One reason for including the political impact of hazards is to assist politicians in determining how the voters will judge their actions regarding whether or not mitigative strategies are implemented. Some politicians have worked to ensure that their communities were well prepared when a disaster occurred (e.g., by testing warning systems and emergency response plans, providing community-based training and education, and implementing mitigation programs). Whenever this has been the case, the community appears to be supportive of its politicians (Stallings 1995).

TABLE X

Vulnerabilities and political impacts

Vulnerabilities	Political impacts
Capacity to respond	Public perception of blame
Community education and training	
Mitigation program	
Warning system	
Outrage factors	

Following a disaster, people ask, "how could this have happened here?" There are a number of different factors that may help to determine what the degree of community outrage might be over having been subjected to particular risks. Those factors used by the HIRV impact analysis have primarily been derived from two sources: Bernstein 1987; Sandman 1991a.[7] The greater the number and seriousness of these outrage factors, the greater the likelihood of public concern and the public perception of blame. In addition to the outrage factors, as with social, environmental, and economic impact analyses, while completing the political impact analysis, the HIRV committee examines the hazards and vulnerabilities and determines their effects as indicated in Table X.

These impacts can be determined for each location and hazard, as is illustrated in Table XI.

The fifth and final phase of HIRV is *Risk Management*. At this point participants evaluate the data for both the risk analysis and the vulnerability analysis phases, and they also provide an impact analysis. The output of the HIRV model is a combined value illustrating those areas of high risk, high vulnerability; low risk, low vulnerability; medium risk, medium vulnerability; and so on. Continuing with the hypothetical example, a completed risk management analysis for a wildland–urban interface fire at a specific location can be illustrated (Table XII).

Were this an actual analysis, it would illustrate that, for this specific location, there was (1) a moderate risk of a wildland–urban interface fire, (2) a moderate degree of vulnerability, (3) low environmental and economic impacts and moderate social and political impacts, (4) a high degree of certainty regarding the risk assessment and impact assessment but a lower degree of certainty regarding the

TABLE XI

Scale for determining the degree of impact of a disaster occurring from a specific hazard

+3	High degree of impact
+2	Moderate degree of impact
+1	Low or no degree of impact

TABLE XII
Sample of completed risk management analysis

Hazard	Risk rating	Certainty	Vulnerability rating	Certainty	Impact analysis	Certainty	Risk & vulnerability analysis
Wildland–urban interface fire	+2	Well established	+2	Probable	En = 1 S = 2 Ec = 1 P = 2	Well established	R = Moderate V = Moderate

Note. S: Social impact; En: Environmental impact; Ec: Economic impact; P: Political impact.

vulnerability assessment, and (5) a combined moderate risk and vulnerability. It is the comparison of the risk and vulnerability assessments (taking into consideration the impact analysis) for the various hazards and for each location that results in the prioritization of hazards, risks and vulnerabilities for the purposes of mitigative action.

4. A Participatory Case Study: Barriere and the North Thompson Sub-Regional District

In order to evaluate the use of the HIRV model and the value of including public participation as part of the HIRV process, a participatory case study was held on 28 March 2000 in Barriere, British Columbia (Figure 3).

Barriere is a small town, with an approximate population of 2800 (Thompson Nicola Regional District [TNRD] 2003), located 66 km north of Kamloops (365 km northeast of Vancouver) in south-central British Columbia. It is part of the Thompson Nicola Regional District (TNRD). There are approximately 5200 residents in the area that includes, and surrounds, Barriere. Because many of the area's residents live in communities outside Barriere, the emergency planner

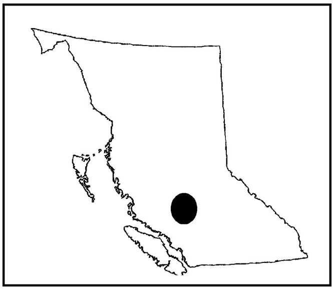

Figure 3. Map of British Columbia indicating approximate location of Thompson Nicola Regional District.

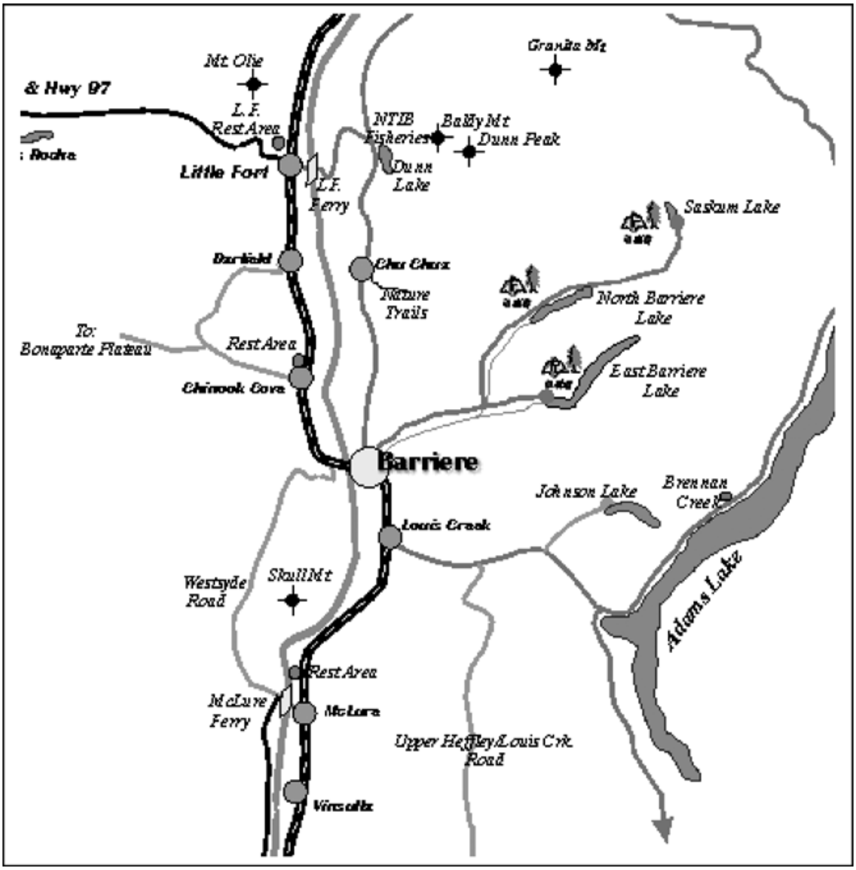

Figure 4. Map of Barriere and North Thompson Sub-Region. *Source*: Adapted from Thompson Nicola Regional District 2003 (http://www.ntvalley.com/barriere/index.htm).

invited residents from the towns of Little Fort, Darfield, Louis Creek, and McLure (see Figure 4).

Barriere, the main town in the area, is situated near the juncture of the Barriere and North Thompson Rivers. It is located in the Central North Thompson Valley and is bordered on the east by the Shuswap Highlands, which rise up to 1830 m. The predominant industry of the area is forestry;[8] three major mills – Tolko Fadear Division, Gilbert Smith Forest Products, and Darfield Building Products – are located in the area. There is an emerging tourist industry, with a new motel having been completed within the last 6 months. The biggest tourist event is the North Thompson Fall Fair, which is held on Labour Day Weekend (TNRD 1997). Barriere is located close to the Canadian National (CN) Rail line and is adjacent to the Yellowhead (No. 5) Highway.

As mentioned, residents from four other towns besides Barriere were invited to the workshop. The northernmost community represented is Little Fort, a community of less than 300 residents. It does not have a major employer, and it consists mainly of self-owned farms and a few stores, a restaurant, a hotel, and a pub. It has an elementary school that goes up to Grade 5 (after that students are bused to Barriere).

Darfield, Louis Creek and McLure are all smaller than Little Fort. Each town has a population of less than 300 residents and boasts a few self-owned businesses. A small ferry service is located in McLure, and it provides people with transportation across the North Thompson River.

4.1. Analysis of the implementation of the HIRV model

The emergency coordinator agreed to hold the HIRV workshop. Earlier, she had been provided with an information package regarding the HIRV model. The Emergency Coordinator invited a number of people to attend and publicized the workshop locally. The following people took part in the workshop and constituted the HIRV committee: (1) the emergency coordinator; (2) the ambulance station chief; (3) a TNRD planner; (4) the Provincial Emergency Program (PEP) regional manager; (5) a reporter for, and owner of, the North Thompson Star Journal; (6) the local Emergency Social Services (ESS) director; (7) an interested community resident; (8) a representative from the BC Ministry of Transportation and Highways; (9) a member of the North Thompson Indian Band; (10) and (11) two representatives from Tolko Industries; (12) a member of Barriere Search and Rescue (SAR); (13) a representative from the Little Fort fire department; and (14) a representative from the Barriere Health Clinic. Seven of the participants were women and seven were men.

Some time was spent at the beginning of the workshop explaining the roles of the individual participants and their potential contribution to the HIRV process. There was only one person from a visible ethnic minority. She was a member of the North Thompson Indian Band, and a number of times participants asked her to provide them with a First Nations perspective although she had not been specifically chosen to represent the First Nations people.

According to the organizational behaviour literature regarding group dynamics, a large, diverse group would engage in diverse input, a high degree of fact finding, and much discussion. This was certainly the case in Barriere. According to Robbins (1998), as group size increases, opportunity for individual participation decreases. In order to maximize individual participation, and in order to benefit from the diversity of the committee, the participants were divided into two groups. This gave people more opportunity to participate in the discussions and, as the findings of each group were shared and discussed with the other group, there was also an opportunity for diverse input.

The workshop was held in the Search and Rescue (SAR) Hall, and participants sat around a long narrow table in the SAR conference room: those sitting at one end of the table formed the first group and those sitting at the other end formed the second group. As soon as the introductions were complete, participants began the workshop by going through the HIRV workbook (which detailed the various phases of the HIRV model) with the participants. Once the hazard identification phase was reached, each group was asked to identify as many hazards as possible. Neither group was able to identify more than thirty hazards (thus supporting the findings of the previous exploratory studies). Participants were then invited to review the comprehensive list of hazards[9] that was provided in the HIRV handbook. The importance of considering all of the potential hazards was stressed, and the participants acknowledged that they had experienced a number of hazards that were on the list but that they had not previously paid any heed to them. The results of the workshop supported the importance of providing definitions and discussions regarding potential hazards as participants often failed to differentiate between types of hazards (i.e., they identified “flood” as a potential hazard but did not identify the different types of floods [e.g., flash flood, snow melt] that could occur).

Each group was asked to choose any two of the seventeen hazards that were included in the HIRV handbook for the purposes of the workshop, and both groups made the same choice: rail accidents and wildland–urban interface fire. The latter choice is not surprising as a number of the participants were volunteer firefighters. Following the HIRV model, both groups were asked to divide the area into logical planning zones. This was the first point in the workshop when group size and composition became factors in the discussion. There was considerable controversy surrounding how the area was to be divided. Some of the SAR members[10] wanted the outer perimeter of the area to be similar to that used by the Barriere SAR team; others wanted to use Electoral Area O. There was some discussion on the part of those from the towns and villages outside of Barriere concerning whether or not they should be included in a regional approach. In the end, the groups decided to use the approximate boundaries of Electoral Area O; namely, all of the area south of, and including, Little Fort (see Figure 5) down to McLure. They also agreed to use a regional approach.

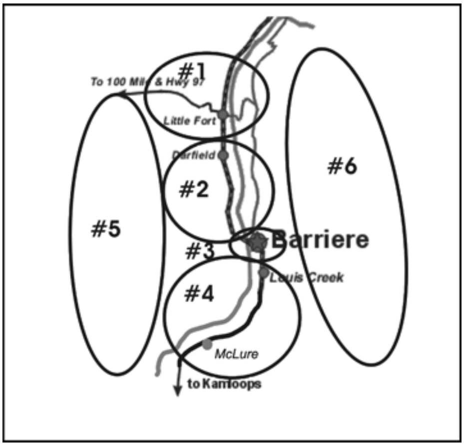

Figure 5. Map illustrating areas used for HIRV analysis.

They divided the area into six zones. Using the river and rail line as a median, they established the following zones: Zone 1 was the area around Little Fort; Zone 2 was the area south of Zone 1 and north of Barriere, and it included the North Thompson Native Reserve and Darfield; Zone 3 was the town of Barriere and its immediate area; Zone 4 was the area south of Barriere down to McLure; Zone 5 was the largely uninhabited area to the west of Zones 1, 2, 3, and 4; and Zone 6 was the also largely uninhabited area to the east of Zones 1, 2, 3, and 4. The zones did not overlap.

For the purposes of the workshop, one group chose to use Zone 2 and the other group chose to use Zone 3. The groups reviewed the historical data for the two hazards in their respective areas. There had been numerous rail accidents and wildfires in both zones. Once each group completed its review, they were asked it to review their findings with the other group. In both cases, members of the other group added incidents that had not been thought of by the group completing the initial data collection. It is expected that individuals will not fully recollect historical events. This supports the HIRV model's emphasis on using community residents and newspaper archives as sources of historical information.

Each group then applied the risk factors for the two hazards to their respective zones. While at least some of the risk factors applied to each zone, there were more risk factors for a rail accident in Zone 3 than in Zone 2, mostly because of the shunting areas and the number of rail crossings in the Barriere area. There were also more risk factors for a wildland–urban interface fire in Zone 3 because its homes were increasingly encroaching upon the forest. While both groups considered the certainty of the information for the wildland–urban interface fire to be well established (a firefighter was on the committee, as were members of the volunteer fire department), both groups also realized that they lacked some information regarding the risk factors for rail accidents and that they needed to bring in experts from CN Rail.

The groups then applied the vulnerability factors and, again, Zone 3 proved to be the most vulnerable to both hazards. Several questions prompted participants to engage in rather lengthy discussions, primarily regarding the location and existence of historical sites for First Nations people, and whether there were areas of significant ecological importance. The impacts of the rail accidents and urban interface wildfires were highest in the social impact area for Zone 3 and highest in the environmental impact area for Zone 2. The HIRV committee had an interesting time attempting to determine the political impact rating for rail accidents. It quickly became apparent that participants did not trust CN Rail personnel. This lack of trust, which was based primarily on the belief that CN Rail was dishonest about reporting derailments[11] and that it tended to minimize previous impacts, was instrumental in raising the political impact for rail accidents to a high factor.

The overall rating for Zone 3 was a moderate to high degree of risk and vulnerability for both rail and wildland–urban interface fire and the rating for Zone 2 was a moderate to low degree of risk and vulnerability for both rail and urban interface wildfires.

All participants actually resided in the same community or region. The benefits of this were apparent, and the workshop was fast-paced and dynamic. Participants did not have to "look up" basic facts and guess at information. All of the participants had an investment in the outcome of the HIRV findings, as was evident in the prolonged discussions that took place concerning whether various risk factors did or did not exist. For example, there was a lengthy debate amongst the various firefighting personnel as to whether or not the buildup of potential forest fuel (e.g., dead pine branches) had increased and whether or not the area was experiencing a drought.

The composition of the HIRV committee was not what it should have been. As previously mentioned, the lack of experts was a problem. For example, in order to complete their analysis, participants needed information that only someone from CN Rail could provide. However, the use of the SPR Model provided participants with an opportunity to complete the HIRV model while also making sure that their reservations regarding the validity of some of their decisions were noted. The use of the SPR model also allowed the groups to identify how an expert could assist (i.e., providing data versus providing clarifying information so as to enable the group to reach an understanding as to the meaning of the data). Having someone from the media on the committee was useful, and there was much discussion as to how the *North Thompson Star Journal* would report the findings of the HIRV committee.

While individual demographics were not particularly relevant to this workshop, the size and diversity of the committee proved to be an asset. The workshop was dynamic, people participated, and the tasks were completed. Participants found few problems in carrying out the analysis. The participants in the Barriere workshop agreed that the HIRV model for HRV analysis met the stated objectives[12] and that the HRV process was both practical and useful. However, they did not continue with the process for any length of time. An informal follow-up with some of those involved in the original workshop would indicate that the lack of financial resources and having only a part-time volunteer emergency coordinator contributed to the failure to continue with the process.

Unfortunately, in August 2003 a series of uncontrolled wildfires broke out in the Barriere area. Hundreds of residents were evacuated and at the time of writing this article well over a hundred people had lost their homes. Very preliminary data would suggest that the build up of forest fuel, and an extended period of little rain and very hot weather had contributed to rapid spread of the fire – factors which were presented and discussed in the workshop.

5. Summary

Disasters will continue to occur, and their social, economic and environmental impacts will continue to increase. With adequate HRV analyses, communities can (1) develop warning systems, (2) focus planning efforts on hazards that are likely to occur and that will have a serious impact, and (3) ensure that planning initiatives and mitigative strategies enhance resilience. Risk communication cannot start without risk awareness and evaluation; consequently, the key points that an adequate model has to take into account are (1) the need to have a dialogue amongst and between local stakeholders and experts, (2) the need to provide stakeholders with essential and easily understood quantitative and qualitative data, and (3) the need to recognize the importance of assessing and understanding community vulnerabilities. Without the political will to allocate enough resources, few communities will be sufficiently prepared to deal with disasters. Two key elements of a successful HRV analysis are: (1) the ability to ensure that information is shared with the public, thus facilitating the development of a political constituency; and (2) the ability to ensure that the concerns of competing special interest groups are incorporated into the overall HRV process. The HIRV model is based on the principle of community participation, and it is comprised of five parts: (1) hazard identification, (2) risk analysis, (3) vulnerability analysis, (4) impact analysis, and (5) risk management. It provides the means for communities to identify potential hazards, to assess the relative risks and vulnerabilities of a particular area, to assess the impact of potential hazards, and to prioritize findings with regard to the allocation of time and resources.

To summarize: (1) completing an adequate HRV analysis is critical to developing strategies for mitigation; (2) public participation is an important factor in ensuring that community and region-based HRV analyses are meaningful; and (3) as demonstrated by the case study, the HIRV model is a good example of how public participation can be integrated with the HRV analysis.

Acknowledgments

The author thanks Professors Anthony Dorcey, Wayne Greene, Peter Nemetz, and Olav Slaymaker (from the University of British Columbia); and Professor Peter Anderson (from Simon Fraser University) for their assistance in the completion of my doctoral dissertation, a portion of which was adapted for this paper.

Notes

1. Project Impact is FEMA's national hazard mitigation initiative. It began with seven pilot communities that were challenged with engaging local government, businesses and civic leaders in a coordinated effort to reduce hazard vulnerability.
2. Paterson (1998, p. 204) defines the third sector as the nonprofit, nongovernmental, independent, or voluntary sector.
3. Despite a federal mandate in the United States to include media members on all local emergency planning committees dealing with chemical hazards, few of the committees have had any active media participation (Hadden, cited in Burkhart 1991)
4. Although the phases are presented in a linear fashion, it is expected that participants will move back and forth between the risk, vulnerability and impact analysis phases as information becomes available.

5. Risk will be used to mean probability or likelihood.
6. Time pertains to periods of time (e.g., hour of day, day of week) during which certain parts of the community may be more vulnerable than during other times.
7. The following can be used to assess the public perception of blame. The Advisory committee can ask if the affected population would consider the situation to be
   - Voluntary – voluntary risks are accepted more readily than are those that are imposed (voluntary versus coerced).
   - Under Individual Control – risks under individual control are accepted more readily than are those under government control.
   - Fair – risks that seem fair are more acceptable than are those that seem unfair.
   - Reported by Trustworthy Sources – risk information that comes from trustworthy sources is more readily believed than is risk information that comes from untrustworthy sources.
   - Ethically objectionable – risks that seem ethically objectionable will seem more risky than will those that do not.
   - Natural – natural risks seem more acceptable than do industrial risks.
   - Exotic – exotic risks seem more risky than do familiar risks.
   - Associated with Memorable Events – risks that are associated with memorable events are considered more risky than are risks that are not so associated.
   - Dreaded – risks that are "dreaded" seem less acceptable than do those that are not.
   - Undetectable – risks that are undetectable create more fear than do those that are detectable.
   - Well Understood – risks that are well understood by science are more acceptable than are those that are not.
   - Chronic – risks that are chronic are better accepted than are those that are catastrophic.
   - Within the Context of a Responsive Process – risks that occur within the context of a responsive process are better accepted than are those that are part of an unresponsive process.
8. Approximately 75 percent of the area's labour force is either directly or indirectly dependent upon the forest industry (TNRD 1996).
9. The list of hazards contains over 70 hazards: natural; diseases, epidemics and pest infestations; and human induced.
10. A number of participants were members of the voluntary SAR team.
11. The reporter recounted an incident in which she had been called by local residents to the site of the derailment of several boxcars. She took photographs of the derailment, and when she subsequently contacted CN Rail its spokesperson denied that it had taken place. Even after she sent them copies of the photographs, they still would not acknowledge that it had happened!
12. For details on the objectives, the questionnaire and the findings from the Barriere workshop questions please contact the author.

References

Aspen Global Change Institute: 1996, 'Natural hazards and global change', in S.J. Hassol and J. Katzenberger (eds.), *The Elements of Change 1996*, Aspen, Aspen Global Change Institute, pp. 11–88.

Auf Der Heide, E.: 1989, *Disaster Response: Principles of Preparation and Coordination*, St. Louis, Missouri, C.V. Mosby.

Berke, P.R. and French, S.P.: 1994, *The Influence of State Planning Mandates on Local Planning Quality*, Texas, Recovery Center, Texas A&M University.

Bernstein, A.B.: 1987, *The Emergency Public Relations Manual*, 3rd ed., Canada, Pase Inc.

Burby, R.J.: 1998, 'Natural hazards and land use: An introduction', in R. Burby (ed.), *Cooperating with Nature: Confronting Natural Hazards with Land-Use Planning for Sustainable Communities*, Washington, DC, Joseph Henry, pp. 1–26.

Burkhart, F.N.: 1991, *Media, Emergency Warnings, and Citizen Response*, Boulder, CO, Westview Press.

Burton, I.: 1994, 'Costs of atmospheric hazards', in D. Etkin (ed.), *Proceedings of a Workshop on Improving Responses to Atmospheric Extremes: The Role of Insurance and Compensation*, Ottawa, Canada, Environment Canada, pp. 2–11.

Burton, L.: 1996, 'What is emergency planning?', in R. Kuban (ed.), *The Canadian Fire Officer's Guide to Emergency Management*, Calgary, Alberta, Pendragon Press, pp. 125–146.

Callahan, R.E., Fleenor, C.P. and Knudson, H.R.: 1986, *Understanding Organizational Behavior: A Managerial Viewpoint*, Columbus, OH, Merrill.

Curran, J.: 1996, 'Mass media and democracy revisited', in J. Curran and M. Gurevitch (eds.), *Mass Media and Society*, 2nd edn., New York, St. Martin's Press, pp. 81–119.

Disaster Preparedness Resources Centre: 1999, *1998 Disaster Preparedness Symposium: Towards an Earthquake Strategy for B.C. Final Repot*, Vancouver, British Columbia, Disaster Preparedness Resources Centre.

Disaster Preparedness Resources Centre (ed.): 1998, *The Mitigation Symposium: Towards a Canadian Mitigation Strategy Comprehensive Symposium Proceedings January 1998*, Vancouver, British Columbia, The Disaster Preparedness Resources Centre, University of British Columbia.

Drabek, T.E.: 1986, *Human System Responses to Disaster: An Inventory of Sociological Findings*, New York, Springer-Verlag.

Federal Emergency Management Agency: 2000, *Project impact: Building a disaster-resilient community*, Available at http://www.fema.gov/impact/pi_01.htm.

Federal Emergency Management Agency: 1997, *Reports on Costs and Benefits of Natural Hazard* Mitigation, Washington, DC, Federal Emergency Management Agency.

Fischhoff, B., Hohenemser, C., Kaspeson, R. and Kates, R.: 1978, 'Handling hazards: Can hazard management be improved?', *Environment* **20**(7), 16–20, 32–37.

Godschalk, D.R.: 1991, 'Disaster mitigation and hazard management', in T.E. Drabek and G.J. Hoetmer (eds.), *Emergency Management: Principles and Practice for Local Government*, Washington, DC, International City Management Association, pp. 131–160.

Godschalk, D.R., Kaiser, E.J. and Berke, P.R.: 1998, 'Hazard assessment: The factual basis for planning and mitigation', in R. Burby (ed.), *Cooperating with Nature: Confronting Natural Hazards with Land-Use Planning for Sustainable Communities*, Washington, DC, Joseph Henry, pp. 85–118.

Hays, W.W.: 1991, 'Hazard and risk assessments in the United States', *Episodes* **14**(1), 7–12.

Institute for Environmental Studies: 1997, *Coping with Natural Hazards in Canada: Scientific, government and Insurance Industry Perspectives. A Study Written for the Round Table on Environmental Risk, Natural Hazards and the Insurance Industry*, Toronto, Ontario, Institute for Environmental Studies, University of Toronto.

Insurance Bureau of Canada: 1994, *Canadian Earthquake Exposure (and the Insurance Industry): A Proposal for Action*, Ottawa, Canada, Insurance Bureau of Canada.

Integrated Resource Planning Committee: 1993, *Public Participation Guidelines for Land and Resource Management Planning*, Victoria, British Columbia, The Land Use Coordination Office, Province of British Columbia.

Ivancevich, J.M. and Matteson, M.T.: 1987, *Organizational Behavior and Management,* Piano, Texas, Business Publications.

Keeney, R.L., Von Winterfeldt, D. and Eppel, T.: 1990, 'Eliciting public values for complex policy decisions', *Management Science* **36**(9), 1011–1030.

Maskrey, A.: 1989, *Disaster Mitigation: A Community Based Approach,* Oxford, Oxfam.

Mairson, A.: 1994, 'The great flood of '93', *National Geographic,* January, pp. 42–86.

May, P.J.: 1997, 'Addressing natural hazards: Challenges and lessons for public policy', *Australian Journal of Emergency Management* **12**, 30–37.

McQuail, D.: 1996, 'Mass media in the public interest: Towards a framework of norms for media performance', in J. Curran and M. Gurevitch (eds.), *Mass Media and Society* 2nd edn., New York, St. Martin's Press, pp. 66–80.

Mileti, D.S.: 1999, *Disaster by Design*, Washington, DC, Joseph Henry Press.

Moss, R. and Schneider, S.: 1997, 'Characterizing and communicating scientific uncertainty: Building on the IPCC second assessment', in S.J. Hassol and J. Katzenberger (eds.), *The Elements of Change 1996*, Aspen, Aspen Global Change Institute, pp. 90–136.

National Oceanic and Atmospheric Administration: 1999, *Community Vulnerability Assessment Tool: New Hanover County, North Carolina*, Charleston, SC, National Oceanic and Atmospheric Administration Coastal Services Center.

National Research Council, Committee on Risk Characterization, Commission on Behavioral and Social Sciences and Education: 1996, *Understanding Risk: Informing Decisions in a Democratic Society*, Washington, DC, National Academy Press.

Parker, R.S.: 1992, 'Issues and trends in emergency preparedness for technological disasters: Moving BEYOND the 'natural' and 'technological' labels', in A. Kreimer and M. Munasinghe (eds.), *Environmental Management and Urban Vulnerability*, USA, World Bank, pp. 237–259.

Paterson, R.G.: 1998, 'The third sector: Evolving partnerships in hazard mitigation', in R. Burby (ed.), *Cooperating with Nature: Confronting Natural Hazards with Land-Use Planning for Sustainable Communities*, Washington, DC, Joseph Henry, pp. 203–230.

Pearce, L.: 2003, 'Disaster management and community planning and public participation: How to achieve sustainable hazard mitigation', *Natural Hazards* **28**(2/3), 211–228.

Pearce, L.: 2001, *An Integrated Approach for Community Hazard, Impact, Risk and Vulnerability Analysis: HIRV*, Thesis, Vancouver, BC, University of British Columbia.

Petak, W.J.: 1985, 'Emergency management: A challenge for public administration', *Public Administration Review* **45**(1), 3–7.

Quarantelli, E.L.: 1986, *Planning and Management for the Prevention and Mitigation of Natural Disasters, Especially in a Metropolitan Context*, Delaware, Disaster Research Center, University of Delaware.

Robbins, S.P.: 1998, *Organizational Behavior: Concepts, Controversies, and Applications* 8th edn., Englewood Cliffs, NJ, Prentice-Hall.

Sandman, P.M.: 1991, *A Formula for Effective Risk Communication*, Video.

Scanlon, T.J.: 1991, 'Reaching out: Getting the community involved in preparedness', in T.E. Drabek and G.J. Hoetmer (eds.), *Emergency Management: Principles and Practice for Local Government*, Washington, DC, International City Management Association, pp. 79–100.

Senge, P.: 1990, *The Fifth Discipline: The Art and Practice of the Learning Organization*, New York, Doubleday.

Spicer, C.: 1997, *Organizational Public Relations: A Political Perspective*, Mahwah, NJ, Erlbaum.

Stallings, R.A.: 1995, *Promoting Risk: Constructing the Earthquake Threat*, New York, de Gruyter.

Thomas, J.C.: 1995, *Public Participation in Public Decisions*, San Fransisco, CA, Jossey-Bass.

Thompson Nicola Regional District [TNRD]: 2003, *Communities of the North Thompson* Valley, Available at http://www.ntvalley.com/barriere/.

Thompson Nicola Regional District [TNRD]: 1997, *Community Profile: North Thompson Subregion*, Available at http//www.tnrd.bc.ca/econ_dev/nthomweb.asp.

United Nations Environment Programme Industry and Environment Program Activity Centre: 1992, *Hazard Identification and Evaluation in a Local Community: Technical Report No. 12*, France, United Nations.

United Nations Office for the Coordination of Humanitarian Affairs: 1998, *Central America: Hurricane/Tropical Storm Mitch OCHA Situation Report No. 11*, Geneva, UN Office for the Coordination of Humanitarian Affairs.

Wynne, B.: 1992, ‘Risk and social learning: Reification to engagement’, in S. Krimsky and D. Golding (eds.), *Social Theories of Risk*, Westport, Praeger, pp. 275–297.

SECTION 2: DEVELOPMENT AND ETHICAL APPROACHES TO MITIGATION

'BENEFIT–COST ANALYSIS' OF DISASTER MITIGATION: APPLICATION AS A POLICY AND DECISION-MAKING TOOL

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(Received 28 February 2003; accepted in final form 4 February 2004)

Abstract. Many proponents of disaster mitigation claim that it offers potential benefits in terms of saved lives and property far exceeding its costs. To provide evidence for this, and to justify the use of public funds, agencies involved in mitigation can use benefit–cost analysis (BCA). Such analysis, if well done, offers a testable, defensible means of evaluating and comparing projects, helps decision-makers choose between mitigation projects, and provides a means to assess the way we spend public funds. In this critical overview of the more contentious issues and latest developments in BCA, I emphasize the pragmatic choices that one can make in accordance with good practice in project evaluation.

Keywords: benefit–cost analysis, mitigation, valuation

1. Introduction

Hazard mitigation can help turn natural disasters into natural hazard events. The people of any country can ameliorate many of the consequences of events like floods, fires and earthquakes by mitigating actions such as relocating homes from the flood plain, regularly clearing dry brush near buildings and attaching shelves to walls permanently. These examples offer but a peek into an entire toolbox of mitigation activities and behaviors limited only by resources and imagination. While many people, armed simply with common sense, find the anticipatory and precautionary qualities of mitigation obvious, mitigation remains the poor relative to reactionary disaster relief and recovery. For example, the leading organization in the United States for disaster mitigation, response and recovery, the Federal Emergency Management Agency (FEMA), spent about $28 billion on recovery between 1988 and 2001, but less than 10% of that (about $2.6 billion) on mitigation over the same period (FEMA website). Of course, mitigation can only do so much to reduce the impact of both natural and human-created disasters, but the challenge currently facing both FEMA in the United States and other agencies around the world continues to be justifying expenditures on mitigation programs. In 2003, FEMA committed over $1 million to an independent study to assess and quantify the savings generated by its hazard mitigation programs.

Traditionally, hazards researchers make a distinction between avoidance, mitigation and preparedness (see, for example, Mileti 1999). However, the more we reflect on how to deal with disasters, the more we see a blurring of any such distinction. Relocating homes from a hurricane pathway constitutes avoidance, but is a traditional mitigation program. Mitigating structures through reinforcement leaves them in the earthquake zone, but reduces the damage that subsequently occurs when the earthquake strikes. Preparedness ranges from a cache of five gallons of potable water and plastic sheeting to evacuation plans of the Florida peninsula, and tries to reduce the secondary impacts once a disaster has occurred. FEMA includes in its list of hazard mitigation tools design and construction, land use planning, organizational plans and hazard control (FEMA 1997).

By its nature, most mitigation involves employing resources in advance of a disaster to reduce subsequent losses. As such, mitigation has a lot in common with an investment in which we trade present consumption possibilities for greater consumption in the future. This similarity also reveals a means by which we can assess the value of mitigation – by calculating the present value of expected future net benefits. Since mitigation commits resources today, before anything specific has happened, all those involved in the decision from budget officers through policymakers to taxpayers realize that any public and private money used to purchase hazard mitigation had alternative uses (Zerbe and Dively 1994, p. 277). We cannot simply assert the value of mitigation and similarly we cannot claim the desirability of more mitigation over less unless we provide evidence of such superiority. Those with the power to allocate public money must provide justification for the expenditures they propose. Since both private and public budgets have limits, not all worthy projects and investments can be undertaken. Public officials must make choices between projects with varying degrees of local and national support. While political and social exigencies play very important roles in decisions to fund various mitigation projects, a method of measuring a project's value is needed and practiced to provide at the very least a common and defensible basis for choosing one program over another.

Even though in the United States, FEMA funds a considerable portion of mitigation activity, state and local government involvement is essential. Consequently, many decision-makers appear at the local level. In fact, a substantial proportion of mitigation occurs at the local level, and the people most familiar with the situation make the decisions. Even though natural disaster mitigation, preparedness and response are rightly seen as national issues, state and local government employees must get involved and cooperate. Successful hazard mitigation programs also require the cooperation and active involvement of private individuals and organizations. Since assessing and implementing any mitigation program involves a very large number and variety of people, any measure of program performance and expected return becomes unwieldy if we consult all those involved and affected. Any method used to measure the performance of mitigation programs should recognize as many impacts as feasible, and include the best data available from as many of those involved as possible. Benefit–cost analysis (BCA), and its variants of cost-effectiveness and cost-utility analysis, apply theory-based methods to determine the value of a mitigation program across a wide range of elements of society, from individuals to groups and organizations as well as society as a whole. Even though a number of limitations exist to the method, the basic problem involves trading the desire to "do it right" with the need to make a decision concerning program value on-time and on-budget. The very best practice of BCA makes the required assumptions and analysis choices explicit while remaining as true as possible to the theoretical foundations of the analysis.

2. The Theoretical Basis for Benefit–Cost Analysis

Since a thorough review of the development of neo-classical economic theory would be redundant here, it is our intention to rather briefly consider the theoretical basis for BCA to see why it stands as the most appropriate methodology for assessing the performance of hazard mitigation. Modern economic theory proposes the fundamental idea that both individuals and society as a whole have a common goal of maximizing well-being, and they are aware of the constraints imposed by limited resources and competing needs and desires. Any project that reallocates resources could make some members of society better off and others worse off. All those made better off increase their own and society's well-being, while those made worse off suffer some burden, and society also suffers this loss. A mitigation project that reinforces buildings against severe ground movement makes many people better off by reducing the damage and possible injury from an earthquake. This will save lives, reduce injuries, lower property damage and shorten the severity and duration of business interruption. The benefits are relatively easy to identify. The costs of such a project include the resources used in the building reinforcement that would otherwise have gone to other projects, including both physical and human resources. The costs are also relatively easy to identify. So long as all these resources receive adequate compensation for their use in the project, the project produces net benefits to some individuals and society as a whole. We can express net benefits as the difference between benefits and costs (positive), or as the ratio of benefits to costs (greater than one). The method of BCA lies firmly on the proposition that any project that produces positive net benefits is a good use of resources, and among competing projects, the more preferred ones produce the greatest net benefits.

BCA requires a complete enumeration of all gains/benefits and losses/costs associated with a project, and as such produces a benchmark for measuring the impact and performance of the project. Unfortunately, we find the term cost-effectiveness used much more in the assessment of public projects. Strictly speaking, cost-effectiveness analysis (CEA) is a particular type of BCA that clearly specifies benefits and usually fixes them at a particular level, often expressed in non-monetary terms. Boardman et al. (2001, p. 437) argue that CEA is done when a full BCA cannot. They list three circumstances that may lead to doing CEA rather than BCA:

when the largest or most important benefit cannot be monetized (e.g., when a policy saves lives, but analysts are unwilling to place a value on those lives); when some benefits can be measured, but others cannot; and when the project interventions function as inputs into other processes, such as may be the case in mitigation, where mitigation products are valued not for themselves, but for what they contribute to the lowering of damage in a disaster. The medical field uses CEA heavily for programs producing well-defined benefits such as "a ten percent reduction in a disease caseload." When the benefits of a mitigation project are not fixed or constant across all applications of the mitigation technology, we should not use a technique that specifically holds benefits constant; only a full assessment of costs and benefits will allow a proper assessment of the project. In this regard, the more limited CEA leaves decision-makers to either assume or ignore many of the other, non-specified benefits generated. Other methods of assessing mitigation projects exist, including cost-utility analysis (CUA). By recognizing the difficulty of measuring or enumerating some benefits, CUA essentially measures the benefit goal using an index of utility or welfare. This method adds further dimensions to CEA (Boardman et al. 2001, p. 444). These other methods do not ignore benefits, but treat them in quite a different and essentially non-numeric way compared to BCA.

BCA uses the economic definition of efficiency as its theoretical basis. Most simply stated, the economic efficiency of a program requires that no change will increase the welfare (happiness) of at least one person without decreasing the welfare of any other person. The corollary of this means we achieve greater economic efficiency by choosing the allocations of resources that increase welfare without decreasing welfare. Unfortunately, few programs will make people better off and no one person worse off. A modified measure called the compensation principle measures the net benefit of a program under the assumption that those made worse off could receive compensation from those made better off, leaving a residual improvement for some people. BCA implements this compensation principle by measuring the benefits and costs generated by a project, and calculating the net benefit by subtracting temporally coincident costs from benefits.

Having established the principle on which BCA rests, many issues, primarily of a practical nature, but some that require a theoretical resolution, emerge in the actual measuring of these benefits and costs. We should measure benefits and costs at their "true" economic values, those that reflect the value of each resource in its best (highest-valued) use. Only under quite restrictive circumstances will the price a resource trades at tell us this economic value. Even if we observe a market in which these resources trade, we cannot rely on the market price if any non-competitive influences on that market exist. When a market does not prevail we have no prices to refer to; we must measure value by the opportunity cost, or value-in-alternative-use method. Some of the theoretical issues of determining economic value in the absence of markets remain unresolved, and even with market prices we must attempt to take account of non-competitive influences on those observed prices (Sen, 1972).

Other issues related to measuring benefits and costs include the treatment of values over time for projects that span many years. At least two major questions emerge in this regard: should we discount future net benefits, realizing we must wait to receive them, and how do we acknowledge the inevitable uncertainty that comes when we predict benefits and costs occurring in the future? Both these issues have generated considerable discussion in the peer-reviewed literature. Stiglitz (1982) provides a comprehensive analysis of discounting, while Arrow and Lind (1970) provide the seminal discussion of dealing with risk and uncertainty. The current practice of BCA uses a positive discount rate to adjust future net benefits to the present, but sensitivity analyses included in the BCA usually present estimates of the influence of differences in rates on the net benefit measures. While few analyses use a zero discount rate, such a value would imply the equal treatment of all future generations with the present one. Interestingly, in a survey of 2160 economists, Weitzman (2001) found only 49 economists who believed the appropriate rate of discount for BCA should be zero or less. The sample produced a mean discount rate of approximately 4%; however, the discount rate did vary with the length of the project, falling as the life of the project increased.

Knowing that BCA has a strong theoretical foundation does not make it any easier to perform a state-of-the-art analysis. In practice, addressing all the controversial issues in BCA presents an almost impossible challenge. Pragmatic considerations place limitations on how much any one BCA can address any and all of these issues. But identifying and understanding them makes for better practice because the analysts must explain and justify their actual decisions. Since all BCAs require assumptions and modeling choices, where the analysts, faced with limited time and financial resources and constrained by the availability of data, make choices of method or analysis and stand ready to defend them. No matter how well the authors of a BCA deal with the contentious problems, the primary value of the method lies in the information it can provide decision-makers. Ultimately, BCA must be seen as an input to a larger decision-making process rather than an end in itself. Most disaster mitigation projects involve decisions with physical, economic, political, social and emotional dimensions. Just as the decision to undertake a project should not be based on engineering considerations alone, neither should it rest on political or economic considerations alone. When done at the level of best practice, BCA provides essential and valuable information to assist the decision-makers to choose the "best" projects, and to review past decisions to improve those coming next.

3. The Practice of Benefit–Cost Analysis

Conducting a BCA involves following the relatively simple menu below, somewhat edited from Boardman et al. (2001, p. 7):

1. select the portfolio of alternative projects;
2. decide whose benefits and costs count;
3. catalog the impacts and select measurement indicators (units);
4. predict the impacts quantitatively over life of the project;
5. monetize (attach dollar values to) all impacts;
6. discount benefits and costs to obtain present values;
7. compute the net present value [of each alternative];
8. perform sensitivity analysis; and
9. make a recommendation based on the net present value and sensitivity analysis.

I would like to highlight point 1 and part of point 7 since their relevance emerges only if comparing multiple projects. As an illustrative list, it does not provide a complete statement of the current, state-of-the-art BCA, and fails to mention nearly all the contentious issues surrounding the use and details of the method – for example, point 5 is clearly not simple. However, the list gives the essential elements of BCAs, and provides a starting point for a discussion of the strengths and weaknesses of the method.

3.1. The scope of the analysis

In theory, a BCA analyst should identify all those individuals who might enjoy gains or suffer losses from a hazard or a related hazard mitigation activity. Generally, analysts try to identify those affected directly and indirectly. In many cases, direct effects outweigh the indirect ones, but researchers from environmental economics have found extremely large values for the preservation of certain natural resources by the wider society (so called existence values). So while the direct/indirect dichotomy is useful in establishing a hierarchy of impacts, we must realize that for some hazards and some mitigation projects large existence values may exist. We can make a similar distinction between primary and secondary impacts of disasters. Primary impacts measure the benefits and costs to those directly affected, and we can measure these by the willingness of people to pay to enjoy the benefits or to avoid suffering the costs. But through the economic system of inter-related markets, these changes in people's welfare and wealth generate secondary impacts, often called multipliers. The distinction between primary and secondary impacts shares much with that made between direct and indirect impacts. Regardless of these distinctions, the BCA analyst must identify whose welfare will increase, and whose will decrease as a result of hazard mitigation, but only as a result of that program, holding all other things constant.

The scope of a mitigation project deals with the geographic, or spatial, extent of impacts and their timing and duration. For a project with highly localized impacts we should consider only the benefits and costs falling on the local population, businesses and government authorities. Decision-makers will also focus on these impacts because of the direct effect on their budgets. While theoretically imprudent, decision-makers can also ignore impacts that occur at a great distance, say outside their jurisdiction, or after a long period of time, because they see them as relatively small and unimportant, or simply someone else's problem. A local project can have some impact at a distance if, for example, the project uses federal funds, or if the project results in migration of resources. Similarly, some projects may have intergenerational impacts that do not appear at first glance. If a project has such intergenerational impacts, future generations should receive standing, despite the difficulties in doing this. We could criticize the analysis of mitigation projects that have large environmental impacts if they do not consider global impacts (Boardman et al. 2001, p. 9). Even if a hazard mitigation project has some real impact on people living in other countries it may be infeasible to calculate the dimensions of that impact and include it in a BCA (Bar-Yam 2000).

A common feature of many BCAs involves choosing from whose perspective the accounting takes place. We should consider the impact of the project from society's point of view, as this would include all effects. Yet often the analyst must determine the net benefits to a particular sector of the community, organization or level of government. We find examples where the BCA analyst calculates the impact on taxpayers, the impact on the government or the net benefits to homeowners. While a comprehensive analysis would take all these views, including the impact to society, and calculate a net benefit to all groups and sub-groups, the resources available may not allow for all these calculations.

Every BCA requires that we circumscribe the population of interest, which determines whose benefits and costs we will measure. If done explicitly, the resulting estimates provide decision-makers with the best available information on which to base their policies.

3.2. Benefits and costs

The value of hazard mitigation lies in avoiding damage and loss. Mitigation provides protection; we can calculate its value in the event of an actual disaster by asking the counterfactual: what society would have lost had mitigation not occurred? This makes defining and calculating benefits and costs more difficult because we rarely observe the counterfactual in history, and we must anticipate it for future events. Past disasters provide "real" data on the benefits and costs of mitigation to the extent that we find two or more similar communities affected by the disaster that vary by the application of the mitigation project. Without past data on hazard mitigation impacts, we can employ physical models and simulations to provide estimates of benefits and costs. Analysts must also consider the effect of the mitigation project on the economic environment when defining the counterfactual. For example, without a flood protection project little new economic activity will enter the region prone to flooding as people avoid the area due to the risk of flooding. With a flood protection project economic activity of greater value might enter the region. Since the subsequent development occurred because of the mitigation, we can attribute the change in economic value between the before and after situations to the mitigation project. In this situation only small losses would have occurred without mitigation, but society avoided far greater losses once the mitigation took place.

An additional problem related to the definition of benefits and costs arises when not all affected individuals view mitigation outcomes the same. Although some people will see benefits produced by a project, others may view those exact same impacts as costs. For example, the relocation of residences from the 100-year flood plain may produce benefits of reduced injury and property damage to residents, yet they may lose their connection to land that was historically and culturally important to them, thereby creating a cost in terms of psychological or emotional pain. If these benefits and costs are borne by the same individuals, BCA can easily account for the apparent conflict by measuring and including a net benefit of relocation for these people. We do not need to measure each component separately, but the change in well-being represents the combined effect of both gains and losses. But if different people bear the benefits and the costs, as when people not relocated bear the costs and those relocated receive the safety benefits, then we have two separate entries in the BCA – the gains to those relocated and the losses to those who remain. Pragmatically, we must count each change in well-being as either a benefit or a cost, however, we remain indifferent to the assignment of impacts to each category so long as gains add to net benefits and losses reduce them.

Identifying benefits and costs separately and correctly helps to realize those groups in society that gain from mitigation and those that might lose. Although the theoretical basis of BCA rests on maximizing economic efficiency, most people do not consider the distribution of those gains irrelevant, especially if policy-makers wish to garner support for hazard mitigation activities. The more we can break benefits and costs down into components across individuals, geographical space and over time, the more easily we can see the distribution of impacts, and possibly the need for compensation of those whose welfare decreases due to mitigation.

Many BCAs for hazard mitigation will contain a general taxonomy of impacts using the following terminology (Thompson and Handmer 1996a; and 1996b, p. 11):

- Direct impacts (example: strengthening an electricity generating plant reduces the damage in an earthquake, reducing downtime).
- Indirect impacts (example: less downtime for the electric plant makes for shorter power outages and reduces business disruption after an earthquake).
- Intangible impacts (example: better built structures will offer tenants a greater sense of security, just as evacuation plans and frequently checked fire extinguishers create a feeling of safety. People value these “feelings” yet they remain difficult to describe, let alone measure and quantify).
- Secondary impacts (as mentioned earlier, these impacts could be the same as the indirect impacts, but usually work through the markets that link wholesalers with retailers and retailers with consumers, energy suppliers with producers, for example).

Experience and consultation with persons and organizations with field knowledge proves essential to identify and categorize all possible impacts and sort them as benefits or costs. Often increasing the scope of the analysis will improve the chances of obtaining a complete list of indirect and secondary impacts.

The following list identifies some of the possible benefits of hazard mitigation. Potential benefits include the reduction of the following:

- loss of life, injury and pain;
- property destruction and damage;
- community, personal and local infrastructure disruption;
- business interruption, including closures, shutdowns, un- or underemployment;
- loss of or damage to culturally and historically important items;
- expenditure on disaster relief by both governments and private organizations;
- caution, fear and suspicion in both everyday and hazardous situations.

These types of impacts fall into the traditional scope of mitigation benefits, but mitigation may also produce benefits in the related areas of preparedness and response. Mitigation projects can create increased awareness in communities of hazards, their impacts and avoidance, and can assist in response efforts (for example, reinforced communications networks can improve the speed of response and recovery).

Some of the potential costs of hazard mitigation include:

- direct project expenditures on relocation, construction and transportation;
- increased costs generated by rules and regulations setup in the name of hazard mitigation, e.g., lower property values due to new zoning;
- denial of access to economic resources (environmental) due to zoning;
- increased business expenses to comply with regulations.

The BCA analyst will probably start with such lists, but quickly add or remove categories depending upon the specific hazard, location and mitigation project under study. Analysts must avoid double counting, something that can occur if they do not properly separate benefits and costs. Good practice requires that the analyst explain all decisions to include or exclude categories of benefits and costs.

3.3. Transfers

A transfer refers to the movement of resources from one person to another, and in general, one gains and the other loses. When the government, through FEMA, allocates federal funds to a disaster, a transfer occurs between taxpayers and disaster victims. Transfers influence and change the distribution of income and resources in the economy. Theoretically, a BCA would only count the so-called transaction costs associated with transfers, if generated at all. These transaction costs involve using economic resources that benefit neither the giver nor the receiver of the transfer. If a hazard mitigation project causes one person to enjoy a benefit because of the transfer of an economic resource from another person, the gain and the loss will cancel each other out, but the transaction cost will remain as a cost.

BCA analysts, or the users of BCA, should deal with transfers if the distribution of impacts of hazard mitigation concerns them. Having made the decision to consider the distribution of gains and losses, the analyst can determine and include distributional weights to represent the relative importance of individuals and groups in society. Layard and Walters (1978) discuss this point in detail, and Boardman et al. (2001) call the resulting analysis distributionally weighted BCA. This type of analysis enumerates benefits and costs by particular groups affected by the mitigation project. When it comes time to sum the component benefits and costs, the procedure weights each value according to the relative importance of the group enjoying or suffering that impact. Of course, how to derive the set of distributional weights remains a difficult and essentially non-economic question. Even if the decision-maker does not use a distributionally weighted BCA, when benefits and costs are identified by group, any particular notion of distributional equity can be incorporated into the decision-maker's process as a supplement to the BCA.

All potential gains and losses to those with standing require cataloguing as benefits or costs. When doing a BCA on a program in advance, we must anticipate benefits and costs over some period and choose some method to predict values for each component. While relatively easy for impacts observed previously, modeling the impacts of natural hazards and related mitigation projects, given constant technological advances and new products and ways of doing things, presents many challenges. Added to this complication is the problem that many benefits and costs do not have an obvious economic value that we can measure by a market price or its equivalent. We can judge a BCA by the attempts made to estimate future benefits and costs when uncertainty is recognized. The analyst can use sensitivity analysis to indicate how the final benefit–cost measures change with various assumptions and future estimates.

Adjusting the scale of the project will affect the size of benefits and costs, which becomes important when comparing alternative projects. If discounted net present value (NPV) measures the project's net benefit, then a larger project will appear superior to a smaller project. A measure such as the benefit–cost ratio will avoid this scale problem. However, we should not pre-judge large projects simply on the basis that they generate large net benefits due to their size alone. The usual decision context has the decision-maker choosing among projects to exhaust a given budget. Very large projects may consume a considerable portion of the budget, leaving money for only a few small projects. Based on economic efficiency alone, we should rank projects by their NPV, and starting with the highest-ranked project, proceed down the list until we exhaust the budget. However, as emphasized throughout this survey, decisions to undertake projects do not rest on rankings of economic efficiency alone, and decision-makers are aware that large projects require political and social support as well.

3.4. MONETIZING IMPACTS

Monetizing an impact requires measuring a benefit or cost and expressing it in terms of the common denominator of currency. The simplest impacts to measure have their consequences reflected in changes in market prices. Under certain conditions, the change in benefits (or costs) to society can be quite well approximated by the change in the consumer and producer surplus. Although technical jargon, these measures simply refer to the surplus of value (benefit) over price paid per unit and price over cost (of all resources used) per unit. If a mitigation measure prevents the destruction of a power station and shortens disruption of essential services, then the surplus that people enjoy from those services is a benefit that would have otherwise been lost without mitigation. We can use the market price of electricity to calculate the lost surplus under the scenario that the power station was destroyed in the disaster. For smaller impacts, since market prices reflect benefits at the margin, we can use changes in prices to reflect changes in benefits. Unfortunately, market prices only measure benefits and costs accurately in competitive markets. If there is any monopoly power in the market, or some other conditions that prevent markets from working unhindered, prices do not reflect the true costs and benefits to society of a given change. These true values are often called shadow prices, and it may be possible to impute their values from an understanding of how the particular market is being influenced by these non-competitive factors. When mitigation prevents or reduces damage to a resource or input to the production process, we can measure the value of that resource by its opportunity cost – the value that society places on the next best alternative use of that resource.

With the goal of monetizing all impacts of hazard mitigation, the analyst should start with a listing of benefits and costs to be valued using market prices, shadow prices and opportunity costs. However, especially in the case of hazard mitigation, many of the benefits and costs are more intangible than commodities traded in markets, and many impacts do not easily lend themselves to valuation. Some impacts even challenge attempts to monetize, such as the loss of lives or the destruction of historically important places and artifacts.

3.5. ALTERNATIVE METHODS TO MEASURE VALUE

Economists have access to a number of methods with which to measure changes in value. All these methods rely on the proposition that willingness to pay to either receive a benefit or avoid a cost reflects value. Market demand and supply schedules and the corresponding surplus generated by market prices directly measure this willingness to pay. When conditions prevent markets from working competitively, or forming altogether, we must find an equivalent of willingness to pay, or surplus, and impute its value. The indirect methods used to estimate values include:

3.5.1. *Revealed Preference Methods*

Collectively, these methods estimate values based on actual observed behavior, or choices made by individuals. This compares to the other class of valuation methods called stated preference methods. Later we list the major revealed preference methods used in BCA.

Value of Intermediate Goods. By carefully studying the production process of the final commodities that used an input affected by a disaster, we can determine changes in the value of input from changes in the value of the final goods so long as we take care to adjust for any other changes that might have taken place coincidentally. This method often contributes values for specific processes or sectors of the economy in conjunction with other methods. Analysts must avoid double counting using this method since it involves both inputs and final goods.

Hedonic Price Model (HPM). This method imputes the value of such things as differential hazard exposure or differential mitigation effectiveness from the value of property in an area (or more generally the value of any traded asset). Controlling for all other factors, housing prices will vary in relation to how buyers and sellers value the differential hazard exposure. For example, a buyer might willingly pay a premium for a house made more earthquake resistant over an otherwise identical house without the treatment. Through their location decisions and willingness to pay for alternative locations people purchase bundles of hazard mitigation services that can be valued *via* the HPM. Data quality remains a problem and the empirical models must include all relevant factors determining property value other than the hazard.

Travel Cost Model (TCM). Analysts can use this method to calculate the value of some economic resource indirectly by measuring differences in associated expenditures across sites that differ in the degree of hazard mitigation. For example, if two otherwise identical recreational sites differ in their hazard risk or level of mitigation, then people's willingness to travel to one over the other, all other things held equal, will provide the analyst with a measure of the value of the hazard or its mitigation. Unfortunately, this method may not be capable of separating the effect of mitigation if other characteristics of the site provide much larger value to visitors.

Unfortunately, while economists prefer to use data from actual behavior in markets, the value of many impacts of hazard mitigation cannot be found in market prices or their equivalent. To address the need for values in BCAs, economists have turned to survey-based methods, which while controversial, have become part of mainstream economic practice in the last two decades.

3.5.2. *Stated Preference Methods*

Contingent Valuation Method (CVM). This method uses responses to hypothetical market scenarios presented in surveys to impute willingness to pay for relevant changes brought about by such policies as hazard mitigation. Both governments and environmental economists accept the basic validity of the method (Arrow et al. 1993). As an example of the method, a survey instrument would present a randomly selected group of people information detailing hazards, and the consequences in both a mitigated and non-mitigated scenario. The respondents then indicate their willingness to contribute to a fund to pay for the mitigation program. From the responses we can obtain an estimate of the total value for the mitigation program, representing the net benefits these people see coming from the program. Despite the considerable research looking into the issues of sample selection, creating a believable valuation scenario, alternative elicitation methods, how to link value with cost and how to convert responses into meaningful economic values, much remains to improve the method. Perhaps the strongest criticism of the method remains its hypothetical nature, and failure of the method to establish a connection between respondents' answers and any real consequence to them of their choices, as would be the case in actual markets.

The strength of the CVM lies in its ability to measure values such as existence and option value that are rarely expressed in markets. The value of a natural habitat or a site of historical importance cannot be determined from prices, even if some exist, since many people may hold these things valuable just because they exist, and may never be observed or experienced first hand. Even at great physical or temporal distance, many people claim to value environmental protection and maintenance of species. CVM studies find relatively large fractions of stated willingness to pay attributable to the existence of an environmental amenity. Although mitigation primarily protects humans and their built environment, which itself has potentially large existence value, mitigation also indirectly protects the natural environment. As such, the ability of the CVM to measure existence values makes it a valuable tool in BCA of mitigation.

Conjoint Analysis (CJ). A method that comes from marketing, it can value multi-attribute commodities and lends itself to valuing changes in environmental amenities and hazard exposure. Compared to the CVM, which collects value data from respondents by offering the same commodity at different buy or sell prices, conjoint analysis asks respondents to choose among various "packages" of commodity attributes, with price as one attribute. The analyst can use this information to derive implicit prices for the attributes, which might include different levels of hazard mitigation, risk exposure, damage for a given hazard event or similar mitigation-relevant characteristics. The advantage of CJ analysis lays in presenting respondents with choices they find more believable and which will consequently elicit more accurate values. At present and despite the increasing use of CJ analysis to value resources and other environmental amenities, the method remains the newcomer to BCA. More work has to be done to reconcile the differences in values that CJ analysis and more established methods such as CVM generate.

Benefits Transfer Method (BT). While not exactly a method of measuring benefits and costs, the procedure of taking estimates of values from other related studies and transferring them to the current study is very common in BCA. Also known as data adaptation or data transfer, the successful use of this method involves understanding the similarities and differences between the original study and the values required for the current study. Demonstration projects of hazard mitigation can provide data for this method to determine benefits and costs for larger projects under study.

The earlier list and discussion proves to illustrate the variety and nature of some methods available to monetize benefits and costs in a BCA. Ultimately, pragmatic considerations will rule the actual choices made when doing an analysis. Stated preference methods are extremely expensive, whether using the US National Oceanic and Atmospheric Administration (NOAA)–recommended telephone method or new Internet-based options. It is quite possible for useable responses to cost from $50 to 500 each in a well designed, pre-tested and carefully executed survey. Standardizing methods and using existing data helps to reduce the cost of analyses, especially when a large number of mitigation projects need evaluation.

3.6. Discounting

Having identified and valued all measurable benefits and costs over the life of the project, the analyst must convert all values to the present to perform the appropriate comparison: does the mitigation project outperform the other current alternatives, including doing nothing? Discounting is contentious because of the many theoretical and practical arguments for choosing one discount rate over another. The theoretical debate concerning discount rates for BCA pits the social rate of time preference against private interest rates, at the extremes. The rate of interest paid by consumers to bring consumption forward to today varies between 4 and 25%, depending on many factors, including the collateral offered against the loan. In the case of tax-funded government projects then perhaps the displaced private borrowing rate is the appropriate discount rate for public projects. But most mitigation projects involve capital expenditures, not the making of consumption goods. The rate of return to private capital investments offers another rate at which we can discount future values. We measure the opportunity cost of public funds by the private rate of return to capital to the extent that public investments displace private investments. But society may place a different value on foregone consumption to fund mitigation projects than either private consumption or private investment, especially if public projects are intended to influence the distribution of income of both current and future generations (Stiglitz 1982). Even though we might conclude from this debate that each project should have a different discount rate, the analyst might make the pragmatic choice and use the rate recommended by the Office of Management and Budget (OMB, 1994, revised 2003). The analyst would normally vary the discount rate in a sensitivity analysis to see what effect different rates have on the final measure of net benefits.

As mentioned earlier, real interest rates can fall to zero or less, raising the question of using a zero discount rate when discounting future net benefits. A zero discount rate becomes a focal value, since it implies that all benefits and costs have equal standing, no matter whether they occur now or later. It also implies that society as a whole does not mind waiting for benefits, and that present generations are indifferent between having benefits now and waiting for future benefits, even if they accrue to future generations. Despite these arguments, very few economists or government project analysts would use a zero or negative discount rate in a BCA (Weitzman 2001).

The choice of discount rate also raises the issue of whether the benefits and costs are monetized in nominal or real currency values. Because the purchasing power of future dollars can differ from that of present dollars, adjusting nominal values measured in future denominations to current values using some applicable price index seems appropriate. However, choosing the correct price index is not always obvious, as in deciding whether the consumer price index for final goods or the producer price index for intermediate goods should be used. Converting nominal to real values guarantees that general inflation does not alter the calculation of net present value. The analyst must take care not to mix nominal and real values: when using nominal values to measure impacts we should use a nominal discount rate, and when measuring impacts in constant dollars we should use the real discount rate.

3.7. Uncertainty

Benefit–cost analyses are fraught with uncertainties. The following list includes some of them:

- the nature, strength and timing of the hazard;
- the relationship between the hazard and the mitigation;
- the outcomes and effectiveness of mitigation;
- the technical, economic, and social environment of the future;
- whether impacts are benefits or costs;
- the future value of presently known benefits and costs;
- the length of the project's effectiveness.

Uncertainties arise from limitations of the data, or our understanding of the relationships between the natural environment, technology and human behavior, or failure to model all relevant relationships in the BCA calculations. Good practice requires that the analyst identify as many sources of uncertainty as possible and attempt to account for them rather than convey the impression that all benefit and cost values are fixed and guaranteed. The simplest way of including uncertainty into the calculation of net present value is to use the expected value of uncertain impacts. This requires that the analyst knows all possible values for the benefit or cost, and specifies the associated probability distribution over those values. More often than not, we know little about these two components of the expected value calculation, so we must settle for a best estimate of the mean, or median value. If the analyst can specify the probability distribution of net benefits it should be presented in the BCA to provide not only the mean, or average net benefit, but also the range and variance of net benefits. While decision-makers have little experience dealing with analyses that provide more than one single-valued conclusion, providing some statistical measure of the variability of the calculation to uncertainty is at least honest and consistent with the data and the modeling.

According to the OMB guidelines for performing BCA, it is inappropriate to use variations in the discount rate to adjust the calculation for particular project risks. But many analyses can capture uncertainty by adding a factor to the discount rate to compensate for the added risk associated with uncertainty (Zerbe and Dively 1994, p. 328). According to standard portfolio investment analyses where variation in return is used to measure risk, a premium could be added to the discount rate to account for the uncertainty in benefits or costs increasing the variance of the estimate of net benefits. If the uncertainties arise from benefits and costs that fall on individuals, these risks should be discounted at a private rate that individuals would choose. Alternatively, to the extent that public projects are a way of spreading the risks across the population through the funding mechanism (taxes usually), government investment decisions should be discounted at a rate that ignores uncertainty (Graham 1981; Arrow and Lind 1970). Unfortunately, no definitive prescription for handling uncertainty in BCA has emerged.

Sensitivity analysis can provide the analyst with a means of communicating the uncertainties in the analysis. It also allows the analyst to indicate the effect of the assumptions made regarding the data, the relationships between elements of the project under review and any modeling used to obtain values. Zerbe and Dively (1994, p. 372) list two general formats for sensitivity analysis: the variable-by-variable approach and the scenario approach. In the first approach, alternative values for certain benefits and costs are inserted in the calculations and the new values of net benefits recorded. The analyst does this for each value or category of impacts, with high and low values the most common choices for alternatives. Rather than indicate the sensitivity of the net benefit measures in such a piecemeal fashion, the second method creates scenarios of values for variables together to produce something like a "best-case" and "worst-case" scenario. Sensitivity analysis can also show how the net benefit measure varies with the scale and scope of the project.

When using sensitivity analysis to reveal the effect of assumptions, the analyst should pay most attention to assumptions regarding the models used to estimate benefits and costs. In the case of hazard mitigation projects, the technical and physical links between the hazard, the mitigation action and the natural and built landscape are key elements in determining the effectiveness of mitigation. Often the analyst will employ sophisticated statistical methods such as Monte Carlo to generate the empirical distribution of estimates. Since value estimates and net benefit calculations rest on many parameters not directly measured or observed for the particular project, such as the discount rate, the inflation rate if real values are calculated, the duration of the project and any terminal net benefits, these become the primary candidates for sensitivity analysis. Because a sensitivity analysis can produce a large number of different net benefit values, often the best way to present the findings is to produce interval estimates of important values as a function of the values of selected parameter (Boardman et al. 2001, p. 171).

4. Other Special Considerations for Disaster Mitigation BCA

Doing benefit–cost analysis for a particular hazard mitigation project properly means comparing the well-being of citizens in two states or the world: after a disaster with mitigation and after a disaster without mitigation. As mentioned earlier, because the comparison involves a counterfactual, such an analysis cannot be performed based on observation alone. This problem leads to the more frequent approach of comparing a before-mitigation world to an after-mitigation state. However, the comparison likely includes the impacts of more than just the mitigation project, since many factors other than mitigation activity could have and probably did change between the two states. The challenge to BCA for hazard mitigation is to creatively describe and hence measure the world in the two properly comparable states – disaster with mitigation and disaster without mitigation. Analysts can combine data from past disasters and mitigation projects with models of new mitigation projects and disasters as they occur to create more realistic frameworks with which to identify impacts and value them. Doing BCA for hazard mitigation requires special cooperation between the people "on the ground" – emergency response teams, risk management people, local bureaucrats, researchers such as flood engineers, seismic experts and building engineers, and economists who can use the methods discussed here to put values to the impacts these other experts identify.

Analysts cannot measure every impact of natural disasters – in particular, the so-called intangible benefits and costs, which include emotional and psychological dimensions. While many benefits of hazard mitigation are losses reduced or avoided, these losses are both physical, in terms of property and commodities, and emotional. Economists are not devoid of emotion, but recognize that valuing changes in emotional states is extremely difficult. Just as in legal cases in which harm has been done to a person, the overriding principle is to make the person whole again to the extent this is possible through compensation. When non-monetary, intangible impacts cannot be included in the BCA directly, Thompson and Handmer (1996a; and 1996b, p. 61) conclude that the analyst identify and list the effects with as much discussion as possible to assist the decision-maker when considering their relative importance. The aim of BCA must always be to value impacts that have changed people's well-being, either positively or negatively, using methods consistent with these more widely applied social and legal principles.

5. BCA of Disaster Mitigation in Developing Countries

Disasters have the most serious impacts on developing nations. These nations, economically poor by most standards, are the least able to bear the costs of natural and human-made disasters. Estimates put the economic costs of natural disasters 20 times higher as a proportion of gross domestic product for developing countries than for industrialized nations (Disaster Relief 2000). For the same reason, developing countries are less able and less likely to divert scarce resources to mitigation activities. Even if the economic return to mitigation is proportionately higher in these countries, the initial costs of mitigation may be too high for governments to consider them. Hazard mitigation is likely to have a low political priority in countries struggling with poor-quality resources, little social infrastructure, high unemployment and large foreign debts. Ironically, policies focused on overcoming the most serious problems in developing countries tend to place the population in greater danger when natural disasters occur. In particular, environmental policies (or lack of them) in developing countries tend to exacerbate the damage and loss that occurs in disasters, as was the case, for example, when extensive clearing of land promoted serious landslides in the Hurricane Mitch disaster (Crone et al. 2001). Many people in developing countries live in highly concentrated areas in structures that are susceptible to extensive damage and complete destruction in a disaster. Consequently, relatively inexpensive hazard mitigation strategies might reap substantial returns in lives saved and economic losses avoided, yet these programs are slow to evolve as these nations rely on foreign organizations to provide the resources to design and implement them.

The procedure of BCA is the same when assessing a mitigation project in a developing country as in an industrialized country like the United States. However, there may be considerable differences in the details, especially in valuing benefits and costs, brought about by the widespread failure of markets to operate competitively in developing countries. Many developing nations have large subsistence and non-market economic sectors of the economy, currencies that are artificially kept above their true values, culturally and historically low labor mobility, tariffs and trade barriers that distort the true values of imports and exports, and credit markets that are highly imperfect (Boardman et al. 2001, p. 417). In recognition of these problems, the analyst should not use market prices to value benefits and costs. Shadow or accounting prices are the preferred values and the LMST (standing for the authors Little, Mirrlees, Squire and van der Tak) methodology uses them for valuing benefits and costs for projects in developing countries. The method makes a distinction between tradable goods (those imported or exported, or close substitutes for these goods) and non-traded goods. All traded goods used or impacted by the project are valued at world prices rather than domestic prices, and all non-traded goods are valued by their connection to traded goods, as using these inputs, producing them as final goods or as substitutes for them. Even labor can be valued this way by considering the opportunity cost of labor employed producing non-traded goods rather than traded goods. By using this method, many of the costs and benefits of hazard mitigation projects can be valued. Of course, all those impacts not easily monetized in developed countries remain difficult to monetize in a developing country.

It is tempting to suggest that since the potential benefits of hazard mitigation are so great for developing countries, all mitigation projects should be funded. However, with limited resources and other priorities, it is unlikely that all mitigation projects will be undertaken in these nations. And evaluation of projects is essential particularly when making choices between many worthy mitigation alternatives. Even if the governments of these countries do not perform the BCAs, or even choose to undertake mitigation activities on their own, the decision by foreign countries and organizations to fund mitigation projects should be informed by the same kind of analyses, as they would perform on mitigation projects in their home countries and described here.

6. Conclusions – Beyond BCA

So what does a practitioner, required to justify program expenses, say to those who would challenge BCA? The pragmatic response not only sounds defensive but also defines the approach: given the limited resources devoted to the analysis, follow the best practices and make all modeling choices explicit. Use as much of the available data as possible, choose the best technical and physical models, stay true to the fundamental economic accounting principles that underlie the methodology and document all decisions and choices carefully and clearly. A critic can understand a transparent analysis and the analyst can defend it. In a world of incomplete data of varying quality where we cannot foresee all impacts or measure every impact, we must make choices. The best practice of BCA explains those choices in the analysis and identifies as many uncategorized, unmeasured and non-monetized impacts as possible to assist the ultimate decision-maker in assessing the project.

Perhaps the strongest criticism of benefit–cost analysis concerns the emphasis on expressing all benefits and costs in monetary terms. Some of the limitations of the measurement methods discussed earlier just reinforce this criticism. This criticism is also often made of economics as a discipline. Monetizing values is simply a convenient metric by which to express value and make comparisons in a world in which comparing apples to oranges is just too difficult. The actions of even the most vociferous critics of economics prove that every choice implies an opportunity foregone, and that with just a little imagination and logic the analyst can link a choice with a foregone opportunity with a known monetary value. The question often left for us to ponder when reviewing a BCA on a particular hazard mitigation project is not what values we place on the monetized impacts, but rather how large or small are these compared to the "value" of the non-monetized impacts.

BCA alone cannot answer this question, but human experience and reflection can. The need for other considerations establishes for BCA the role as an input to the decision regarding hazard mitigation.

If not BCA, then what method should we use to choose among mitigation projects and to justify them? Even if other methods, such as cost-utility analysis, offer a way around monetizing all benefits and costs, is anything gained or do we just sidestep the tough issues? Everyone involved in disaster mitigation appreciates the emotional, psychological and social impact of disasters and knows how mitigation can reduce, and even eliminate, some of these impacts. There is already a large body of evidence from completed mitigation projects and the experience of disasters to document the effectiveness of mitigation. The question remains of presenting this evidence in a way that satisfies the public purse watchdogs as well as helping those wishing to make better mitigation decisions with their limited budgets. No method designed to measure the effectiveness of mitigation projects stands immune to criticism, but if done well BCA offers a consistent, theoretically based and pragmatic method to present the evidence of the past and look into the future.

Acknowledgments

I would like to acknowledge the Multi-hazard Mitigation Council of the National Institute for Building Sciences for inviting me to participate in their study on the future benefits of hazard mitigation activities. Tom Tobin and others on that study supported my efforts to bring some more economics to the hazard mitigation discussion. In particular, thanks go to Dennis Mileti for inviting me to speak to the 2002 Boulder Hazards Conference on the economics of hazard mitigation.

References

Adler, M.D. and Posner, E.A.: 2001, *Cost Benefit Analysis: Legal, Economic and Philosophical Perspectives,* Chicago, University of Chicago Press.

Arrow, K., Solow, R., Leamer, P.R.E.E., Radner, R. and Schuman, H.: 1993, 'Report of the NOAA panel on contingent valuation', *Federal Register* **58**, 4601–4614.

Arrow, K.J. and Lind, R.C.: 1970, 'Risk and uncertainty', reprinted in R. Layard and S. Glaister, *Cost–Benefit Analysis*, Cambridge, Cambridge University Press, 1994, pp. 160–178.

Bar-Yam, Y.: 2000, 'Butterfly effect', New England Complex Systems Institute, http://necsi.org/guide/concepts/butterflyeffect.html, accessed Feburary 18, 2003.

Boardman, A.E., Greenberg, D.H., Vining, A. R. and Weimer, D. L.: 2001, *Cost–Benefit Analysis* (2nd edn.), New Jersey, Prentice Hall.

Crone, A.J., Baum, R.L., Lidke, D.J., Sather, D.N.D., Bradley, L. and Tarr, A.C.: 2001, 'Landslides induced by hurricane Mitch in El Salvador – An inventory and descriptions of selected features', *U.S. Geological Survey Open-File Report* 01–0444.

Disaster Relief: 2000, website provided by American Red Cross, CNN Interactive and IBM, http://www.disasterrelief.org/, accessed January 28, 2003.

Federal Emergency Management Agency: March 1997, *Report on Costs and Benefits of Natural Hazard Mitigation*, Washington, DC.
Graham, D.A.: 1981, 'Cost–benefit analysis under uncertainty', *Am. Econ. Rev.* **71**(4), 715–725.
Government Accounting Office: 1999, 'Disaster assistance: Information on the cost effectiveness of hazard mitigation projects', GAO/T-RCED-99-106.
Layard, R. and Walters, A.A.: 1994, 'Income distribution', reprinted in R. Layard and S. Glaister, *Cost–Benefit Analysis*, Cambridge, Cambridge University Press, pp. 179–198.
Mileti, D.S.: 1999, *Disasters by Design*, Washington, DC, Joseph Henry Press.
National Research Council: 1999, *The Impacts of Natural Disasters*, Committee on Assessing the Costs of Natural Disasters, Washington DC, National Academic Press.
Office of Management and Budget: 1994, 'Guidelines and discount rates for benefit–cost analysis of federal programs', circular no. A-94 (revised 2003).
Thompson, P. and Handmer, J.: 1996a, *Economic Assessment of Disaster Mitigation: An Australian Guide*, Middlesex, GB, Flood Hazard Research Center.
Thompson, P. and Handmer, J.: 1996b, 'Economic assessment of disaster mitigation', Center for Resource and Environmental Studies, ANU.
Roe, B., Boyle, K. and Teisl, M.: 1996, 'Using conjoint analysis to derive estimates of compensating variation', *J. Environ. Econ. Manag.* **31**, 145–159.
Sen, A.K.: 1972, 'Shadow prices and markets', reprinted in R. Layard and S. Glaister, *Cost–Benefit Analysis*, Cambridge, Cambridge University Press, 1994, pp. 100–115.
Stevens, T.H., Belkner, R., Dennis, D, Kittredge, D. and Willis, C.: 2000, 'Comparison of contingent valuation and conjoint analysis in ecosystem management', *Ecol. Econ.* **32**, 63–74.
Stiglitz, J.E.: 1994, 'Discount rates: The rate of discount for benefit–cost analysis and the theory of the second best', reprinted in R. Layard and S. Glaister, *Cost–Benefit Analysis*, Cambridge, Cambridge University Press, pp. 116–159.
Weitzman, M.L.: 2001, 'Gamma discounting', *Am. Econ. Rev.* **91**(1), 260–271.
Zerbe, R.O. and Dively, D.D.: 1994, *Benefit–Cost Analysis in Theory and Practice*, New York, Harper Collins College Publishers.

Mitigation and Adaptation Strategies for Global Change (2005) 10: 467–490

MITIGATING NATURAL DISASTERS: THE ROLE OF ECO-ETHICS

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(Received 29 January 2003; accepted in final form 4 February 2004)

Abstract. Natural disasters are complex phenomena, the causes of which lie to a large extent in human behavior that creates vulnerable communities. In order to reduce vulnerability and thereby mitigate the risk of disasters, it is important to consider underlying values, particularly with respect to how people view and interact with the natural world. Advancing an interdisciplinary, ecological paradigm, this paper argues that disaster mitigation needs to be addressed through a process that results in a greater emphasis on our interactions with and reliance upon the natural world, and the development of community resilience.

Keywords: ecology, ethics, mitigation, natural disaster

1. Introduction

Disasters are about human misery. They are about unraveling and reconstruction. Understanding them means more than developing conceptual frameworks, drawing diagrams and calculating numbers. It means glancing into the tragedy that strikes people's lives. Few have expressed this more eloquently than Susanna Hoffman (1998) after her home, along with 3,356 others, was destroyed in the Oakland firestorm of 1991.

> I had no salt. By this I mean I had no salt to put upon my food, and also that I had no salt left for tears. My weeping depleted every grain from my being.
>
> I had no thread. By this I mean I had no thread to stitch my daughter's hem, and also I lost the thread of my life . . . .
>
> I had no numbers. I had lost all the addresses and phone numbers of everyone I knew or had ever known... I lost both my connections and the equations that lead to opportunity.
>
> I had no paper, no sheets, no warm, woolly sweater, no lights... but also no lightness. No joy . . . .
>
> . . . it was a rapid introduction into deconstructionism.

> While standing amid the rubble of my home, I also stood amid the rubble of a social and cultural system.

Whether or not one chooses to explicitly address human impacts in one's work, it is important to keep in mind that our decisions have important consequences, and that we must not divorce disaster prevention from ethics, culture or the broader social and environmental systems that sustain us. Recent work has discussed natural disasters within the context of sustainable development and holistic thinking (Mileti 1999). This paper is an attempt to build upon that discussion by considering where mitigation lies within the broader conceptual geography of our disaster experience.

We address several main themes in the following pages. Following our clarification of some central terms, we identify certain problems arising from current, sectoral approaches to mitigation. Recognizing the limits of these strategies and the need for a broader perspective, we then put forward some tentative suggestions for a holistic eco-ethical understanding of natural disasters that situates the issue of mitigation within a more comprehensive framework.

In presenting mitigation of disaster issues within an eco-ethical framework, this paper emphasizes the interconnectedness between humans and nature, and how a dysfunctional relationship can contribute towards vulnerability. The importance of considering this issue from an interdisciplinary perspective is also critical. Values affect the decisions people make to mitigate risk and, for this reason, differing values can lead to varying degrees of vulnerability. Economist William Reese wrote, "for sustainable development . . . the need is more for appropriate philosophy than for appropriate technology" (noted in Stefanovic 2000). This paper attempts to echo that sentiment.

2. Clarifying Terminology

We would like to begin by clarifying our understanding of some key terms employed in this paper. Of primary importance is our interpretation of the very concept of *mitigation*, which we define as sustained actions to reduce or eliminate the long-term impacts and risks associated with natural and human-induced disasters.

Mitigation actions can be a blend of policies, educational programs, structures (such as dams), design of resistant or resilient systems, retrofitting (such as reinforcing buildings to ground shaking) or land use planning (such as restricting development within flood plains). As such, these actions affect both the social and natural realms. The particular choice of strategies and blend of approaches depends upon a variety of factors, including world view, ethics, taken-for-granted assumptions, resources, capacity to adapt, disaster history and socio-political institutions.

Generally, mitigation occurs through activities that (1) reduce risk or (2) transfer/share risk. Risk reduction can be accomplished by (1a) modifying the hazard or (1b) reducing vulnerability. Studies of some hazard-reduction programs, such as weather modification (including hail suppression), have either had mixed results or have not been encouraging. In fact, the American Meteorological Society policy statement on planned and inadvertent weather modification, dated October 2, 1998, says, “there is no sound physical hypothesis for the modification of hurricanes, tornadoes, or damaging winds in general” (WMO 1995; NOAA 2003). Others strategies, such as floodways, dykes, land-use planning, revegetation of slopes and irrigation can be very effective and have been widely used.[1]

Within Canada, transferring risk is mainly achieved through (2a) insurance (both private and government-sponsored, such as crop insurance) and (2b) government disaster assistance programs. Internationally, the World Bank and International Monetary Fund (IMF) provide grants and loans to assist developing countries recover from disasters.

Another key term employed in this paper is *ecology* (including its variation within “eco-ethical”) – a concept that emerged originally from the work of German biologist, Ernst Haeckel in the 1860s. Haeckel recognized that the etymology of the word leads to the Greek *oikos*, which means house, habitation or dwelling place, and *logos*, meaning the articulation or “study of.” Ecology, then, is the study of the relationships between organisms and their home environments.[2] While the science of ecology has interpreted these relations in diverse ways, from community to energy models, our reliance upon the term is meant simply to emphasize that individual, living entities (including human beings) cannot exist in isolation from their surrounding habitats.[3] Indeed, there is a case to be made that these linkages are so fundamental as to be a necessary condition of human existence in the first place (Stefanovic 2000). In this vein, we argue that natural disasters occur because of the interdependent relationship between our human species, their dwelling places and the natural world, and that it makes sense to understand this relationship within a broad, eco-ethical framework.

Moreover, when we refer to the “eco-ethical,” we are seeking to acknowledge that a genuinely interdisciplinary ecology is also one that invokes questions about tacit value judgments, taken for granted assumptions and world views that shape our outlooks on life. The ancient Greeks recognized that *êthos* refers to our fundamental ways of dwelling in the world. Recognizing our rightful place and a fitting attunement between what *is* the case and what *ought* to be the case becomes a central task in critical thinking about disaster mitigation policy.

Vulnerability is used in this paper to refer to the propensity to suffer some degree of loss (e.g., injury, death and damages) from a hazardous event. This depends upon coping capacity, relative to potential impact. For example, a supertanker is not vulnerable to 2-m waves, though a rowboat certainly is. There are a number of different types of vulnerability that are traditionally addressed:

- physical (such as living in a location exposed to hazards),
- personal (such as age),

- cultural (such as how risks are perceived and responded to),
- socio-political (such as no or limited accessibility to information, limited control over resource allocation and pertinent decisions)
- structural (such as poorly built, or insufficiently strong or resilient systems),
- economic (such as wealth distribution, economic diversity),
- institutional, both regulatory and jurisdictional (such as enforcement of standards and codes, type of governance), and
- psychological (dread, avoidance, denial)

It may make sense to add another vulnerability classification – eco-ethical, which occurs when our value system leads to the loss of resilience in the natural ecosystem, which then in turn results in increased hazards or greater human vulnerabilities. In practice, these vulnerabilities are intertwined. Particularly, decisions that determine how and where we build are largely determined by our culture, value systems, economy and institutions.

Approaches to vulnerability reduction tend to focus on increasing *resistance* (by changing design criteria to protect against more extreme events) or by increasing *resilience* (by creating the capacity to "bounce back" more quickly and easily after a damaging event occurs). The former reduces the number of damaging events, the latter, given that a damaging event occurs, reduces its impact.

The nature and characteristics of resilient ecosystems is discussed at length in Gunderson and Holling (2002). They differentiate between engineering resilience, which tries to maintain an equilibrium near a stable state, and ecosystem resilience, which is measured by the size of a disturbance that can be absorbed before a system changes its structure and flips into a different state. The former emphasizes command and control, predictability and efficiency; the latter a set of conditions that allow for adaptive decision-making. They argue (and we concur) that it is the second definition of resilience that is needed for a sustainable relationship between people and nature. Organizations that optimize economic efficiency, for example, do so at the price of losing ecosystem resilience.

Finally, it is our contention that, at the present time, we easily tend to slip into a reductionist, *positivist* framework for environmental decision-making. Reductionism assumes that complex problems are best analyzed when they are broken down into smaller, component parts. When such sectoral reduction occurs, a positivist epistemology tends to support the view that reality consists of those entities that can be empirically seen, touched, felt, measured and "positively" quantified (Stefanovic 2000). While such an approach boasts many accomplishments, it fails to adequately account for less obvious, intangible (and therefore, difficult to measure) *relations between* entities within the holistic context that ecology does address. In the following section, we consider some of the problems associated with employing a reductionist, positivist framework for considering issues of disaster mitigation.

3. Problems with Positivist, Human-Centered Approaches to Mitigation

In a scientific era the tendency in the Western world has been to try to understand, as well as manage and control, the complexities of nature through sectoral, reductionist analysis. Frequently, such an approach operates within an ‘anthropocentric’ framework, where humans are implicitly viewed as being above nature, and nature itself is viewed as an unlimited inventory of resources for human consumption and control (Stefanovic 2000). Within such a framework, the natural environment is a collection of resources exploited by society for sustenance and growth, principally from an *economic* perspective.

The environment is also present as a source of risk, when natural extremes create temporary conditions that lie beyond the normal coping ranges of society. Hopefully, one builds social/economic/physical environments with natural risks in mind such that vulnerability is minimized (for example, using building codes or other safety standards), but when these natural hazards do trigger an existing social vulnerability, natural disasters occur.

Society’s coping range is defined in part through a series of sectoral design decisions related to infrastructure, lifelines of communication or transportation and land-use practices. Commonly, systems are designed to be resistant to some level of probability, often defined by a return period. This construct, used to define acceptable risk, has often had the net, cumulative, long-term effect of increasing the costs of natural disasters (Mileti 1999). The positivist rests assured that measurements of probability have been quantified and regulated. At the same time, simply because a design provides safety against a 100-year flood (for example) does not mean that a community is safe, as the vagaries of nature eventually will create a flood of greater proportions. Risk is increased when people or communities act as if safety has been assured, when in fact it has not.

We mistakenly believe that our quantificational systems are objective, scientifically proven measures, but nature does not always respect our human assessments of boundaries. For example, where urban development occurs and natural infiltration of rainwater into the ground is greatly reduced, storm sewers are used to limit flooding. However, extremes sometimes occur beyond the design of the sewer system and, frequently, few natural buffers exist to control flooding. When a flood does occur, the costs are unexpected. By such actions, society has not been engaged in “wise use” as Gilbert White would say, and ultimately has transferred risk to future generations (Mileti 1999).

Generally, in risk assessment, we tend to rely upon quantificational methods of analysis, but increasingly such approaches are seen to be limited in scope. Often, we concentrate upon identifying ‘objective’ probabilities of failures of technical systems at the expense of incorporating non-quantifiable probabilities of human error, for instance. Conrad Brunk (1995, p. 160) questions these priorities, suggesting that non-quantifiable elements can be crucial. “Just what was the ‘objective’ probability,” he asks, “that the maintenance crew at Three Mile Island would forget to re-open the valves in the auxiliary cooling system after routine maintenance (the major contributory factor in the accident)?" Try as we might to capture all eventualities within our reductionist frameworks, the human factor is one example of an element that exceeds positivist measures in any definitive sense.

It is beginning to be evident that many environmental risks exceed simple, mathematical measures. Is risk to be measured simply in terms of the number of human lives lost, diagnosed illnesses or GDP? New concepts are emerging that cannot be easily quantified and yet are seen as valuable. Examples include notions of integrity, resiliency, sustainability and ecosystem health. Brunk (1995, p. 157) reminds us that, "because probabilistic risk assessment is a quantitative methodology, whose output is only as reliable as the quantitative precision of the data input into its algorithms, it is strongly biased in favor of identifying only those values 'at risk' that are easily quantifiable. These are not necessarily the values most important to the general public. Among the values excluded, for example, are those of personal and collective autonomy, matters of fairness in the distribution of risks and benefits, as well as cultural, religious and 'metaphysical' values."

Brian Wynne, Director of the Center for the Study of Environmental Change in Lancaster, UK, echoes these sentiments when he points out that, "what can actually be measured frequently dictates the structure of the resulting knowledge" (1992, p. 113). Certainly, averaging, standardization and aggregation are necessary components in quantifying risk. Nevertheless, "the fact that this is necessary and justified does not alter the point that it imposes man-made intellectual closure around entities which are more open-ended than the resulting models suggest" (Wynne 1992, p. 113).

To quantify and assess risks, then, in a narrow, reductionist manner is to jeopardize significant issues that cannot fit the model, but nevertheless are important to the broader public and do substantially affect mitigation efforts. Real social, as well as ecological impacts, may be excluded in such a system that neglects to address non-quantifiable concerns.

In fact, reductionist paradigms very frequently lead to an overemphasis on risk in the first place. Mary O'Brien (2000) questions this emphasis by providing numerous examples to show how current, narrow approaches to risk assessment – aiming at impartiality – have led, nonetheless, to governments and industry sanctioning the widespread contamination of air and the poisoning of wildlife and groundwater. She offers another decision-making technique that she calls 'alternatives assessment' that is broader in scope than traditional risk assessments. Instead of attempting to unsuccessfully quantify risks and thereby generate oversimplified predictions, O'Brien argues from the premise that it is simply unacceptable to harm human or ecological health if there are reasonable alternatives. Through broader public dialogue more informed decisions can emerge from a holistic framework that seeks to minimize ecological damage while achieving social goals.

In a similar vein, Wynne (1992, p. 114) argues that other forms of uncertainty than risk are at play in hazardous situations, such as indeterminacy and ignorance, for example, where we may not know what we don't know, and causal chains remain open and unsure. Many hazards are basically indeterminate: the dangerous decrease in stratospheric ozone in the earth's atmosphere was not recognized until it had actually occurred. We are asking the impossible from scientific risk assessment if we expect "objective" analysis of previously unacknowledged possibilities – which is not to say that we ought not to assess risk, but rather that we should simply recognize the limits of the process, and perhaps look to supplement these methods of analysis with other, less conventional approaches.

When we ignore these broader considerations of uncertainty, risk is potentially increased in two ways: (1) firstly, vulnerability is increased due to a 'command and control' approach that ultimately fails (Holling and Gunderson 2002), and (2) secondly, some hazards increase as a result of environmental degradation resulting from a consideration of nature as an unlimited resource that can be used as a tool to fuel economic growth, the use of which lacks consequences. This latter approach has resulted in, for example, depleted ozone layers, deforestation, desertification and climate change. The underlying issue is the assumption that as a result of environmental degradation, systems will not fail, or are not vulnerable to feedbacks resulting from technological adjustments.

Such a positivist, engineering approach to mitigation is embedded in a belief that nature is predictable and controllable by human beings, the roots of which lie in the 17th and 18th century paradigms of Newton, Descartes and other rationalist thinkers, and can be traced back even to Plato (Stefanovic 2000). In part, this approach assumes that science can understand, predict and perfectly engineer the natural world. It also is based on a belief that it is humankind's natural right to control nature, a perspective that places us "above" the natural world (Devall and Sessions 1985).

Such anthropocentric value systems that favor human beings over the natural world have deep historical roots in our Western metaphysical tradition. Current mitigation strategies often reflect those human-centered normative theories. Consider, for example, the construction of dams and dykes. These engineered structures are intended to alter and control hydrological systems, expressly for human purposes of flood control and power generation at the expense of preserving ecological balance.

Examples of such anthropocentric interventions include the Three Gorges dam in China, which may cost more than any other construction project in history. The dam requires the resettlement of many communities and, "would alter the current ecosystem and threaten the habitats of various endangered species of fish, waterfowl and other animals, and . . . would necessitate extensive logging in the area and erode much of the coastline" (China Online 2003). Likewise the W.A.C Bennett dam in British Columbia, Canada, has caused a significant drop in water flow to the Peace-Athabaska delta, one of the largest freshwater deltas in the world (Environment Canada 2003).

At times, such interventions have placed environmentalist groups at odds with the proponents of these systems. Failure of technological systems designed to protect people and their built environment can occur in two ways, one being a natural trigger beyond the design criteria of the system, and the other being failure due to such things as lack of maintenance, quality of construction issues or human error. The 1996 Saguenay flood in Quebec is a spectacular example of such system failure and of the limitations of complete human control over nature, despite engineering ingenuity. A complex system comprised of 45 watercourses and about 2,000 flood control structures owned by 25 different organizations, the defense mechanisms were unable to deal with the extreme rainfall of July 19–20, 1996, when the Saguenay River broke through an earthen dam and created a cascading wave of destruction downstream along its natural hydrological pathways.

The nature of urban development in Canada also reflects this anthropocentric, technocratic bias. Natural drainage systems are eliminated and replaced with impermeable paving and storm sewers. The result has been an increase in urban floods (Dore 2003). A more ecological approach includes rooftop gardens, increased respect for natural floodways and paving designs that allow infiltration to reduce the urban flood problem and also help curtail urban air pollution.

Anthropocentric views are reflected in several aspects of the recovery process as well. Take the examples of reconstruction using disaster financial assistance arrangement (DFAA) and private insurance. Both of these programs fund recovery after disasters, and can either increase or reduce vulnerability to future hazards, depending upon how they are implemented.

DFAA is funded using tax dollars and, in many respects, assumes a utilitarian ethic. All Canadians contribute towards this funding mechanism. The assumption is that financial assistance for community recovery ensures the overall greater good for Canada or Canadians. This redistribution of wealth is applied using the precept that greater amounts of aid should go towards those who have lost the most, up to some maximum amount. There may well be some people in far greater need who get no or little assistance (the homeless for example), but this particular application of the greatest good is based upon equal distribution of opportunity in proportion to incurred loss (in the sense that all those who suffered from the disaster should have an opportunity for maximum possible aid), as opposed to the uniform distribution of welfare or resources.

At the same time, the disaster financial assistance program also motivates us to assist those who have suffered through no fault of their own. Canadians feel obliged to help those in need and, in some sense, the assumption is also that citizens have an individual right to expect some aid from governments during their times of need. This right is not unlike the perceived right to health care that, supporters claim, ought to be available for all Canadians, no matter their income level.

While this kind of social aid is crucial to the recovery process, it has been criticized from a number of perspectives that can be traced back to conflicting moral claims. For instance, one criticism arises within a concern of who carries the burden of responsibility for recovery costs. A utilitarian ethic supports the notion that financial assistance should be distributed to advance the maximum possible good for the greatest number. In this case, one concludes that governments ought to provide assistance for disaster recovery to the maximum number of those who have been affected by a disaster.

On the other hand, does this blanket obligation to assist in recovery apply to all equally? Do our individual rights and freedoms as Canadians also include the right to choose to live in risk-prone areas? Some people who bought properties in flood plains zoned for residential use by a municipality may not have had knowledge that they did so. However, it is a different case when victims of a disaster are perceived as knowingly and willingly having accepted undue risk by living in hazardous zones, without taking reasonable risk-reduction actions (such as flood-proofing or buying extra insurance). Then, there is a strong argument to be made that the misery is self-inflicted, and that the responsibility for recovery remains with the afflicted community and individuals. This is similar to the argument that smokers should pay more for health care. While we may, as utilitarians, wish to maximize the greatest good for the greatest number, do all members of that "greatest number" have equal rights to compensation?

Indeed, DFAA programs can be criticized, precisely because they shift the burden of responsibility to governments who will eventually cover the costs and, therefore, allow citizens to engage in more risk-prone activities. Disaster assistance tends to create a culture of complacency (or even dependence). Such a culture, when it occurs, increases vulnerability and raises the question of whether disaster recovery initiatives should more properly be assumed by individual property owners, and in a more direct manner.

The same dilemmas apply when it comes to insurance. In the US, a government sponsored National Flood Insurance Program (NFIP) exists. One of the founders of the program, Gilbert White, has noted that the net effect of the program was to encourage development within flood plains, thereby increasing flood damage and the overall vulnerability of society.

> The net effect ... of practicing such a national policy – for which now about 30% of the property owners in flood plains these days buy insurance – may be counter-productive, and the result is an increase in annual losses from floods rather than a decrease. Rather than promoting wise use of floodplains, it might enforce ... unwise use (White 1999).

This view has also been supported in a recent paper by Larson and Plasencia (2001) who state that, "annual flood losses in the United States continue to worsen in spite of 75 years of federal flood control and 30 years of the National Flood Insurance Program." In the UK, a similar situation seems to exist. David Crichton (personal communication, March 2002) noted that the "1961 UK insurance guarantee ... has had the effect that in many ways flood insurance has been taken for granted by government, planners, and developers, and many housing developments have taken place since 1961 in high flood hazard areas."

This kind of risk-prone behavior occurs because individuals and communities view the consequences of their actions upon the environment as lying elsewhere. Instead of seeing their conduct in terms of broader, eco-ethical impact, they choose to either ignore the risk or shift responsibilities for their actions or inactions to other agencies. At least one Canadian study supports this view, that being the Michigan vs. Ontario flood damage comparison (Brown et al. 1997). In this study, it was found that a set of storms affecting both areas resulted in costs of about $ 500 million US in Michigan, but less than $ 0.5 million CDN in Ontario, as a result of greater development in Michigan flood plains. This difference results from different cultures, the former that allowed flood plain development (with some restrictions with respect to the purchase of flood insurance), and the latter that restricted it. Within Ontario, development within flood plains was actively discouraged and prohibited, with planning and flood control done on a watershed basis through conservation authorities. The US relied largely upon the National Flood Insurance Program (NFIP), which was based upon the theory that "if property owners are required to purchase flood insurance at actuarial rates that reflect flood risk, and if risk is reduced through regulations that require the elevation of new construction in floodplains and avoidance of development in floodways, the added costs of construction in the floodplain should dissuade uneconomic uses" (Burby 2001).

In practice, the NFIP suffered from a number of deficiencies, including incomplete flood hazard identification, flawed methods and poorly marked penetration. Burby (2003) noted that the NFIP may even have stimulated building within the 100-year floodplain. Also, even if buildings within flood plains were protected against the 100-year flood, they would certainly be vulnerable to events of greater severity, which could account for increased flood losses relative to a strategy prohibiting flood-plain development. Though our entrenched beliefs in property rights may also lead some to conclude that we have the right to build in risky areas, the reality is that some portion of the costs for such actions are inevitably borne by society at large and thereby increase overall social and ecological vulnerability.

Nevertheless, many do believe that individuals at risk have the responsibility to purchase insurance to protect their property so that recovery can occur, should disaster strike. Those who do not buy insurance have gained the benefit of not paying premiums, and have made a choice to assume the risk that goes with that benefit. It follows that they should accept the cost of their decision in the event of calamity.

The issue becomes complicated, however, when one realizes that the ability to buy insurance varies with the socio-economic stratum of the individual or community and, therefore, recovery relying upon this process tends to maintain or accentuate socio-economic ramps. Reliance upon this method alone discriminates against the less wealthy classes of society, who are presumed to contribute towards the greater social good, but who may not be able to purchase insurance, or sufficient insurance. This is one of the reasons that societies with unequal distributions of wealth are considered to be more vulnerable to natural disasters.

From a utilitarian perspective, insurance is a useful but insufficient tool for disaster recovery.

In fact, it must be remembered that not all hazards are insurable (for instance, residential flood insurance is not available in Canada). In practice, the purchase of disaster insurance is not always encouraged, since it is often politically expedient to assist the recovery of victims whether they have purchased insurance policies or not. Ecological damage to wildlife and their surrounding habitats are rarely considered in such moments, and yet no amount of insurance can protect them from hazards.

While insurance and DFAA recovery programs have been designed to reduce the impact of disasters, here in Canada as well as in many other parts of the world, they have been criticized for reconstructing vulnerability. One of the reasons for this is that these programs are typically based upon the principle of returning a community to its pre-disaster state. This policy may have something to do with an enduring sense of place identity on behalf of residents. If that location remains particularly vulnerable to hazards, then recovery has simply made another future disaster inevitable.

Both types of programs require constraints to discourage risk-taking behavior where it is not appropriate, and to encourage risk-reduction activities. Incentives through reduced insurance premiums have been shown to be one good tool (e.g., FEMA Project Impact uses a "carrot" approach that rewards risk reduction activities). Refusing disaster aid to those who have taken excessive risks (the "stick" approach) might also be a useful but harsh tool, though historically the political response to this has often been to not enforce it. Refusing aid to disaster victims, especially in media-intensive events, is not politically expedient and runs against an accepted utilitarian ethic of promoting the greater good. As well, people are likely to discount risks associated with rare, extreme events, making the stick approach not as effective as an agent of change as the carrot one.[4]

No matter what kind of insurance policy is put in place, as a society we must begin to realize that neither technocratic, positivist solutions, nor juggling different forms of compensation, are going to the root of the problem. The fact is that in developing in flood plains, for example, we are acting *in opposition to* existing natural states. To be sure, we need not passively submit to nature's constraints but, at the same time, neither must we act in total disregard of pre-existing natural conditions. Whether we feel justified in damming rivers or fine-tuning insurance policies, moving beyond narrow, egoistic, anthropocentric perspectives opens up different possibilities for mitigation activities. That means that even if a municipality is legally empowered to develop in flood plains, and even if an insurance policy is put into place to compensate potential victims, we must continue to ask questions such as: what kind of compensation are we extending to ecosystems and other non-living victims of disastrous planning? And what kind of imbalances are we creating by refusing to find a proper eco-ethical "fit" between our human actions and the needs and constraints of the natural world?

In an effort to reduce risk, it is important to clarify ethical assumptions and to resolve competing claims (Stefanovic 2003). As the examples above indicate, many value judgments underlying current discussions of mitigation are rooted in a predominantly human-centered ethical paradigm that aims to address such issues as human rights, the greatest good for the greatest number of human beings and, ultimately, the risk to human well-being. In the following section we shall consider expanding these parameters to include broader ecological communities within the dialogue of ethical obligations.

4. The Need for a Broader, Eco-Ethical Perspective

While reductionist, anthropocentric values are persistent, the development of chaos theory, our experience with the rising costs and impacts of disasters, numerous case studies that show the negative impact of decision-making that excluded the environment, and the development of ecological models that place humans within, not outside, the natural environment, have given impetus to a different paradigm. Natural disasters must be considered within the framework of human ecology, where a complex set of interdependencies exist between society and its natural environment.

We might glean some lessons from Aboriginal traditional ecological knowledge (often abbreviated as TK or, more ironically, TEK). According to traditional Native American teachings, the world exists as an intricate balance of parts to a whole, and humans must recognize this balance in order to maintain ecological health (Booth and Jacobs 1993, p. 523; Callicott 1994). Environment Canada's *Science and the Environment Bulletin* (2002, p. 1) rightly points out that, "over centuries of living in harmony with their surroundings, Aboriginal peoples in Canada have gained a deep understanding of the complex way in which the components of our environment are interconnected." A number of resource management boards, commissions and legal agreements, such as the Convention on Biological Diversity, explicitly recognize that Aboriginal traditional knowledge emerges from a holistic view of the world, encompassing biophysical, social, cultural and spiritual awareness and arises from a perception of "humans as an intimate part of [the environment] rather than as external observers or controllers" (Environment Canada 2002, p. 1). This recognition is passed on orally through songs and stories. The Haudenosaunee Creation Story, for instance, "tells us of the great relationships within this world and our relationships, as human beings, with the rest of Creation" (Haudenosaunee Environmental Task Force 1992, p. 2).

While the term "traditional ecological knowledge" only came into widespread use in the 1980s and was often dismissed as mere anecdote, governments and policy-makers are increasingly coming to a recognition of the importance of indigenous knowledge in public policy. "Time-tested and wise," traditional aboriginal approaches to the land provide qualitative information about a variety of natural phenomena (Berkes 1999, p. 9).

Environment Canada researchers and officials have organized several Elder/scientist retreats to share their knowledge and learn from one another (Environment Canada 2002, p. 2ff). Projects across the country bring together government scientists and indigenous peoples to profit from one another's knowledge. Examples include a project in the North, where the Vuntut Gwich'in people – hunters and trappers from the Yukon – advised biologists of dropped water levels in more than 2,000 shallow lakes and ponds in the Old Crow Flats. Upon satellite investigation, supplemented with aerial photos, scientists were able to confirm that lakes are either drying up or draining "catastrophically," – likely one more indicator of climate change (Environment Canada 2002, p. 3).

The Government of Canada concludes that these sorts of collaborative initiatives between scientific research and traditional aboriginal knowledge only "improves our understanding of the many and complex influences affecting our environment and the steps we must take to ensure sustainability for future generations" (Environment Canada 2002, p. 3). One wonders, for instance, whether an aboriginal reverence of the land as sacred could find much justification of large-scale damming of waterways in the first place.

Aboriginal societies are no longer alone, of course, in recognizing the importance of a holistic perspective on environmental issues. A significant, interdisciplinary approach to urban planning and, in some specific cases, to natural hazards assessment, emerged some years ago through work in Ekistics – the science of human settlements. Leading back to the same etymological root as ecology, *oikos*, interdisciplinary Ekistic research has shown that a series of elements and functions define every human settlement at all scales, from individual dwelling to an urbanized world (Doxiadis 1968). The elements include:

- nature,
- human beings,
- society,
- buildings and physical infrastructure, and
- communication and information networks.

In addition, social, cultural, economic, regulatory, technological and biological functions are virtually always present in any human settlement. Different underlying world views and attitudes affect their specific manifestation and characteristics. Needless to say, these elements and functions interrelate and any disaster mitigation policy must recognize both the scope of each item individually, as well as the complexity generated through the synergistic relations exhibited in our human settlements. We can no longer address simply one item on the list but must aim towards a genuine interdisciplinary approach to disaster mitigation and recovery programs in order to generate more resilient communities.

James Mitchell (1999, p. 40) has recently pointed out our serious failure as a society, "to treat natural hazards as complex systems with many components that often require simultaneous attention. We tinker with one or another aspect of these systems when what is required are system-wide strategies." Mitchell concludes that there has been a growing recognition that, "broader interpretive frameworks are necessary – frameworks that incorporate both society and nature and a variety of contextual variables" (1999, p. 43).

Ekisticians have made attempts some time ago to generate such comprehensive interpretive frameworks. Ovsei Gelman and Santiago Macias from the Mexican National Autonomous University (1984, p. 509) presented some preliminary work toward a conceptual framework for interdisciplinary disaster research that would offer the methods and terminology, "with which to facilitate the integration of various studies and the consolidation of all related efforts... to safeguard and guarantee the continuity of socioeconomic development at the community, regional and national scales."

In a similar vein, Canadian architect and planner, Alexander B. Leman (1980) generated an interdisciplinary matrix that plotted the impacts of disasters upon the Ekistic elements and functions. Not unlike environmental impact assessments, this model served as a tool for identifying patterns and trends, as well as providing a global overview of priorities for disaster mitigation.

Such an interdisciplinary tool might also help to highlight strengths and weaknesses of mitigation policies. Consider, for example, how plotting such a grid may indicate how a narrow focus on technological solutions may have ignored local social and cultural conditions, thereby decreasing a community's overall resiliency. The very success of some government disaster assistance programs is a debated topic, with some aid agencies such as the Red Cross claiming that the World Bank and IMF have historically contributed to the disaster cycle due to their particular, narrow philosophical/cultural approaches (IFRC 2001). These approaches, which typically have been short term, ignored local cultures, emphasizing technologically based solutions. Increasing debt loads have at times reduced local resiliency and led to cultures of dependency. Both the World Bank and IMF organizations have apparently recognized these issues and are increasingly advocating broader-based solutions that recognize local capacity building (World Bank 2002; IMF 2003). By identifying impacts through an interdisciplinary model, there is a chance that a broader net is cast over a wider set of human settlement elements and functions in our policy development.

As noted in Section 2, reducing vulnerability can be accomplished by increasing resistance or resilience (i.e., building fail-safe, as compared to safe-fail). Both are important. However, it is more common for resistance to be emphasized. For this reason, the following discussion focuses on the resiliency aspect of vulnerability, where more opportunities seem likely.

"Building resilient communities" is a phrase that one sees more and more often in the disaster mitigation literature. This makes good sense, but a clear idea of what resilience means is needed. Webster's dictionary defines it as "recovering readily." What does it take for this to occur?

There are two sides to the issue, (1) the first relating to the extent and nature of damage inflicted upon a community, and (2) the second related to capacity (i.e., having the resources available for rebuilding). Canada has done a good job, overall, on the latter. A relatively wealthy country with a well-entrenched insurance culture, strong technical capabilities and a disaster assistance program, it has the capacity to recover from many severe disasters. No doubt it could be improved, but greater opportunities to increase the resilience of our communities seem likely to exist within the first category; thus an emphasis on mitigation as opposed to recovery. This view has been supported by Senator Terrance R. Stratton, Chair of the Subcommittee on Canada's Emergency and Disaster Preparedness. He noted in 1999 that, "we react very well, but we do not mitigate or plan properly for these events – we react to these events. I believe we must go through the process to find out how we can mitigate these events and minimize the damage to human lives. Fundamentally, that is what it is all about. We must do some proper planning."

Within this context, there are two main problems leading to a lack of resilience. (1) The first is that society is obsessed with short-term economic efficiency (which can only be achieved with a loss of resilience, such as eliminating system redundancy or capacity). Being economically efficient requires minimizing costs and maximizing benefits. System resilience can only be achieved at some cost, examples being the maintenance of secondary backup systems to essential services, and maintaining stockpiles of goods (as compared to systems reliant upon complicated transportation systems). For example, Britain was hit by a foot-and-mouth disease catastrophe in 2001. The disease was able to spread so rapidly because the system that transported cattle created fast disease vectors, as compared to a more conservative but perhaps more expensive one. (2) The second problem leading to a lack of resilience is that we do not incorporate the risk of rare high-consequence events appropriately into design (Etkin 1999). For example, had the transmission towers that failed during the 1998 Quebec and Ontario ice storm been designed with safe-fail properties (such as with collapsible arms, so that the entire tower did not fail) then recovery would have been faster and less expensive. Making systems or structures more resistant does not eliminate or reduce the individual cost of disasters; it makes them less frequent. Designing resilient systems can truly lessen the impact of a disaster.

Building resilience into our designs and systems requires the assumption of failure – something we are often loathe to do, but that experience has shown to be a reality of our existence. We have grown up in a culture that believes humankind can control nature and, while we are successful in this human undertaking in general, the episodic occurrence of extremes beyond our coping range demonstrates the falsity of this conviction. The concept of resilience applies not only to engineered structures, but equally to social systems and ecosystems, which act as important buffers to natural hazards.

In fact, integrating technological innovations with environmental, social, cultural and economic concerns opens up new possibilities for disaster mitigation. A prime example emerges from research conducted by Brad Bass at the University of Toronto (personal communication 2002). Studies have shown that green roofs (rooftop gardens) can have a similar storage capacity for rainwater as compared to large underground storage tanks, used as a safety valve to reduce flooding when sewer systems are overwhelmed. The green roofs cost less, can reduce the storm surges more effectively than storage tanks, and offer a series of co-benefits, including energy efficiency for buildings as a result of reduced cooling costs and improved urban air quality, as well as non-quantifiable benefits related to an improved urban landscape. By "greening mitigation," numerous benefits accrue to society.

Generating solutions requires not only answering, but also asking the right questions. Building resilience requires asking a greater variety of questions, including "under what circumstances will this 'widget or whatever' fail?" "are the consequences of failure acceptable?" and "what can be done to minimize the consequences of failure, when it occurs?"

Though the above paragraphs have emphasized infrastructure issues, the concept of resilience applies equally to the socio-economic fabric. More than one disaster case study has shown how safe building or recovery has been delayed or paralyzed as a result of lack of enforcement of existing codes, lack of incorporation of natural hazards into planning activities, bureaucratic inefficiency, incompetence, corruption or other human factors (IFRC 2001). Creating resilient communities requires a culture of disaster awareness, good policy and political will. Without these elements, success is unlikely.

Cultural change is difficult to achieve. At a minimum, it requires social learning and adaptive capacity. Through social learning (which emphasizes the importance of observing and modeling the behaviors, attitudes and emotional reactions of others), people can learn from the experience of others who have reacted to disasters in constructive ways. Increasingly, it is thought that social cohesion is critical for societies to prosper economically and for development to be sustainable. A lack of institutions and networks can be a strong barrier to cultural change, even with the occurrence of social learning. Finally, there must be a capacity for adaptation, both in terms of infrastructure and within the socio-economic framework. Capacity depends upon many factors, including human, physical and economic resources and institutions capable of change. White et al. (2001) explored various reasons as to why disaster losses have been increasing, and conclude that to a large extent knowledge of how to reduce losses exists, but was not used effectively. This suggests that the solution to the disaster problem lies more in the social than in the physical or engineering sciences. In order to create a less vulnerable society, it seems that we must learn to do things differently.

Moreover, increased resilience means expanding the boundaries of what we value. Simply directing our attention to narrow, anthropocentric concerns means missing out on wider questions of *appropriate fit* between our own policies and environmental constraints. For too long, we have envisioned ourselves as *above* the environment, rather than as members of the biotic community (Leopold 1949). As a result, we have operated under the belief that nature could be molded to our own desires and dominated through technical quick-fixes. Some philosophers argue that healthier human settlements can only emerge through respectful attitudes towards the environment that assign it intrinsic worth, rather than mere instrumental value (Leopold 1949; Devall and Sessions 1985). For many, it is also a source of wonder and beauty, and in that sense of value in its own right.

Whether or not one chooses to assign intrinsic value to the natural environment, most environmentalists do agree that rather than centering purely on human concerns, a more appropriate ecological model of ethics means focusing on the *relation between* human beings and the natural world. It is when the *relationships* are out of balance – and included are those cases of heavy-handed technological manipulation of natural systems that ultimately compromise human and environmental health and safety – genuine disaster mitigation is at serious risk. Natural disasters are most fundamentally a social/political problem, rooted in the manner in which humans interact with their natural environment. Increasingly, the hazards literature emphasizes how development decisions made by society determine future disasters by placing us at risk (Mileti 1999). The term 'natural disaster' is somewhat of a misnomer, since the cause of disasters is often complex, and embedded in human decision-making about one's proper place in the world.

Our worsening relationship with the natural world relates to natural disasters in two ways. Firstly, humans tend to deal with natural hazards by either ignoring them (for example, by building in flood plains) or by transferring risk to future generations by designing vulnerable systems or communities that will eventually suffer a disaster. The difficulties experienced in obtaining international consensus and approval of the United Nations Framework Convention on Climate Change, designed to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, is one good example of this at the global level. Secondly, our use of the environment for economic growth results in environmental degradation that often increases risk. Examples of this include climate change, devegetation of slopes resulting in more land and mudslides, and the paving of urban areas resulting in greater runoff and flooding.

Some of these eco-ethical relationships are schematized in Figure 1. In the center of the figure are two boxes with solid lines, which represent our human and natural environments. The human environment box is placed within the natural environment one, emphasizing the ecological perspective taken by this paper. Within the human environment box is a circle representing our interaction with those parts of nature that can potentially be resources for society, or hazards. Component A represents that part of society vulnerable to natural hazards, and those hazards. An example would be a city built near a fault line, and therefore subject to earthquake risk. This is essentially a simple representation of the 'disaster pressure model' discussed in Blaikie et al. (1994), which defines risk as a function of both hazard and vulnerability. Component B represents that part of nature which is a resource,

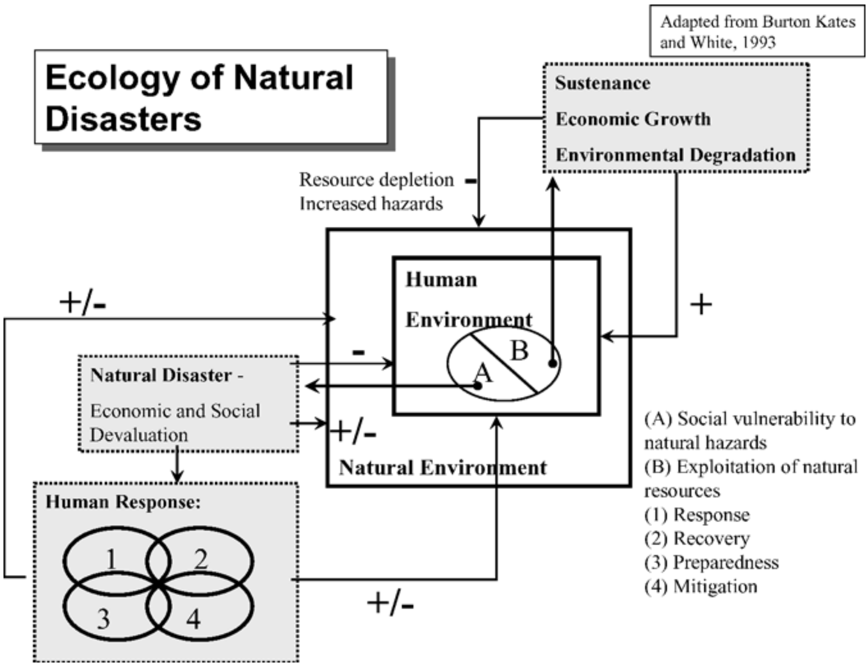

Figure 1. Ecology of natural disasters.

and exploited by humans for sustenance and economic growth (such as harvesting forests for lumber, urban development, paving over land for urban development or converting the natural landscape into agricultural land). The idea that nature is both a resource when it functions within our coping range, and a hazard when it exhibits extremes beyond that range, has been explored, for example, by Burton et al. (1993, p. 32).

This flow chart illustrates how the complex relationship between the human and natural environment contributes towards natural disasters. The human environment is situated within, as opposed to separate from, the natural environment. Within the human environment, nature can be either a resource or a hazard. Where it is a resource (B) it leads to sustenance, economic growth, but also environmental degradation (the top right cycle). Therefore, it can feedback in a positive way into the human environment, especially in the short term, but also in a negative way, where environmental degradation leads to increased hazards. Where the natural system is hazardous and social vulnerability exists, natural disasters can occur (the bottom left cycle). Such disasters have an immediate negative impact on society, but also trigger a complex cycle of human response that affects both the natural and human environments. These responses are intended to reduce vulnerability, but at times have increased it, and therefore the feedbacks are shown to be both positive and negative.

From these boxes there are various arrows pointing in and out, with + and − signs beside them. Those signs are meant to represent the average direction of feedback, either positive (constructive to the system) or negative (destructive to the system). Clearly, there are value judgments inherent in these terms, and what one person may consider constructive, another may consider destructive. We suggest that the terms be interpreted within the context of total resources within the system and complexity; greater resources and increased complexity would be reflected by a + sign. Therefore, a flux of resources from the natural environment to the social environment would be positive for the social, but negative for the natural system.

'B' (exploitation of resources) leads to economic growth, but also to environmental degradation (on average); it is represented by the dashed box in the upper right-hand corner of the figure. This results in feedbacks into the human and natural environments. One leading to the human environment is positive, reflecting how the use of natural resources enhances our society. However, the feedback into the natural environment is negative, as our experience is dominantly that environmental degradation has resulted from resource exploitation. This feedback has the net result of increasing risk by altering the hazards themselves.

'A', where extreme natural events act as a trigger to vulnerable systems, leads to natural disasters. Disasters typically trigger an overlapping and complex cycle of human behavior, starting with response and recovery, but often also including preparedness and mitigation. The latter two activities do occur in a continuous fashion in theory, but experience has shown that changes in behavior occur most often following disasters, within what is often called a 'window of opportunity'.

Environmental values and the nature of the relationship between humans and nature play a crucial role in the nature of the feedback loops involving 'A' and 'B'. Where nature is not valued, or when the links between human and natural environments are discounted, then ultimately hazards are made worse or vulnerability is increased, though short-term benefits may accrue to social systems.

Some mitigation programs appear to have been ineffective, or even counterproductive in the long term. Examples of this include the Canadian FDR program in parts of Quebec (Benoît et al. 2003) and some aspects of the US flood insurance program (Larson and Plasencia 2001). The reasons for this are many and complicated – some are political, some are cultural and some are technical. For this reason the feedbacks from the Human Response box at the bottom of Figure 1, to the Social and Natural Environments box have a ± sign.

Mitigation activities, in order to be effective, need to reduce vulnerability. There are many different ways we can be vulnerable, including physical, personal, geographical, structural, environmental, psychological, cultural, social, economic and institutional.[5] These vulnerabilities are often linked in complex ways; for example, a poor economy can lead to a lack of institutional capacity and a greater use/misuse of environmental resources, with consequent environmental degradation. These linkages lead to the notion that any strategy designed to mitigate risk needs to be very broad-based. In particular, they should encourage a use of the natural environment that does not degrade it in ways that make hazards worse.

5. Recommendations for Future Action

If mitigation issues are complex, grounded in a holistic system of eco-ethical relationships, then clearly, interdisciplinary analysis is called for. Furthermore, to resolve conflicting ethical value judgments and taken-for-granted assumptions that underlie the development of any environmental policy, it makes sense to expand the discussion of ethics beyond human-centered parameters to include broader ecological values.

Such a discussion requires cultural change and the development of a cohesive inter-disciplinary community. If such a change is to take place within Canada, we believe that a coherent community of hazards people needs to be formed. At present, hazards research and application is fragmented, with people mainly working within their own organizational, professional or departmental stovepipes. For this to change, institutions and/or networks need to be strengthened or created to encourage cross-disciplinary research: and to regularly bring practitioners, policy makers and researchers together from both the public and private sectors to share information and perspectives. In particular, city planners, people involved in emergency management and insurance, climatologists, geologists and hazard and disaster researchers in government and universities (particularly from the social sciences), as well as representatives from native communities, should begin to work together in interdisciplinary ways.

One useful model for such an institution is the Natural Hazards Center at the University of Colorado, Boulder, which houses a large library that is accessible by any person interested in hazards, publishes journals and newsletters, facilitates networking and holds an annual interdisciplinary workshop. Within Canada, the Canadian Risk and Hazards Network, the Institute for Catastrophic Loss Reduction, Publics Safety and Emergency Preparedness Canada, the Geological Survey of Canada, the Meteorological Service of Canada and the Canadian Center for Emergency Preparedness all take on some of these functions, and have the potential to assume a much larger role given the mandate and additional resources. The structure and characteristics of networks and institutions that enable cooperative behavior for the common good, in order to avoid 'social traps' such as those discussed by Hardin (1968) in "The Tragedy of the Commons," is an important topic, but beyond the scope of this paper. The reader is referred to Ostrom et al. (2002) for more discussion on this topic.

More effective mitigation means changing the way people think about hazards. This cannot be done solely by implementing new policies, standards or laws, though those tools are extremely important (consider how much of the damage caused by Hurricane Andrew in Florida occurred because existing standards and laws were not adhered to). It can be advanced by the interchange of ideas and experience by people who care and work with hazards issues.

Almost two decades ago, planner Spenser Havlick advocated increased exchange of documentation and experience, not only cross-regionally but internationally. "There is a need for new natural hazards research," he wrote, "which takes into account proper long-term planning periods and for more international exchange of building codes and specifications which have proven effective in both disaster resistance and cost over a reasonable payback period" (Havlick 1984, p. 404). Still today, researchers are calling for, "a commitment to mutual understanding and collaboration among academics, professionals and laypersons, who are hazard specialists and academics, professionals and laypersons who are urban specialists" (Mitchell 1999, p. 46).

Certainly, electronic listservs, conferences, advisory groups and research centers are important elements of interdisciplinary collaboration. However, Havlick raised an important point when he suggested that, "the greatest and most lasting contribution to the reduction of risk from natural hazards comes from the universities, the academies and other centers where architects, engineers and planners are trained" (1984, p. 405). His survey of universities at the time revealed almost no interdisciplinary courses on hazards mitigation and preparedness, and little has changed since then. Unless we are educating our students about how to make linkages, any long-term hopes for holistic understanding of the ecology of disaster mitigation is at serious risk.

It is difficult to underemphasize the importance of broad perspectives in solving real-world problems, and until our educational systems and professional development encourage such, it is unlikely that much progress will be made in the mitigation of natural disasters. It has been said that, "a way of seeing is also a way of not seeing" (Kenneth Burke, in Klein 1990, p. 182). Our personal experiences, our personal and disciplinary biases and deeper underlying paradigms allow us to see mitigation from various, unilateral perspectives. It is only in a wider dialogue that collectively we can hope to evolve a broader, eco-ethical approach to disaster mitigation by moving our sights towards the greater whole.

Notes

1. It is a somewhat debatable point, whether these strategies are classified as 'modifying the hazard' or as 'modifying vulnerability'. For example, if you build a house on a flood plain, the house is vulnerable to flooding. If a dam is built so that the flood plain is changed, you have reduced vulnerability – but one could also argue that the hazard – the river – has been modified. For practical purposes the distinction is probably not important.
2. For a discussion of some of the contemporary interpretations of ecology, see Molles, Jr. (1999).
3. Frederick Clements, for instance, viewed ecosystems and the climax community as a complex organism – "a new kind of organic being with novel properties" (cf. Worster 1985, p. 211). The community model itself was advanced by thinkers such as English zoologist, Charles Elton, who viewed ecosystems as functional models. By the early 20th century, English biologist Arthur

Tansley moved toward an energy model of ecosystems, denying that they consisted of simply physical, mechanical elements but reflected complex energy flows. Our emphasis is on the theoretical importance of emphasizing fundamental, ecological relationships between human beings, living entities and biotic and abiotic environments.

4. Increased mitigation of risks from natural hazards has been addressed through Ontario's Emergency Readiness Act (Bill 148), which states that, "Every municipality shall develop and implement an emergency management program," and through the Quebec Civil Protection Act (Bill 173), which requires municipalities to engage in risk identification, prevention and emergency response plans.
5. For a review on vulnerability, see, for example, Anderson (2000), Hewitt (1997) or Blaikie et al. (1994).

References

Anderson, M.B.: 2000, *Vulnerability to Disaster and Sustainable Development: A General Framework for Assessing Vulnerability*, in Piekle and Piekle (eds.), Storms, Vol. 1, New York, Routledge, pp. 10–25.

Benoît, R., Simon, F. and Rousselle, J.: 2003, *The Effectiveness of Flood Damage Reduction Measures in the Montreal Region*, Natural Hazards.

Berkes, F.: 1999, 'Sacred ecology', *Traditional Knowledge and Resource Management*, Philadelphia and London, Taylor and Francis.

Blaikie, P., Cannon, T., Davis, I. and Wisner, B.: 1994, *At Risk – Natural Hazards, People's Vulnerability and Disaster*, London, Routledge.

Booth, A.L. and Jacobs, H.M.: 1993, 'Ties that Bind: Native American Beliefs as a Foundation for Environmental Consciousness', in S.J. Armstrong and R.G. Botzler (eds.), *Environmental Ethics: Divergence and Convergence*, New York, McGraw-Hill, pp. 519–526.

Brown, D.W., Moin, S.M.A. and Nicolson, M.L.: 1997, 'A comparison of flooding in Michigan and Ontario: 'Soft' data to support 'soft' water management approaches', *Canadian Water Resources Journal* **22**(2), 125–139.

Brunk, C.: 1993, 'Technological risk and the nuclear safety debate', *Proceedings from a Workshop*, Ottawa, Ontario, Institute for Research on Environmental and Economy, October 1–2, 1993.

Burby, R.J.: 2001, 'Flood insurance and flood plain management: The US experience', *Environmental Hazards* **3**, 111–122.

Burton, I., Kates, R. and White, G.: 1993, *Environment as Hazard,* 2nd edition, New York, The Guilford Press.

Callicott, J.B.: 1994, *Earth's Insights: A Survey of Ecological Ethics from the Mediterranean Basin to the Australian Outback*, Berkeley, CA, University of California Press.

China Online: 2003, http://www.chinaonline.com/refer/ministry_profiles/threegorgesdam.asp, accessed July 7, 2003.

Devall, B. and Sessions, G.: 1985, *Deep Ecology: Living as if Nature Mattered*, Salt Lake City, Peregrine Smith Books.

Dore, M.H.I.: 2003, 'Forecasting the conditional probabilities of natural disasters in Canada as a guide for disaster preparedness', *Natural Hazards* **29**(2–3), 249–269.

Doxiadis, C.A.: 1968, *Ekistics: An Introduction to the Science of Human Settlements*, New York, Oxford University Press.

Environment Canada: 2003, http://www.mb.ec.gc.ca/nature/whp/ramsar/df02s06.en.html, accessed July 7, 2003.

Environment Canada: 2002, *Science and Environment Bulletin*, Issue No. 32, September/ October 2002. Also available at http://www.ec.gc.ca/science.

Etkin, D.A.: 1999, 'Risk transference and related trends: Driving forces towards more mega-disasters', *Environmental Hazards* **1**, 69–75.

Gelman, O. and Santiago, M.: 1984, ‘Toward a conceptual framework for interdisciplinary disaster research’, in *Ekistics* **309**, 507–510.

Gunderson, L.H. and Holling, C.S. (eds.): 2001, *Panarchy: Understanding Transformations in Human and Natural Systems*, Washington, DC, Island Press, pp. 507.

Hardin, G.: 1968, ‘Tragedy of the Commons’, *Science* **162**,1243–1248.

Havlick, S.W.: 1984, ‘The urgency of accelerated application of natural hazards research findings in human settlements’, *Ekistics* **308**, 398–405.

Haudenosaunee Environmental Task Force: 1992, *Words that Come Before All Else: Environmental Philosophies of the Haudenosaunee*, Haudenosanunee Task Force.

Hewitt, K.: 1997, *Regions of Risk – A Geographical Introduction to Disasters*, England, Longman, p. 389.

Hoffman, S.: 1998, ‘Eve and adam among the embers: Gendered patterns after the oakland berkeley firestorm’, in Enarson and Morrow, *The Gendered Terrain of Disaster: Through Women’s Eyes*, Florida, Florida International University, pp. 55–62.

Holling, C.S. and Gunderson, L.H.: 2002, ‘Resilience and adaptive cycles’, in L.H. Gunderson and C.S. Holling (eds.), *Panarchy: Understanding Transformations in Human and Natural Systems*, pp. 25–62.

IFRC: 2001, *World Disasters Report: Focus on Recovery*, Bloomfield, CT, Kumarian Press Inc.

IMF: 2003, *The IMF’s Poverty Reduction and Growth Facility*, http://www.imf.org/external/np/exr/facts/prgf.htm, accessed July 10, 2003.

Klein, J.T.: 1990, *Interdisciplinarity: History, Theory and Practice*, Detroit, Wayne State University Press.

Larson, L. and Plasencia, D.: 2001, ‘No adverse impact: New direction in floodplain management policy’, *Natural Hazards Review* **2**(4), 157–181.

Leman, A.B.: 1980, ‘Human settlements: Framework for disaster assessment’, *Housing Science* **4**(6).

Leopold, A.: 1949, *A Sand County Almanac with Other Essays on Conservation from Round River*, Reprinted in 1981, New York, Oxford University Press.

Mileti, D.: 1999, *Disasters by Design – A Reassessment of Natural Hazards in the United States*, Washington, Joseph Henry Press.

Mitchell, J.K.: 1999, ‘Natural disasters in the context of mega-cities’, in J.K. Mitchell (ed.), *Crucibles of Hazard: Mega-Cities and Disasters in Transition*, New York, United Nations University.

Molles, M.C., Jr.: 1999, *Ecology: Concepts and Applications*, New York, McGraw-Hill.

National Oceanographic and Atmospheric Administration: 2003, Atlantic Oceanographic and Meteorological Laboratory, NOAA web site, http://www.aoml.noaa.gov/hrd/hrd_sub/modification.html, accessed Jan 23, 2003.

O’Brien, M.: 2000, *Making Better Environmental Decisions: An Alternative to Risk Assessment*, Cambridge, MA, MIT Press, in association with the Environmental Research Foundation.

Ostrom, E., Dietz, T., Dolsak, N., Stern, P.C., Stonich, S. and Wever, E.U. (eds.): 2002, ‘The Drama of the Commons’, *Committee on the Human Dimensions of Global Change*, Washington, DC, National Academy Press, pp. 521.

Stefanovic, I.L.: 2000, *Safeguarding Our Common Future: Rethinking Sustainable Development*, Albany, NY, State University of New York Press.

Stefanovic, I.L.: 2003, ‘The contribution of philosophy to hazards assessment and decision making’, *Natural Hazards* **28**(2–3), 229–247.

White, G.: 1999, ‘A conversation with Gilbert F. White’, *Environmental Hazards* **1**, 53–56.

White, G., Kates, R.W. and Burton, I.: 2001, ‘Knowing better and losing even more: The use of knowledge in hazards management’, *Environmental Hazards* **3**, 81–92.

Worster, D.: 1985, *Nature’s Economy*, Cambridge, Cambridge University Press.

WMO: 1995, 'Meeting of experts to review the present status of hail suppression', *World Meteorological Organization*, WMP Report No. 26, Golden Gate Highlands National Park, South Africa, WMO/TD No. 764.

World Bank: 2002, *Leadership Capacity Building for Post Conflict Reconstruction*, http://www.worldbank.org/wbi/B-SPAN/sub_leadership_postconflict.htm, accessed July 10, 2003.

Wynne, B.: 1992, 'Uncertainty and environmental learing: Reconceiving science and policy in the preventive paradigm', *Global Environmental Change* **2**(2), 111–127.

SUSTAINABLE DEVELOPMENT AND HAZARDS MITIGATION IN THE UNITED STATES: DISASTERS BY DESIGN REVISITED

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(Received 13 August 2003; accepted in final form 30 June 2004)

Abstract. It has become clear that natural and related technological hazards and disasters are not problems that can be solved in isolation. The occurrence of disasters is a symptom of broader and more basic social problems. Since 1994, a team of over 100 expert academics and practitioners – including members of the private sector – have assessed, evaluated, and summarized knowledge about natural and technological hazards in the United States from the perspectives of the physical, natural, social, behavioral, and engineering sciences. The major thesis of the findings was losses from hazards and inability to comprehensively reduce losses of all types are the consequences of narrow and shortsighted development patterns, cultural premises, and attitudes toward the natural environment, science, and technology. To address these broad and basic problems, the study included proposals for ways in which people and the institutions of the United States can take responsibility for disaster losses, reduce future hazard losses, and link hazard mitigation to sustainable development.

Keywords: disaster, hazard, local sustainability, mitigation, reduction, second assessment, sustainable development

1. Introduction

Over a quarter century ago (*cf*. Mileti 1999), geographer Gilbert F. White and sociologist, J. Eugene Haas published a pioneering report "*Assessment of Research on Natural Hazards*" on the United States' ability to withstand and respond to natural disasters (White and Haas 1975). Noting that physical scientists and engineers dominated research on disasters, White and Haas conducted the first assessment of natural hazards research in the United States in order to better understand the economic, social, and political dimensions of extreme natural events.

White and Haas advanced the critical notion that rather than solely responding to the damage from specific disasters, the nation could employ comprehensive planning, land-use, and other preventive measures at local as well as federal levels to mitigate their toll. As public and private programs and policies advanced into the twentieth century, mitigation was adopted as the cornerstone of the United States' approach to addressing natural and technological hazards.

The 1975 report had a profound impact on the creation and formalization of an interdisciplinary approach to research and management. The first assessment, along with the second national assessment in 1999 (profiled in this paper), have revolutionized traditional understandings of and perceptions about reducing the social, economic, and environmental impacts of hazards. Today, the "hazards community" comprises people from many fields and agencies who address the myriad aspects of natural disasters. Hazards research now encompasses disciplines such as climatology, economics, engineering, geography, geology, law, meteorology, planning, natural resources management, seismology, and sociology. Professionals in these and other fields investigate how engineering projects, warnings, land-use management, planning for response and recovery, insurance, and building codes can help individuals and groups adapt to natural hazards, as well as reduce the resulting deaths, injuries, costs, and social, environmental, and economic disruption (Mileti 1999). The people of the hazards community have significantly improved our understanding of situations before, during, and after disasters. Yet, at the close of the last century, it was clear that troubling questions remained about why more progress has not been made in reducing dollar losses. The seminal work of White and Haas raised significant issues and questions. Their ground-breaking work was taken up by the second assessment, and their perspectives and approaches, modified by the researchers whose work comprises the second assessment, continue to inform research and practice through the present day.

1.1. Moving forward: the second assessment (1999)

In the late 1990s, it became clear that an updated evaluation of the current research of hazards and disasters in the United States was necessary to both assess the outcomes of recommendations made in the first assessment and determine new directions for research. In 1995, the nation's "Second Assessment of Research and Applications" for natural hazards began, headed by sociologist Dennis S. Mileti (*cf.* Mileti 1999). From the beginning, one of the project's goals was to link hazards mitigation with sustainable development. The genesis for the second assessment began in the early 1990s, when conversations took place among individuals in the Subcommittees on Natural Hazards and Risk Assessment of the Committee on the Environment in the Office of Science and Technology Policy in the White House. The committee's charge came directly from the President of the United States. Following the lead of then Vice President Al Gore, committee members began to consider the importance of recasting the environmental and hazards missions of their agencies in ways to link them more directly with the concepts of sustainability and sustainable development.

The members of these subcommittees knew well that to accomplish such a mission the nation's research community would need to be involved in an effort to broaden the current thinking about hazards and disasters. To this end, they requested a comprehensive national assessment of natural hazards that would produce valuable insights and also lead to big-picture thinking on sustainable hazards mitigation.

This article, and the book on which it is based (Mileti 1999), reflects the efforts of over a 100 experts who have worked and debated since 1994 to take stock of current knowledge and practice in the United States. The effort got underway during a workshop in the summer of 1992 in Estes Park, CO. Attended by over 60 of the nation's leading hazards experts, the workshop participants overwhelmingly agreed that it was appropriate to move forward with a second assessment of hazards in the United States. They also agreed that the unifying theme for the work should be sustainable development. A subsequent workshop in Boulder, CO, in October 1994, brought many of the same people together with others together to detail the specific agenda for the second assessment.

The second assessment's mission was to summarize current knowledge in the various fields of science and engineering that was applicable to natural and related technological hazards and disasters and to make research and policy recommendations for the future. Over 120 leading disaster experts in the United States contributed to the work, and a number of written products resulted from the project (Cutter 2001; Tierney et al. 2001; Burby 1998; Kunreuther and Roth 1998). "Disasters by Design," which was published in 1999, summarizes the project and its findings. Aimed at a general audience, including laypeople, policy makers and practitioners and researchers, the book has a broad focus.

The researchers in "Disasters by Design" called for a significant shift the national culture to stop the ever-increasing spiral of losses from natural and technological hazards and disasters. The main challenge they faced was to formalize the concept of "sustainable hazards mitigation" in the United States. Sustainable mitigation is a concept that links the wise management of natural resources with local economic and social resiliency, and views mitigation as an integral part of a much larger set of issues. This resulted in perhaps the single most important contribution of the second assessment. This study called for a fundamental shift in the character of how citizens, communities, governments, and businesses in the United States conduct themselves in relation to the natural environments they occupy.

The concept of sustainable hazards mitigation stemmed from the central problem that many traditional and accepted methods for coping with problems in the environment were based on the idea that nature can be controlled through technology. Most strategies for managing hazards follow a traditional planning model: study the problem, implement a situation-specific solution, and move on to the next problem. This approach casts hazards as static and mitigation as an upward, positive, linear trend. Continuing losses from hazards have resulted from short-sighted and anthropocentric perceptions of human domination over an unchanging natural environment. Contrary to this understanding, events during the past quarter century demonstrate that natural disasters and the technological hazards that may accompany them are not linear and cannot be solved in isolation. To address these realities, a shift was needed to a policy of sustainable hazard mitigation.

In an effort to head off the continued rise in tolls from disasters, the second assessment sought to nurture and bridge the concept of a sustainability to make the principles of deliberate attention to the larger context of the dynamics of the biophysical and the social more explicit. Many aspects of this strategy were implicit in the recommendations formulated by White and Haas over a quarter century ago.

The contributions of the experts were used to outline a comprehensive approach to enhancing society's ability to reduce the costs of disaster. The second assessment involved many key players in the federal agencies whose mandates encompassed aspects of hazards mitigation, preparedness, response, and recovery along with academics and practitioners at state and local levels. Key players were involved so that they would "own" the results and recommendations of the second assessment, thereby facilitating action.

2. Challenges in Disaster Mitigation

Many disaster losses – rather than stemming from unexpected events – are the predictable result of interactions among three major systems: the physical environment (the events themselves); the social and demographic characteristics of the communities that experience them; and the buildings, roads, bridges, and other components of the built environment. Growing disaster-related losses in the United States result partly from the fact that the nation's capital supply is expanding and partly from the fact that these systems – and the myriad way in which they interact – are becoming more complex with each passing year.

Three main influences are at work. First, the earth's physical systems constantly change and these systemic changes directly impact the severity and characteristics of future disasters. Forecasts cannot simply be based upon static projections from the past. For instance, scientists expect a warming climate to produce meteorological events such as storms, floods, drought, and extreme temperatures that were more dramatic than previously experienced. To attempt to predict disasters, forecast financial losses, and plan recovery strategies without an understanding of the dynamic nature of the natural world is shortsighted. Natural hazards mitigation will not be successful in isolation and without considering factors such as climate change and societal adaptation (Pielke 1998). Pielke defines adaptation as referring to "adjustments in individual, group, and institutional behavior in order to reduce society's vulnerability to climate, [in this instance]" (Pielke 1998, p. 159). Secondly, changes in the demographic composition and distribution of the United States population mean a greater exposure to many hazards. The number of people residing in earthquake-prone regions and coastal counties subjected to hurricanes, for example, is growing rapidly. Increasing inequality in the distribution of wealth also makes many people more vulnerable to hazards and less able to recover from them. Finally, the built environment – public utilities, transportation systems, communications, homes, and office buildings – is becoming denser, making the potential losses from natural forces larger.

Another major problem noted in the second assessment is that some of the efforts to head off damages from natural hazards only postponed or displaced their effects (Mileti 1999). While it is true that communities below dams or behind levees may have avoided losses from the floods those structures were designed to prevent, these communities often had more property to lose when their dams or levees failed, impacting the additional development that had occurred in the protected areas. Such a situation contributed to catastrophic damage from the 1993 floods in the Mississippi basin. Many of the dams, bridges, and other structures in the United States are approaching the end of their design life. Similarly, by providing advance warnings of severe storms, the United States may well have encouraged more people to build in fragile coastal areas. Such development, in turn, made the areas more vulnerable by destroying dunes and other protective natural features.

3. Growing Disaster Losses in the United States

The research conducted for the second assessment found that from 1975 to 1994, natural hazards killed over 24 000 people and injured some 100 000 in the United States and its territories (Mileti 1999). About one quarter of the deaths and half the injuries resulted from events that society labeled as disasters. The rest resulted from less dramatic but more frequent events such as lightning strikes, car crashes owing to fog, and localized landslides.

The assessment found that the United States has succeeded in saving lives and reducing injuries from some natural hazards, such as hurricanes. However, casualties from floods – the nation's most frequent and injurious natural hazard – have not substantially declined. Deaths from lightning and tornadoes remained constant. Meanwhile injuries and deaths are growing from dust storms, extreme cold, wildfire, and tropical storms.

The dollar losses associated with most types of natural hazards in the United States is rising. According to Mileti (1999), a conservative estimate of total dollar losses during the past two decades was $500 billion (in 1994). More than 80 percent of these costs stemmed from climatological events, while around 10 percent resulted from earthquakes and volcanoes. Only 17 percent of the people in these disasters were insured. Determining losses with a higher degree of accuracy is impossible because, the United States had not yet established a systematic reporting method or a data repository. Further, these numbers do not include indirect costs such as downtime for businesses, lost employment, environmental damage, or emotional effects on victims. Most of these losses resulted from events too small to qualify for federal assistance, and most people were not insured, so victims bore the costs.

Seven of the 10 most costly disasters – based on dollar losses – in United States history occurred between 1989 and 1994. Since 1989, the nation has frequently experienced losses from catastrophic natural disasters that averaged about $1 billion per week. This dramatic increase in disaster losses is projected to continue.

However, many of the most severe recent disasters could have been far worse. If Hurricane Andrew had been slower, wetter, or torn through downtown Miami, it would have wreaked devastation even more profound than what occurred. The second assessment predicted that the most likely catastrophic events, such as a great earthquake in the Los Angeles area, have yet to occur. Such a California disaster would cause up to 5000 deaths, 15 000 serious injuries, and $250 billion in direct economic losses.[1]

4. A Shift in Approach – Sustainable Development

The second assessment resulted in a novel and comprehensive approach toward viewing hazards and their impacts. It called for researchers and practitioners in the hazards community to shift their tactics from simply responding in an ad hoc way to the disasters that confronted them, toward coping is a more holistic way with the complex factors that contribute to disasters in today's – and especially tomorrow's – world. This new approach should include a global systems perspective that recognizes the adapting role of society that contributes to disasters. People and societies must accept responsibility for hazards and disasters and view human actions as the cause of disaster losses. This responsibility stems from the choices we make about where and how human development will occur. For example, multimillion-dollar homes are being on the edge of the ocean, directly in the approach pattern of former hurricanes. Were a hurricane to hit these homes, the economic damage alone would be huge.

The researchers decided to abandon the notion that there was a "final" solution to natural hazards mitigation. Technology cannot make the world safe from all the forces of nature. Technology is not the sole "solution" because elucidations need to be as fluid and interactive as the problem and its participants. Society must take a long-term view that values mitigation, rather than short-term luxury rewards, for example. If disaster losses are to decline, mitigation should emerge as a concept that most, if not all, citizens deem worthwhile.

Contributing researchers were unanimous in their call for a global systems perspective to recognize that disasters arise from the interactions among the earth's physical systems, its human systems, and its built infrastructure, rather than from discrete environmental events. This broad view, a characteristic of mitigation and social adaptation, is necessary to encompass all three of these dynamic systems.

The view of hazards as static had led to the conclusion that any mitigation efforts would reduce the grand total of future losses. The researchers of the second assessment determined that this was erroneous. In reality, changes occur quickly and nonlinearly. The researchers found that human adaptation to hazards must become as dynamic as the issues presented by the hazards themselves.

Societal factors, such as how people view both hazards and mitigation efforts or how the free market operates, play a critical role in determining which steps are actually taken and which are overlooked. Because these social forces are now known to be much more powerful than disaster specialists had previously thought, growing understanding of physical systems and improved technology alone cannot suffice. To effectively address natural hazards, mitigation must become a basic social value.

The second assessment found that disasters are more likely to occur in tandem with unsustainable development. For example, economically disadvantaged persons may only have the option to live in houses built in flood plains due to their cost and availability. The converse is also true: disasters hinder movement toward sustainability because, for instance, they degrade the environment. The quality of life is undercut; hurricanes erode sandy foundations of houses. Most natural disasters interrupt basic human needs such as housing. With this in mind, sustainable mitigation activities should identify vulnerabilities and strengthen the community's social, economic, and environmental resiliency.

5. People at Risk

The second assessment revealed an underlying inconsistency between how professionals estimate risk from natural hazards and how people and societies perceive and deal with those same risks. Engineers, scientists, statisticians, and some others view risk probabilistically and often presume that people and societies will act rationally to mitigate losses and costs in proportion to the risks faced. This is not always or even often the case. In general, human beings, as individuals and groups – even entire societies – dichotomize risks into those that will be acted on and those that will be ignored. Because human risk perception does not follow objective estimates and definitions, human and societal action to mitigate risk can often be inconsistent with estimated scientific probabilities (Slovic 2000; Tweeddale 1996). Professionals in risk estimation are often frustrated in their attempts to motivate people and group to take what they perceive to be appropriate action (Mileti et al. 1992). Research has shown that people are typically unaware of all the risks and choices they face. We only for the immediate future, overestimate our ability to cope when disaster strikes, and rely heavily on emergency relief.

Hazard researchers have come to recognize that demographic differences play a large role in determining the risks people encounter, whether and how they prepare for disasters, and how they fare when disasters occur. Certain actions intended to mitigate risk and reduce losses in the short-term for select segments of a population have been shown to actually increase losses and shift risk onto others. Society's most vulnerable groups are often the poor, women, racial and ethnic minorities, and those who are members of other disenfranchised groups. Research conducted during the second assessment reinforced the finding that the vulnerability to disaster is unequally distributed. Unsustainable global settlement patterns, resource management, social organization, and political economies increasingly put some population groups more at risk than others from disaster (Enarson and Morrow 1998).

Women are the most at risk when hazardous conditions unfold as disastrous events (Schroeder 1987). This group is particularly subject to environmental risk through urban displacement and migration, environmental degradation, migration, poverty, and other social limitations and barriers to choice (Anderson 1994; Cutter 1995). As one might expect, the less economic and cultural power women possess before a disastrous event, the greater the suffering in the aftermath. This is largely due to having fewer resources to draw from during the disaster and during the recovery period (Fothergill 2001).

The poor are at greater risk from disastrous events worldwide mainly because they live in lower quality housing, which is more likely to be damaged and is often located closer to technologically hazardous sites (Mileti 1999; Fothergill and Peek forthcoming). Poor families around the world suffer the greatest losses and have access to the fewest public and private recovery assets, both in developing societies and wealthy industrialized nations (Bates 1982; Bolin 1982).

Existing research on race, ethnicity, and disasters during the period of the second assessment suggest that minority group members of a society experience different and more devastating consequences of disastrous events than non-minority citizens (Fothergill et al. 1999). In highly stratified societies, minority group members are often disenfranchised from power and influence, which often results in a long and slow recovery phase after natural disaster strikes.

The second assessment stresses the need for mitigation and response efforts to acknowledge the importance of demographic differences in the United States as we become more diverse. The assessment recommends that further research is needed to shed additional light on how mitigation programs ranging from public education to disaster relief can be rendered equitably.

6. Fostering Local Sustainability

In the context of hazards and disaster studies, sustainability means that a locality can tolerate – and overcome – damage, diminished productivity, and reduced quality of life inflicted by an extreme event without significant outside assistance. To achieve sustainability, communities must become more active in determining where and how development proceeds. Localities should evaluate their environmental resources and hazards, and evaluate the type and extent of possible future losses that they are willing to bear, for example, building in a flood plain. Communities also need to ensure that development and other community actions and policies adhere to those goals.

The second assessment yielded six objectives (Table I) for communities to be aware of when they consider actions for sustainable hazards mitigation.

A long-term, comprehensive plan for averting disaster losses and encouraging sustainability will provide localities with the opportunity to coordinate their goals and policies. Although the actual planning and follow-through occurs at the local

TABLE I

Objectives for local sustainability: United States second assessment findings

Maintain and enhance environmental quality
Human activities to mitigate hazards should not reduce the carrying capacity of ecosystems, in recognition that to do so will increase long-term losses from hazards.
Hazard mitigation activities should link efforts to control and ultimately reverse environmental degradation by coupling hazard reduction to natural resource management and environmental preservation.
Maintain and enhance people's quality of life
A population's quality of life includes, among other factors, access to income, education, health care, housing, and employment, as well as protection from disaster.
Local communities must consciously define the quality of life they want and select only those mitigation strategies that do not detract from any aspect of that vision of sustainability.
Foster local resiliency and responsibility
Resiliency to disasters means taking mitigation actions such that a locale can withstand an extreme natural event with a tolerable level of losses.
Recognize vibrant local economies are essential
Take mitigation actions that foster a strong local economy rather than detract from one.
A diversified local economy, not overly dependent on a single productive force, would be more sustainable over the long-term and less easily disrupted by disasters.
Ensure inter- and intragenerational equity
Select mitigation activities that reduce hazards across all ethnic, racial, and income groups, and between genders equally to avoid shifting the costs of today's advances onto later generations or less powerful groups.
Adopt local consensus building
Demonstrate sustainability by selecting mitigation strategies that evolve from full participation among all public and private stakeholders.
The participatory process itself may be as important as the outcome.

level, a great deal of impetus comes from higher levels. Nothing short of strong leadership from state and federal governments will ensure that sound planning occurs.

7. Mitigation Tools

An array of techniques and practices has evolved to address losses from hazards and disasters (Table II). These include sound land use planning, warning systems, engineering and building codes, insurance, new technology, and emergency preparedness and recovery. When used, these tools can help to save lives and injuries, limit property damage, minimize disruption, and enable communities to recover more quickly.

Successfully utilizing these tools and practices is a dynamic process that entails shared decision-making and interaction among all stakeholders, households,

TABLE II

Mitigation tools: Overview of United States second assessment findings

Land use planning

Wise planning limits expansion to keep people and property out of the way of hazards and maintain the natural environment.

An overarching leadership to inform development in hazard-prone areas corrects a confusing blend of innumerable federal, state, and local regulations.

Warnings

There is a need to develop a national comprehensive model for how warning systems work as well as providing the model to local communities along with technical assistance.

The model of better local management and decision-making for the long-term proved to be more critical than most future advances in technology.

Short-term warning systems did not significantly limit damage to the built environment, nor did they mitigate economic disruption from disasters.

Engineering and building codes

Disaster-resistant construction of buildings and infrastructure are essential components of local resiliency and play a direct role in determining the casualties and dollar costs of disasters.

Shortcomings in construction techniques and code enforcement need reevaluation in light of the goal of sustainable mitigation.

Insurance

Most property owners are not buying coverage against special perils, and look to federal disaster assistance to function as a kind of hazard insurance.

The insurance industry already has problems providing insurance in areas subject to catastrophic losses because many insurers do not have the resources to pay for a worst-case disaster.

While companies help minimize disruption by compensating their clients during recovery, they could further facilitate mitigation through information, education, helping to create model codes, and offering financial incentives for mitigation.

New technology

Computer-mediated communication systems, geographic information systems, remote sensing, electronic decision-support systems, and risk-analysis techniques have begun to fill the gaps in hazards management decision-support systems by analyzing information from core databases, including data on building inventories, infrastructure, demographics, and risk.

The lack of comprehensive local data to ask "what if" questions about future losses constrains technology systems, but these systems will be important to the processes of evaluating and managing risk as they grow in complexity.

Emergency preparedness and recovery

Create policies for disaster preparedness, response, and recovery.

Recovery evolved to a process that entails decision-making and interaction among all stakeholders.

Vital to communities' ability to become disaster resilient, local disaster plans need to be extended not only to explicitly address recovery and reconstruction but to identify opportunities for rebuilding in safer ways and in safer places.

businesses, governments, and the community at large. These tools are not meant to represent the "final" solution to mitigating hazards. Rather, these are mechanisms that when utilized, were found to aid in a more comprehensive long-term view of strengthening a community's social, economic, and environmental resiliency.

8. Essential Steps

The ongoing shift toward a sustainable approach to hazards mitigation requires extraordinary actions. Presented below are several essential steps that were called for in the second assessment. Since the assessment, many of these recommendations have been enacted, not only in the United States but also around the world.

Build local networks, capability, and consensus. Hazard specialists, emergency planners, resource managers, community planners, and other local stakeholders often seek to solve problems on their own. An integrated approach forges local consensus on disaster resiliency and nurtures it through the complex challenges of planning and implementation. The second assessment was instrumental in conceiving and convincing Congress to fund The Federal Emergency Management Agency's Project Impact, which sought to achieve these very goals. Despite its success, Project Impact has now been abandoned in part as a result of shifts of government.

Establish a holistic governmental framework. To facilitate sustainable mitigation, policies and programs related to hazards and sustainability need to be integrated and consistent. For example, there are over 100 national policies to deal with the drought hazard alone, and many more when other hazards are considered. This myriad of policies is incomprehensible to even those well-versed in hazards programs and policies. A holistic governmental framework would result in fewer, more highly integrated policies. No action on this recommendation has been taken to date.

Conduct a nationwide assessment of hazards and risks. The second assessment revealed that not enough is known about the changes in or interactions among the physical, social, and constructed systems of our nation. It was suggested that a national risk assessment be undertaken to link information from these systems with the goal of estimating hazard losses in a dynamic and comprehensive manner to quantitatively provide support for local efforts on sustainable mitigation. Although this recommendation has not been acted upon with a major effort as was originally conceived, several smaller efforts are now underway. For example, the U.S. Geological Survey in Golden, CO, is now host to an ongoing project to estimate hazards and risk globally by integrating the physical, sociodemographic, and constructed environments.

Build national databases. The second assessment found that there is no existing repository for the collection, analysis, and storage of standardized data on losses from past and current disasters. Such databases will help establish a baseline for comparison with future losses, which is crucial to gauge trends and possible progress. Such a data repository needs to include information on the types of losses, their locations, their specific causes, and the actual dollar amounts, taking into account problems of double-counting, comparisons with gross domestic product, and the distinction between regional and national impacts. The second assessment also found that a second database was needed to collate information on identifying mitigation efforts, where they occurred, and how much they cost in order to provide a baseline for local cost-benefit analysis. These archives would be fundamental to informed decision-making and should be made accessible to the public. Two efforts immediately began to explore this idea further. The National Research Council (1999) began one database and the other database was started by the Heinz Center (2002). Both of these projects sought to catalogue the full range of factors that would be included in such a database.

Provide comprehensive education and training for hazards practitioners. Due to the increasingly complex interactions between physical and social systems, contemporary hazard managers are called upon to tackle problems they may have never before confronted. The second assessment recommended that education in hazard mitigation and preparedness should be expanded to include interdisciplinary and holistic degree programs at universities to make them better prepared to address the real-world problems associated with linking hazards and sustainability. Major advances on this recommendation have been achieved. For example, the Federal Emergency Management Agency's Higher Education Project has established an educational program in every state, and created degree programs at the Associate, Bachelor, Master, and Ph.D. levels.

Measure the progress of hazard mitigation efforts. Baselines for measuring sustainability need to be established so the nation can gauge future progress. It was recommended that interim goals for mitigation and other aspects of managing hazards be set, and progress in reaching those goals regularly evaluated. This effort requires determining how to apply criteria such as disaster resiliency, environmental quality, intra and intergenerational equity, quality of life, and economic vitality to the plans and programs of local communities. Each disaster yields a new and unique knowledge relevant to hazard mitigation and disaster response and recovery, yet at the time of the assessment, no entity collected this information systematically, synthesized it into a coherent body of knowledge, and evaluated the nation's progress in putting knowledge into practice. Systematic post-disaster audits, called for in the 1975 assessment by White and Haas, are still needed. Although some progress toward this recommendation has been achieved – for example, the Federal Emergency Management Agency created "sustainability desks" in its Disaster Field Offices – no real progress to achieve this recommendation has occurred thus far.

Shift Toward a Sustainable Approach to Hazards Mitigation and the International Sharing of Knowledge. The second assessment recognized that the United States needs to share knowledge and technology related to sustainable hazard mitigation with other nations, and be willing to learn from those nations as well. In the United States and abroad, disaster experts also need to collaborate with those in the community as well as development experts to address the root causes of social vulnerability to hazards, including overgrazing, deforestation, poverty, and unplanned development. Disaster reduction should be an inherent part of everyday development processes, and international development projects must consider vulnerability to disaster. Based on the recommendations of the second assessment, hazards mitigation and sustainable development are now clearly linked in the minds of researchers and practitioners. Moreover, the World Bank quickly moved on the advice of the second assessment to require hazards mitigation plans as part of development loans to lesser-developed nations.

9. Conclusion

The second assessment of hazards and disasters, undertaken in the late 1990s, establishes that to support sustainable mitigation, researchers and practitioners need to ask new questions as well as continue to investigate traditional topics. Ongoing efforts should include interdisciplinary research and education, and the development of local hazard assessments, computer-generated decision-making aids, and holistic government policies.

Future work also needs to focus on techniques for enlisting public and governmental support for making sustainable hazard mitigation a fundamental social value; that is something that every citizen desires and supports. “Complex, overlapping, plural, interdependent civic institutions embodying diverse combinations of several basic strategies extend capabilities to develop in a sustainable fashion, even – especially – when confronted with surprise” (Rayner and Malone 1997). Members of the hazards community play a critical role in initiating the urgently needed national and global conversations on attaining this goal.

Acknowledgements

This work to summarize knowledge and catalogue research and policy need related to hazards and disasters in the United States was funded by the National Science Foundation under Grant Number CMS93-12647, with supporting contributions from the Federal Emergency Management Agency, the U.S. Environmental Protection Agency, the U.S. Forest Service, and the U.S. Geological Survey. The support of these agencies is greatly appreciated; however, only the authors are responsible for the information, analyses, and recommendations in this paper. The authors also wish to express their gratitude to Wendy Steinhacker, Lori Peek and David Butler for their input and assistance.

Note

1. See *Natural Hazards Observer* January 2004 for an engaging invited scenario exploring this "Disaster Waiting to Happen."

References

Anderson, M.B.: 1994, 'Understanding the disaster-development continuum', *Focus on Gender* **2**, 7–10.

Bates, F.L. (ed.): 1982, *Recovery, Change, and Development: A Longitudinal Study of the 1976 Guatemalan Earthquake*, University of Georgia, Athens, GA.

Bolin, R.C.: 1982, *Long-Term Family Recovery from Disaster*, Institute of Behavioral Science, University of Colorado, Boulder, CO.

Burby, R.J.: 1998, *Cooperating with Nature: Confronting Natural Hazards with Land Use*, Joseph Henry, Washington, DC.

Cutter, S.: 2001, *American Hazardscapes: The Regionalization of Hazards and Disasters*, Joseph Henry, Washington, DC.

Cutter, S.: 1995, 'The forgotten casualties: Women, children, and environmental Change', *Global Environmental Change: Human Policy Dimensions* **5**, 181–194.

Enarson, E. and Morrow, B.H.: 1998, 'Why gender? Why women? An introduction to women and disaster' in Enarson, E. and Morrow, B.H. (eds.), *The Gendered Terrain of Disasters*, Praeger, Westport, CT, pp. 1–10.

Fothergill, A. and Peek, L.A.: 2004, '*Poverty and Disasters in the United States: A Review of the Sociological Literature*' *Natural Hazards* **32**, 89–110.

Fothergill, A.: 2001, *Women in Crisis: An Ethnographic Study of Gender and Class in a Natural Disaster*, Ph.D. Dissertation, Department of Sociology, University of Colorado, Boulder, CO.

Fothergill, A., Maestas, E. and Darlington, J.D.: 1999, 'Race, ethnicity and disasters in the United States: A review of the literature', *Disasters* **23**, 156–173.

Heinz Center: 2002, *Human Links to Coastal Disasters*, The H. John Heinz III Center for Science, Economics and the Environment, Washington, DC.

Kunreuther, H. and Roth, R., Sr.: 1998, *Paying the Price: the Status and Role of Insurance against Natural Disasters*, Joseph Henry, Washington, DC.

Mileti, D.S.: 1999, *Disasters by Design: A Reassessment of Natural Hazards in the United States*, Joseph Henry, Washington, DC.

Mileti, D.S., Fitzpatrick, C. and Farhar, B.C.: 1992, 'Fostering public preparations for natural hazards: Lessons from the Parkfield earthquake prediction', *Environment* **34**, 16–39.

National Research Council: 1999, *Reducing Disaster Losses through Better Information*, National Academy Press, Washington, DC.

Rayner, S. and Malone, E.L.: 1997, 'Zen and the art of climate maintenance', *Nature* **390**, 332–334.

Pielke, R.A., Jr.: 1998, 'Rethinking the role of adaptation in climate policy', *Global Environmental Change* **8**(2), 159–170.

Schroeder, R.A.: 1987, *Gender Vulnerability and Drought: A Case Study of the Hausa Social Environment*, Institute of Behavioral Science, University of Colorado, Boulder, CO.

Slovic, P: 2000, *The Perception of Risk*, Earthscan Publications, Sterling, VA.

Tierney, K.J., Lindell, M.K. and Perry, R.W.: 2001, *Facing the Unexpected: Disaster Preparedness and response in the United States*, Joseph Henry, Washington, DC.

Tweeddale, M.: 1996, 'The nature and handling of risk', *Australian Journal of Emergency Management* **11**, 2–4.

White, G.F. and Haas, J.E.: 1975, *Assessment of Research on Natural Hazards*, MIT Press, Cambridge, MA.

SECTION 3: NATIONAL AND REGIONAL MITIGATION POLICIES AND STRATEGIES

CANADA'S EXPERIENCE IN DEVELOPING A NATIONAL DISASTER MITIGATION STRATEGY: A DELIBERATIVE DIALOGUE APPROACH

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(Received 2 December 2003; accepted in final form 4 March 2004)

Abstract. Canada is vulnerable to a wide range of natural and human-induced disasters. Recent experience with major natural disasters demonstrated that more needs to be done to protect Canadians from the impacts of future disasters. The Government of Canada, through the Department of Public Safety and Emergency Preparedness Canada, has conducted consultations with provinces, territories and stakeholders to develop a national disaster mitigation strategy (NDMS) aimed at enhancing Canada's capacity to prevent disasters before they occur and promoting the development of disaster-resilient communities. This paper provides an overview of Canada's emergency management and hazards context. It reports on the preliminary findings of consultations with stakeholders and evaluates the usefulness of the deliberative dialogue methodology that was used to facilitate the consultations. Examples that are illustrative of recent Canadian efforts on disaster mitigation and the challenges respecting the development and future implementation of a NDMS are also discussed.

Keywords: consultations, deliberative dialogue, disasters, emergency management, hazards, mitigation, prevention, risk reduction

1. Introduction

One of the key roles and priorities for the Government of Canada is to promote quality of life for, and ensure the safety and security of, individual citizens and their communities. A new Department of Public Safety and Emergency Preparedness Canada (PSEPC) that incorporates the former Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP 2002a; 2002b), the Department of the Solicitor General of Canada, the Canada Border Services Agency, the Crime Prevention Secretariat of the Department of Justice and enforcement components of Citizenship and Immigration Canada and the Canadian Food Inspection Agency, was created by the Prime Minister of Canada in December of 2003. In assuming the responsibilities of the former OCIPEP, PSEPC is now the Government of Canada's department with lead responsibility for integrating national security and emergency preparedness partly through coordinating responses to national emergencies and protecting Canada's national critical infrastructure. This includes activities that reduce disaster vulnerability, support emergency preparedness and response efforts, and supplement disaster recovery, in part through financial assistance to provincial and territorial governments after disasters. Other federal government departments play important roles to mitigate potential hazards or their consequences based on delegated authorities and departmental expertise.

Canada is fortunate that relatively few lives have been lost due to natural disasters, but the costs related to personal property and public infrastructure damage are significant. The Disaster Financial Assistance Arrangements (DFAA), established in 1970, are the primary mechanism by which the Government of Canada provides assistance to Canadians affected by natural disaster through *ex post facto* payments to provincial and territorial governments. Since 1996, Canada has experienced a significant escalation in DFAA costs. The physical devastation and economic losses resulting from the Saguenay River flood (1996), the Red River flood (1997) and the eastern Canada ice storm (1998) exposed the susceptibility of Canadians to major natural hazards. Together, these events affected approximately 20% of the Canadian population and cost the Canadian government an average of $366 million each in disaster financial assistance payments. Notably, prior to 1996, the Canadian government's disaster assistance costs per incident did not exceed $30 million.

Mitigation receives comparatively less attention than preparedness, response or recovery, making it the least developed component of Canada's emergency management system. The three major natural disasters mentioned above prompted the Government of Canada to embark on a major initiative to develop a NDMS and consider explicitly the need for pre-event mitigation measures to limit Canada's vulnerability to disasters. A NDMS would enhance Canada's capacity to implement measures that reduce risk, limit social disruption and contain the economic costs that result from disasters. It would replace a piecemeal approach with a proactive and systematic coordination of mitigative activities that foster the development of disaster-resilient communities.

In 1998, and again in 2002, the Canadian government undertook a collaborative and multidisciplinary consultation with stakeholders that focused attention on disaster mitigation as a vital component of comprehensive emergency management. This paper provides an overview of Canada's natural hazards context and disaster trends, descibes the experience of the deliberative dialogue consultative process that was utilized to facilitate the 2002 NDMS consultations and reports on the progress that Canada has made to advance the concept and practice of disaster mitigation.

2. Canadian Natural Hazards Context

Canada's immense size, varied climate and extensive geography expose it to numerous natural hazards. The geologic characteristics of western Canada make it susceptible to rock falls, snow avalanches and earthquakes. Approximately 1500 earthquakes are recorded in Canada each year with potential risk to several major Canadian cities on Canada's west coast, the Ottawa-Montréal corridor and the St. Lawrence Valley (Natural Resources Canada 2004). Since older buildings (pre-1970) are not subject to the seismic provisions stipulated in the 1995 National

Building Code of Canada, the potential for severe damage due to a moderate or severe earthquake is high (Foo and Davenport 2003).

Approximately eighty percent of Canadian disasters are due to weather and weather-related hazards such as tornadoes, hurricanes, hail storms, blizzards, storm surges, ice storms and floods. Hail storms and as many as eighty tornadoes are recorded annually in southern Ontario, southeastern Québec and in the Prairie provinces of Manitoba, Saskatchewan and Alberta (McBean and Henstra 2003). Canada's Atlantic coast is susceptible to hurricanes and storm surges (Bruce 2002) and severe winter storms occur frequently across parts of the country. In the summer months, high temperatures and low humidity often create conditions ideal for wildfires that typically threaten rural settlements on the Prairies, in British Columbia, Ontario and Québec. Flooding, which is Canada's most frequently occurring disaster, affects all provinces and territories, with the highest frequency in Ontario, New Brunswick, Québec and Manitoba (Canadian Disaster Database 2004; Shrubsole et al. 2003).

A population is made more vulnerable by characteristics within the built, natural and socio-economic environment that make it susceptible to harm. An array of natural hazards highlights the likelihood that Canadians could suffer loss due to natural hazards. What makes Canada vulnerable is the concentration of its population in regions of high risk. Canada's population is concentrated in 25 census metropolitan areas (McCrea 2003), some of which are located in seismically active regions, on coastal plains or river basins that have a higher risk of flooding. For example, Vancouver, with a metropolitan population of 2.1 million, faces risks from earthquakes, tsunamis, flooding and rising sea levels. Canada's northern territories, which by comparison are sparsely populated, are less vulnerable to the same perils. Furthermore, the urban infrastructure in many Canadian communities is aging and its ability to withstand the impacts of extreme events is increasingly uncertain.

In Canada, as in other parts of the world, the tendency towards more disasters and escalating disaster costs seems inevitable. Processes such as urbanization, globalization, climate change and reliance on technologically based and interdependent infrastructure have the potential to significantly increase risks, direct and indirect costs, and the complexity of managing disasters that Canadians could face in the future – including establishing an efficient national emergency management system that encompasses mitigation, preparedness, response and recovery. Canadians experienced an array of disasters in 2003: flooding in Manitoba, British Columbia, Newfoundland and New Brunswick; destructive tornadoes and hailstorms in Manitoba and Alberta; major forest fires in Alberta, British Columbia, Manitoba and Ontario; and hurricanes in Ontario, Nova Scotia and Prince Edward Island. These events illustrate what the future could entail should the climate-change predictions of scientists materialize. Using the Canadian Disaster Database, Dore (2003) developed statistical profiles of major Canadian disasters that occurred between 1900–2000 to estimate conditional probabilities and approximate costs due to natural disasters. He concluded that Canadians can anticipate at least one geophysical disaster and as many as twelve hydro-meteorological disasters to occur annually with costs estimated at $29 million (CDN) and $1.8 billion (CDN) respectively. Curtailing this escalating trend begets a need to focus on reducing disaster vulnerability and to protect Canada's economic and social assets through concerted efforts in disaster mitigation.

3. Canada's Emergency Management Framework

The structure of Canada's emergency management system is shaped by Canada's legislative, regulatory and policy framework. The *Emergency Preparedness Act* (1988) outlines the emergency preparedness roles and responsibilities of federal departments and establishes the federal government's relationship with provincial and territorial governments which in turn delegate responsibility to local-level authorities. This jurisdictional relationship demands a "teamwork" approach to managing Canadian emergencies that is based on three key principles outlined below.

First, those closest to the emergency are considered best placed to provide emergency services. Local-level authorities provide the first level of response and are supported by provincial or territorial governments when a disaster exceeds local-level capacity to cope. The Government of Canada provides support when provincial or territorial resources are exhausted, when specialized support residing in federal government institutions is required or in areas that fall exclusively under federal jurisdiction (e.g., national parks and First Nations' reservations). Notably, the vast majority of Canada's natural disasters are managed at the local or provincial level.

Second, an *all-hazards* approach is taken to deal with a broad range of emergencies and disasters. This generic approach encourages emergency management organizations to plan for, and reduce vulnerability from, potential adverse consequences regardless of the source, to avoid the duplication of planning efforts across the range of hazards.

Finally, a comprehensive approach integrates four interrelated, but not necessarily sequential, pillars of emergency management: mitigation, preparedness, response and recovery. These pillars are defined as:

- Mitigation – sustained measures to reduce or eliminate risks and impacts associated with natural and human-induced disasters.
- Preparedness – development of effective policies, procedures and capacities to plans for how best manage an emergency.
- Response – actions taken before, during after an emergency occurs.
- Recovery – efforts taken to repair and restore a community following an emergency.

There are two commonly held views of disaster mitigation in Canada. One that considers mitigation as occurring during all stages of the emergency management continuum (Pearce 2003) and another that views mitigation as the "upstream" cornerstone of action taken before a disaster occurs on which comprehensive emergency management is predicated. In terms of Canada's ongoing efforts to develop a NDMS, PSEPC's conceptualization of mitigation is pragmatic. This approach recognizes that the emergency management system operates in a continual feedback loop that is essential to improving the capacity of Canadians to manage future events. Particular emphasis is placed on the need to strengthen and integrate pre-event disaster mitigation into the broader practice of emergency management in Canada.

Until now, pre-event mitigation has been an implicit requirement despite evidence that "an ounce of prevention is worth a pound of cure." Disaster mitigation undertaken well in advance of a disaster is arguably the most critical and effective intervention for reducing risk. Its premise, unlike the other three pillars, is more closely linked to sustainable development and the ongoing everyday activities of a community. By contrast, the other three pillars are reactive and primarily seek to diminish the severity of impacts following the onset of an event or facilitate recovery efforts, rather than proactively reduce susceptibility to future harm.

Canada's current emergency management approach remains overtly response-focussed. Recurrent natural disasters, anticipated increases in hydro-meteorological disasters due to climate variability and potential disaster-related costs to society are placing pressure on all levels of government to modernize the existing emergency management system. Placing greater emphasis on disaster risk reduction measures would help to address an "emergency-centric" orientation and reduce growing fiscal and social demands associated with response and recovery.

4. National Consultations on Mitigation

A first round of national consultations co-hosted by the former Emergency Preparedness Canada (predecessor to OCIPEP and now PSEPC) and the Insurance Bureau of Canada were held with stakeholders in 1998. The results of those consultations indicated that a strategy was needed to re-orient Canada's response-focussed emergency management system and to foster a culture of disaster prevention. The consultations also highlighted the need for strategic partnerships and shared responsibility among all levels of government, the private and non-governmental sectors to enable communities to work together to strengthen their resilience to the negative consequences of hazard events.

Subsequently in spring 2002, PSEPC (then OCIPEP 2002a; 2002b) used the recommendations stemming from the 1998 consultations to consult on six proposed elements of a NDMS (Appendix 1). The objectives of these consultations were to clarify the potential roles and responsibilities of all levels of government and stakeholders; learn about progress on mitigation measures developed nationally, locally or regionally; provide a forum for dialogue that would help shape policy direction; recommend priority areas for action; and model the kinds of collaborative behavior that would be required to implement a national mitigation policy.

PSEPC embarked on a consultation process in the spring of 2002 using a publicly accessible web site, bi-lateral discussions with provincial and territorial governments, and six regional consultation workshops with stakeholders representing academia, the private and not-for-profit sectors, and industry to solicit input on disaster mitigation. The preliminary results of the regional consultation workshops and the utility of the deliberative dialogue process used to facilitate them are the focus of this paper.

4.1. Deliberative dialogue

Deliberative dialogue is a structured facilitation process that engages stakeholders in a way that helps draw out important values and trade-offs associated with pursuing a particular strategic policy direction. Through a shared exploration of different perspectives, participants thoughtfully discuss a complex issue in potentially new ways that tend to break away from habitual positions or "stuck" and pre-determined solutions. Deliberative dialogue builds on participants' knowledge and experiences to find common ground from which alternative strategies or policies can be pursued (Dale 2002). In contrast to other public involvement processes, such as town-hall meetings that emphasize debate or advocacy of positions, deliberative dialogue is founded on collaboratively exploring underlying values and assumptions, sharing of collective views and building on the perspectives of others to arrive at a shared solution (Dale 2001; Mathews and McAfee 2003).

The usual application of deliberative dialogue is for citizens' groups (Mathews 1999). In this case, deliberative dialogue was used with stakeholders as a first step toward creating a long-term relationship among diverse stakeholders with ownership and commitment toward shared outcomes and responsibilities for disaster mitigation. The process brought together informed stakeholders to develop approaches for advancing disaster mitigation in Canada and to conceptualize potential roles and responsibilities for a nationally coordinated mitigation strategy.

4.2. Deliberative dialogue methodology

An "issue framing" session was held in January 2002 with a small group of selected subject-matter experts and mitigation-relevant stakeholders from government and non-governmental sectors to initiate the deliberative dialogue consultation process. During this session, participants considered various approaches to disaster mitigation as the basis for developing a deliberation (consultation) guide which provided an overview of disaster mitigation and explained the deliberative dialogue process. It also outlined three objective approaches for pursuing disaster mitigation – risk management, research and empowerment that provided the "springboard" for discussion in the subsequent dialogue workshops held accross Canada.

The risk management approach supported a NDMS in which comprehensive all-hazard risk assessments would be conducted as the first step to ensuring that mitigation measures do not postpone or transfer risk to other areas or inadvertently increase risk(losses from other hazards. The research approach envisioned a NDMS oriented primarily towards creating and disseminating knowledge to emergency management practitioners and decision-makers. Under the empowerment approach, a NDMS would focus on establishing a supportive context by raising awareness of disaster mitigation and empowering citizens and stakeholders to undertake proactive measures within a framework that facilitates a greater degree of coordination and effective allocation of limited resources.

In May 2002, approximately 170 participants with diverse experience and views regarding emergency management, hazards research and risk management attended regional consultation workshops in Halifax, Toronto, Montréal, Winnipeg, Edmonton and Vancouver. Participants included representatives from the private sector, non-governmental organizations, academia and professional associations representing the engineering and construction industry, Canadian municipalities, First Nations groups, emergency preparedness associations, police services, urban planners and the transportation sector. Federal government and provincial officials participated as observers and information resources. Workshop participants explored each approach with the assistance of a facilitator trained in the deliberative dialogue method. The purpose of the process was to identify alternative approaches and key elements for a NDMS as well as to develop common ground that included establishing a goal, principles and scenario ideas considered essential to the development of a NDMS. The outcomes of the consultation sessions are discussed in further detail in this paper.

4.3. Deliberative Dialogue and Disaster Mitigation

Deliberative dialogue corresponds suitably with the sustainable hazards mitigation paradigm. Sustainable hazards mitigation is premised on six essential components: environmental quality; quality of life; disaster resiliency; economic vitality; inter- and intra-generational equity; and participatory processes (Mileti 1999). The sixth component and the consensus-based approach of deliberative dialogue have similar conceptual underpinnings and intentions. In both, the involvement of local participants – people who have a stake in an issue and its outcome – is considered essential for identifying concerns and issues, generating solutions for addressing them, reaching agreement on how they could be resolved and in recommending measures to be undertaken. Both challenge stakeholders to raise first their awareness of their own assumptions and then to suspend those pre-existing biases in order to consider new ways of seeing and resolving issues that are significant to society. Stakeholders are forced to think beyond the facts and "preferred" options and consider fully the implications of the decisions being made and whether or not they represent the interests and values of society.

According to Mileti, a participatory process should be utilized for the information it generates and distributes, for the sense of community it can foster, for the ideas that grow out of it and for the sense of ownership that it creates. How deliberative dialogue can contribute to participatory processes within the sustainable hazards mitigation framework and the building of a culture of collaboration among stakeholders is discussed as part of the outcomes of the consultations.

4.4. Preliminary results of the NDMS stakeholder consultations

The most significant result of the consultations perhaps was the realization that substantial interest and common ground exists among government and non-governmental stakeholders. They agreed that disaster mitigation should be an emergency management priority of the Government of Canada. Overall, stakeholders were supportive of the six proposed NDMS elements and participants appreciated the use of the deliberative dialogue methodology to gather their views on disaster mitigation. Participants re-affirmed the need for Government of Canada leadership to address the existing piecemeal approach to disaster mitigation across the country by facilitating systematic coordination of these initiatives at all levels (i.e., government, private and non-governmental stakeholders). Given the multi-sectoral and interdisciplinary nature of disaster mitigation, participants advised that specific cooperative arrangements that assign responsibilities for disaster mitigation are needed. They also recommended that a NDMS should involve and empower communities to ensure that risk reduction measures do not inadvertently transfer risk to other areas or potentially increase risk from other hazards. Interdisciplinary research enhancing Canadian knowledge about hazards and disasters should be encouraged and used to inform decision-making. It was acknowledged that there is an information gap; unless a concerted effort is made to inform citizens about the risks they face and how they may be resolved, misconceptions and resistance to disaster mitigation would persist.

Participants recommended a “carrot and stick” approach using both financial incentives (e.g., tax breaks, reduced insurance premiums, grants and loans) and non-financial incentives (e.g., awards and recognition) to encourage progress on disaster mitigation. There were varied views on the use of penalties to discourage some risk-taking behavior. The insurance sector, for example, noted that individuals who choose to live in risk-prone locations should not be “rewarded” for the risk they deliberately assume. Others said that a NDMS should balance the ethical and normative values of Canadian society and seek to ensure the greatest good for the greatest number – not all individuals have a choice in the risks they assume. Evidence exists that socio-economic and cultural factors such as employment, income, education, disability and ethnicity are positively correlated with the degree of hazard exposure, individuals’ risk-taking behavior and their ability to cope with hazard impacts or undertake mitigative measures (Blaikie et al. 1994; Ferrier and Haque 2003; Mileti 1999).

A range of other ideas for strengthening disaster mitigation were suggested. A NDMS should incorporate sufficient flexibility to accommodate the varying risks

Goal	Principles
Protect lives while maintaining sustainable and resilient communities by fostering disaster mitigation as a way of life.	Preserve Life – protect lives through prevention. Safeguard Communities – enhance economic and social viability by reducing disaster impacts. Fairness – equity and consistency in implementation. Sustainable – balance long-term economic, social and environmental considerations. Flexible – responsive to regional perspectives. Shared – shared ownership and accountability through partnership and collaboration.

Figure 1. Draft: National Disaster Mitigation Strategy – Goal and Principles.

as well as regional and local circumstances that exist across the country. Many participants strongly advocated an incremental approach to implementing a NDMS – to start modestly with what we have and what we know, and sustain the evolution of the work over the long-term. This approach would facilitate the requirement to link a NDMS to other relevant government initiatives such as reform of the federal Disaster Financial Assistance Arrangements (DFAA), climate-change adaptation, critical infrastructure protection (e.g., energy and utilities, communications and information technologies, finance, health care, food, waste and water, transportation, safety, government and manufacturing), and non-governmental initiatives. First Nations groups spoke compellingly on the need for a "seven generation" perspective linking a NDMS with a principle that underpins sustainable development – mitigation is an investment in our future and the decisions taken today should benefit, not burden, future generations.

Input from workshop participants was used to develop a vision for a NDMS, including a draft goal and set of policy principles (Figure 1) that could guide a nationally coordinated mitigation strategy and facilitate the creation of disaster-resilient communities.

4.5. Utility of Deliberative Dialogue to NDMS Consultations

Stakeholders acknowledged the value of the deliberative dialogue methodology. In particular, participants found that the method was preferable to other consultation approaches because it enabled a deeper and more meaningful exploration in the time allocated. Dialogue tended to be generative rather than argumentative or fixed in predetermined positions. In terms of the three approaches that were advanced in the deliberation guide, research was viewed as an essential tool – not a strategy in itself; risk assessment was seen as the starting point but not a complete strategy on its own; and empowerment was viewed as the over-arching approach to reach long-term and sustainable change. Each approach embodied important prerequisites for a NDMS, however, pursued individually, neither would provide a solid foundation for a comprehensive NDMS. Participants also noted that pursing each approach individually would perpetuate the existing piecemeal approach to mitigation.

In many ways, the deliberations supported the consensus-building thrust which is integral to the sustainable hazards mitigation paradigm. The dialogue workshops brought a significant number of key participants into the process who, until then, had not been actively engaged. By bringing together diverse and "non-traditional" stakeholders to discuss disaster mitigation policies and goals, the deliberative dialogue methodology raised the level of understanding among stakeholders and the development of new insights on disaster mitigation. Although "citizens" (i.e., individuals unaffiliated with any particular organization) were excluded from the deliberations, the significance of key stakeholders in supporting the aspirations of local communities cannot be overlooked (Fishkin 1992). The success of local-level planning and implementation of risk-reduction initiatives by community stakeholders cannot be achieved without strong leadership from all levels of government (Geis 1996; Mileti 1999; Pearce 2003). The stakeholders' deliberations on goals, policy principles and approaches to disaster mitigation generated a sound body of knowledge and assisted in the identification of priority areas for action. These results of the consultations will be influential in formulating recommendations to the Government of Canada. Provinces and territories have reviewed the outcomes of the deliberative dialogue process and have expressed general support for the thrust of the proposed NDMS vision, goal and principles.

There appears to be momentum, in part due to the 1998 and 2002 NDMS consultations and the efforts of the Canadian Natural Hazards Assessment Project (Etkin et al. 2003), to strengthen the links between the emergency management practitioner community and the hazards research community. In 2002, the deliberative dialogue consultations re-affirmed the need for knowledge generation, stronger networks of researchers and practitioners, and the creation of mechanisms to help inform the decisions of policy-makers and the actions of individual Canadians. A nationally coordinated, multi-stakeholder Canadian Risk and Hazards Network (CRHNet) has been established. The CRHNet hosted the first canadian Symposium on disaster mitigation in November and is in the process of planning for the second in November 2005.

The deliberative dialogue process was evaluated by participants and some shortcomings were identified. The view of some participants was that the three approaches presented in the deliberation guide were not distinct. Based on that, there was some unease that the deliberative discussions were superficial as there were no "real choices" to be considered. It is acknowledged that participants' familiarity with the dialogue process and more time during the "issue framing" workshop could have aided the development of more discrete approaches that more accurately reflected the intent and values of the process. Despite this shortcoming, the stakeholder deliberations were constructive and the richness and diversity of the views generated are useful for directing policy and action on disaster mitigation in Canada.

It was noted that not all stakeholders were represented at the workshops, and even among those involved, not all participants became fully engaged in the deliberations despite the method's explicit goal of opening "space" and allowing all views to receive fair and equal consideration. This limitation was partly overcome by establishing parallel consultation mechanisms. For example, a publicly accessible web site augmented the deliberations to encourage the broadest representation of all views.

In the view of the majority of participants, the one-day dialogue stimulated thought-provoking discussions on disaster mitigation in Canada. A relatively small percentage felt that the process was unfamiliar and did not provide sufficient time to fully deliberate the policy and practical implications of pursuing any particular approach to disaster mitigation.

A final but key observation was that additional resources and commitment are required to understand and further develop alternative ideas raised through the workshops.

5. Progress on Disaster Mitigation

A NDMS is yet to be approved as of July 2005. Despite this, existing programs and new initiatives continue to provide the Government of Canada with a basis upon which to move forward on significant structural and non-structural aspects of disaster mitigation. A long-standing committee of Senior Officials Responsible for Emergency Management (SOREM), a federal/provincial/territorial advisory group and a Government of Canada Inter-departmental Mitigation Coordination Committee (IMCC) that was established by PSEPC in 2001 presently serve as the primary coordination mechanisms for governments to discuss mitigation issues. Through these bodies, mitigation-related initiatives within the Government of Canada and at the provincial and territorial levels are being identified as the basis for determining priority areas for action and future collaboration on disaster mitigation. PSEPC is also trying to find concrete ways to collaborate with non-governmental stakeholders to identify projects and initiatives that complement the government's efforts.

The process and the means by which community needs are met during recovery have a bearing on disaster mitigation. The PSEPC review of Canada's Disaster Financial Assistance Arrangements (DFAA) includes consideration of ideas relating to post-event mitigative enhancements that could augment the pre-event emphasis of a national mitigation strategy. Alignment of any DFAA modifications and a NDMS will be considered as PSEPC moves forward on both initiatives.

In addition to PSEPC's work related to disaster mitigation, other Government of Canada departments and agencies have existing programs and initiatives that lend themselves to the strategic objectives of a NDMS. For example, Environment

Canada, through the Meteorological Service of Canada, plays a significant role in predicting and informing the public about weather-related risks. Environment Canada's completion of the National Doppler Radar Project (Environment Canada 1997) and funding support for research related to high-impact weather will provide more accurate and timely weather forecasts, potentially reducing personal injury and property damage that could result from extreme weather events.

Recent initiatives within Natural Resources Canada to implement a Natural Hazards Action Plan, and to develop detailed hazard and risk assessments along with the proposed development of a Canadian Disaster Management Information System, contribute to disaster mitigation planning and emergency response, potentially diminishing risks from earthquakes, tsunamis and landslides. Through the Climate Change Impacts and Adaptation Directorate, Natural Resources Canada is also providing leadership for Canadian efforts to anticipate and plan for the impacts of climate change relating to extreme weather events.

The Canadian government is investing substantially in the renewal of Canada's public infrastructure through the Canada Strategic Infrastructure Fund (CSIF). The CSIF provides a unique partnership opportunity for the federal, provincial and territorial, and municipal governments to reduce disaster vulnerability and to support the development of disaster-resilient communities by incorporating risk-reduction measures during the design, building and refurbishing of major infrastructure. The National Research Council has a mandate to develop and update Canada's national building codes (providing another area linked to the proposed NDMS goal and principles) which may be further enhanced to strengthen national efforts in disaster mitigation.

PSEPC also promotes a "levers and lenses" approach that allows it to strategically influence and coordinate disaster risk reduction efforts through horizontal collaboration with key federal departments. In the case of major infrastructure initiatives, for example, the use of an analytical "mitigation lens" would encourage better foresight at an early stage to incorporate risk-reduction measures when developing or upgrading major public infrastructure. Such steps would help encourage more effective use of resources and adoption of development policies that are aligned with the objectives of disaster mitigation. PSEPC's success in establishing linkages with other federal initiatives was reflected in an April 2003 announcement by the Government of Canada (concerning the Canada Strategic Infrastructure Fund) and the Government of Manitoba to cost-share the first stages of a major expansion of the Red River Floodway which will further protect the City of Winnipeg from devastating floods. The current "levers and lenses" approach stems from advice advanced during the spring 2002 round of disaster mitigation consultations and is aimed at maximizing the use of existing limited resources, programs and initiatives of other federal and national agencies.

Provincial and territorial governments have embarked on important initiatives that enhance disaster mitigation. In the Northwest Territories, the government has initiated an innovative forest fire protection program that involves community participation to construct and maintain fire breaks and reduce fuel loads by planting deciduous trees with low flammability. Québec's *Civil Protection Act* of December 2000 and Ontario's *Emergency Readiness Act* of November 2002 (both of which require municipalities to undertake hazard identification and risk assessment, and adopt preventive measures to reduce disaster vulnerability) are further examples of forward-looking provincial measures that help strengthen Canada's emergency management system through disaster mitigation.

In the summer of 2003, the Canadian Natural Hazards Assessment Project, jointly funded by PSEPC, the Meteorological Service of Canada and the Institute for Catastrophic Loss Reduction, published Canada's first comprehensive assessment on the state and nature of knowledge about Canadian hazards and disasters. The joint funding approach and the voluntary technical input provided by Canadian hazards research experts and emergency management practitioners are illustrative of new partnerships that are generating knowledge, informing the public and supporting policy-makers and emergency management practitioners with improved risk-management information.

6. Challenges

Thus far, the process of developing Canada's NDMS has highlighted a number of areas to be addressed. Governance issues, for example, could be complex to address depending on the eventual scope of a NDMS. What should be the proper balance and type of leadership on the part of the federal, provincial and territorial, and municipal governments? Provincial and territorial emergency management organizations (EMOs) have the legislative authority to support a range of emergency management efforts, but current laws do not necessarily position EMOs to influence action on pre-event mitigative measures. For example, the enforcement of building codes or land-use regulations are delegated to municipal authorities or viewed by provincial ministries as non-emergency management responsibilities. The pressing issue is not whether, but how, to best integrate disaster mitigation into the evolving emergency management framework. Jurisdictions are unlikely to welcome any increased responsibility related to disaster-mitigation planning without corresponding increases in resources. Fiscal pressures have led to further questions about how municipalities and other stakeholders could be involved in the decision-making process and, in particular, whether a NDMS should be implemented on a voluntary basis, through legislation, or by using a "bottom-up" or "top-down" approach.

Determining funding requirements for a NDMS remains a fundamental and ongoing challenge. No decisions on the scale of investment, if any, for a NDMS have been made at the time of writing. Some stakeholders noted during consultations that a credible NDMS would need to be sufficiently funded upfront to strengthen capacity in identified areas of significant weakness. Other stakeholders noted that obtaining additional resources was important, although significant initial progress could be made with modest incremental resources. Questions were also raised on how to estimate new resource needs for disaster mitigation. For example, should funding mechanisms be separate or linked to existing programs? How should cost-sharing with the private and non-governmental sector be explored? There were mixed views on these questions, particularly on whether to link a NDMS to resources available through the CSIF. In the absence of nationally consistent cost-benefit methodologies, quantifying disaster costs and making the business-case for additional resources to support disaster-mitigation efforts remains an ongoing challenge.

Terrorist events (e.g., September 11, 2001) and the new security environment, animal diseases (e.g., Bovine Spongiform Encephalopathy), human diseases (e.g., Severe Acute Respiratory Syndrome) and a widespread power failure (August 2003) that affected Ontario and parts of the United States have demanded immediate attention and resources from affected sectors across all levels of government. While the social and economic costs associated with these disasters have once again highlighted the need to take action before disaster strikes, these compelling and urgent priorities for emergency response may have drawn the focus of decision-makers and practitioners away from the NDMS development process.

7. Future Direction on Disaster Mitigation

With the creation of PSEPC in December 2003, the Government of Canada signaled its intent to renew Canada's emergency management system through a new "whole-of-government" approach to public safety and emergency preparedness. The new approach places clear emphasis on the need for a robust and comprehensive emergency management system. With respect to disaster mitigation, building a NDMS is an evolutionary process integral to the enhancement of the current emergency management system. A NDMS may best be initiated through existing programs and resources at the outset, and be built up as more resources become available. Future areas of focus for a NDMS should build on the six proposed elements (Figure 2). Targeted initiatives would be implemented by all levels of government, private and non-governmental sectors to influence public attitudes pertaining to risk reduction. Efforts could be directed toward ensuring that a NDMS is underpinned by high-quality research and technical expertise, and takes advantage of new technologies to improve risk-management decisions and disseminate knowledge about hazards.

It is envisaged that a NDMS would encourage cost-shared efforts and partnered initiatives to ensure that mitigation activities are implemented and monitored at the most appropriate level. The Government of Canada will continue to promote a "whole-of-government" approach to disaster mitigation. Both structural and non-structural mitigation approaches will be encouraged using "levers and lenses" to incorporate risk-reduction criteria in future infrastructure projects.

Element	Description
Leadership and Coordination	Coordination of disaster mitigation activities occurring at all levels of government, the private sector, non-government organizations and communities to ensure an integrated approach to managing mitigation.
Partnership and Shared Responsibility	Encouraging partnerships among all levels of government, professional groups and academia, and the private and voluntary sectors to develop consensus on disaster-mitigation matters.
Hazard Identification and Risk Assessment	Ensuring that measures to reduce the impact of probable disasters are taken based on sound hazard identification and risk assessment.
Research, Information Dissemination and Decision Support Systems	Ensuring that research provides current, accessible, coordinated and complementary tools that assist informed decision-making on disaster mitigation.
Public Awareness, Training and Education	Ensuring that governments and the public perceive and understand the risks and the range of contingencies for reducing the risk or impact.
Incentives and Resources	Incentives for disaster mitigation are required if mitigation is to become a consideration for all stakeholders.

Figure 2. Proposed elements of a national disaster mitigation strategy.

8. Conclusion

Stakeholders strongly supported the concept of a NDMS as part of the need to create a robust national emergency management system. They agreed that mitigation would be a wise investment in Canada's future. The existing commitment is supported by the fact that governments at all levels continue to make meaningful, albeit modest, investments in disaster mitigation in the absence of a fully-developed NDMS. An overarching framework for disaster mitigation would address the current shortcomings associated with a piecemeal approach to mitigation. Greater attention to mitigation would also strengthen the broader emergency management framework in Canada.

While progress on disaster mitigation has been made during the last 3 years now, more work is required to collate, quantify and assess mitigative capacities across the country and help build a compelling business case for a NDMS. The right mix of incentives and "disincentives," balanced legislation, regulations and policies could augment local-level responsibility and investment in disaster mitigation. Participatory attributes of deliberative dialogue are relevant and complementary to the prevailing emergency/disaster management paradigm because they bring into focus essential knowledge and expertise to inform and support effective decision-making.

Dialogue with key stakeholders has advanced the determination of a common vision, goal and set of principles for a NDMS. The potential roles of governments and stakeholders are also taking shape. The motivation for finding effective mitigation solutions that will help renew Canada's national emergency management system is a society better able to withstand and manage the consequences of disasters.

Acknowledgments

The author wishes to acknowledge PSEPC colleagues Peter Hill, Brian Klotz and Michael Holmes for their contribution to this paper.

References

Blaikie, P., Canon, T., Davis, I. and Wisner, B.: 1994, *At Risk: Natural Hazards, People's Vulnerability, and Disasters*, Routledge, London.

Bruce, J.: 2002, *Consequence Analysis of Storm Surge in Charlottetown, Prince Edward Island*, Public Safety and Emergency Preparedness Canada, Ottawa, Canada.

Canadian Disaster Database: 2004, Public Safety and Emergency Preparedness Canada. Available at: www.ocipep-bpiepc.gc.ca/disaster/default.asp.

Dale, J.: 2001, *Opening Dialogue, Opening Minds: Encouraging Citizen Engagement*, Caledon Institute for Social Policy, pp. 1–8.

Dale, J.: 2002, *Public Dialogue: Bridging the Gap Between Knowledge and Wisdom,* Master's Thesis, Master of Management for National Voluntary Sector Leaders, McGill-McConnel Program.

Dore, M.: 2003, 'Forecasting the conditional probabilities of natural disasters in Canada as a guide for disaster preparedness', *Natural Hazards* **28**, 249–269.

Geis, D.: 1996, 'Creating sustainable and disaster resilient communities', Working Paper, The Aspen Global Change Institute, Aspen, Colorado. Available at: www.sustainable.doe.gov/articles/CREATING.shtml.

Ferrier, N. and Haque, E.: 2003, 'Hazard risk assessment methodology for emergency managers: A standardized framework for application', *Natural Hazards* **28**, 271–290.

Fishkin, J.S.: 1992, *The Dialogue of Justice: Toward a Self Reflective Society*, Yale University.

Foo, S. and Davenport, A.: 2003, 'Seismic hazard mitigation for buildings', *Natural Hazards* **28**, 517–536.

Environment Canada: 1997, 'Improving public safety with Canada's Doppler Radar Network'. Available at: www.ec.gc.ca/press/dopp_b_e.htm.

Etkin, D., Haque, C.E. and Brooks, G.R. (eds.): 2003, 'An assessment of natural hazards and disasters in Canada', *Natural Hazards* **28**(2–3), 211–593.

McBean, G. and Henstra, D.: 2003, 'Climate change, natural hazards and cities', Institute for Catastrophic Loss Reduction Research Paper Series 31, Toronto.

McCrea, J.: 2003, *Identifying Determinants of Urban of Health: A Review and Assessment of the Literature,* Prepared for Health Canada.

Mathews, D.: 1999, 'Deliberation as seen by citizens who deliberate', *Kettering Review* **17**(1), 45–52.

Mathews, D. and McAfee, N.: 2003, *Making Decisions Together: The Power of Public Deliberation*, Kettering Foundation, Dayton, Ohio. Available at: www.kettering.org/Foundation_ Publications/Publication_List/publication_list.html#Public%20Choice%20Pub.

Mileti, D.: 1999, *Disasters by Design – A Re-Assessment of Natural Hazards in the United States*, Joseph Henry Press.

Natural Resources Canada: 2004, *Earthquake Canada: Major Earthquakes in Canada – 20th Century*. Available at: www.seismo.nrcan.gc.ca/major_eq/majoreq_e.php

Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP): 2002a, Discussion paper, *Towards a National Disaster Mitigation Strategy*, Government of Canada.

Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP): 2002b, *National Disaster Mitigation Strategy, Towards a Canadian Approach, A Guide for Deliberation*, Minister of Public Works and Government Services, Canada.

Pearce, L.: 2003, 'Disaster management and community planning, and public participation: How to achieve sustainable hazards mitigation', *Natural Hazards* **28**, 211–228.

Shrubsole, D., Brooks, G., Halliday, R., Haque, E., Kumar, A. and La Croix, J.: 2003, *An Assessment of Flood Risk Management in Canada*, Institute for Catastrophic Loss Reduction, Paper series No. 28.

Mitigation and Adaptation Strategies for Global Change (2005) 10: 525–540

AN ANALYSIS OF RISK MITIGATION CONSIDERATIONS IN REGIONAL RECONSTRUCTION IN TURKEY: THE MISSING LINK

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(Received 23 February 2003; accepted in final form 4 February 2004)

Abstract. Turkey's disastrous earthquakes in 1999 required a monumental task for rebuilding the affected regions. This has now been largely completed by the massive loans borrowed from international institutions and domestic resources. The organization of the resources to accomplish reconstruction is described. Yet, having successfully accomplished the tasks of addressing the long-term needs of the victims in terms of reconstruction/restoration of lost homes and businesses, and dealing with the disruption that the disaster has caused in community life, cannot be viewed as signs that success has been achieved. This article stresses that once the initial shock of the disaster has worn off, institutional adjustments required for mitigation for future disasters have not been enacted vigorously.

Keywords: mitigation, policy, reconstruction, risk, Turkey

1. Introduction: Turkey's Largest Reconstruction Program

The housing stock and infrastructure in the northwestern part of Turkey underwent a completely unplanned, severe large-scale dynamic structural test on August 17, 1999. A magnitude of 7.4 earthquake centered within the province of Kocaeli shown in Figure 1 (where İzmit and Kocaeli are located) shook violently an area nearly half the size of Switzerland, causing in no fewer than ten provinces the most widespread destruction of the urban built environment in the history of the country. The same level of depredation occurred again about three months later on November 12 when a magnitude of 7.2 earthquake occurred in the province of Bolu near Düzce. This time the affected area was smaller. These two earthquakes caused some twenty thousand deaths and fifty thousand injuries.

The combined impact of these earthquakes proved to be overwhelming for Turkey as it would have been probably for almost any other country. It is estimated that 25,000 buildings, many with multi-dwelling or business units, collapsed or were so badly damaged as to require subsequent razing. With as many as 600,000 people left homeless, it fell on the Government of Turkey (GoT) to provide at first acceptable temporary shelter for them before winter arrived. This was achieved in a variety of ways. Empty land in and around the affected areas were used to erect 45,000 small container-type temporary homes and tent cities were assembled in similar areas. Public buildings such as schools were turned into temporary shelters.

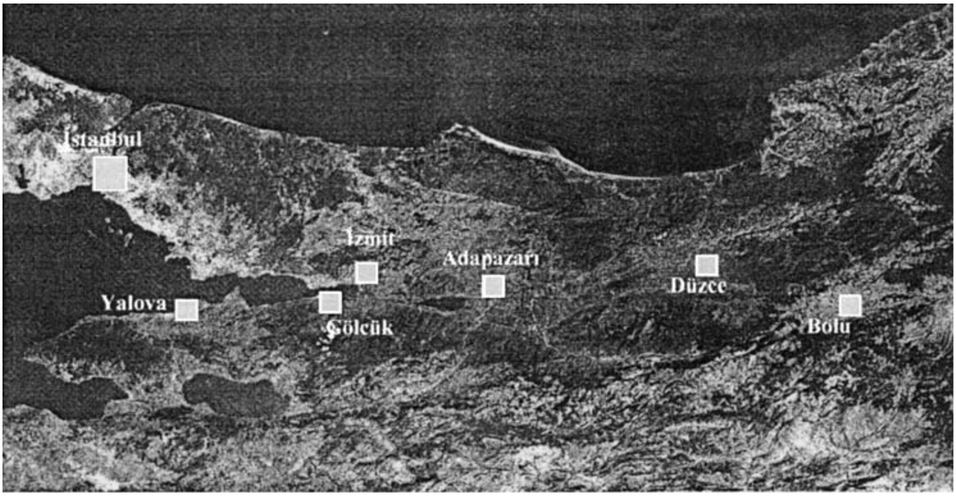

Figure 1. Affected area with principal cities (the distance from İstanbul to Bolu is 250 km).

Summer recreation camps belonging to institutional agencies were made available on an as-requested basis. Traditional ways of the Turkish society made it possible for many families to find residence with their relatives or friends. Those who chose not to live in a prefab or tent community were given $175 per month for a year so that they could rent homes for themselves.[1]

Turkish law concerning assistance and relief for natural disaster victims (Law No. 7269) required GoT to provide a home to each affected family.[2] Rebuilding settlements for the purpose of re-housing hundreds of thousands of persons required a tremendous organizational effort that involved many national agencies, international finance establishments, contractors and consultants. One purpose of this article is to provide a synoptic summary of this regional reconstruction and redevelopment program.[3] It also provides an assessment of this effort although the work has not yet been fully accomplished. The principal objective is to call attention to the fact that while Turkey may have been effective in rebuilding cities reduced to a rubble, it has in the past shown reluctance in enforcing meaningful mitigatory policies to spare itself the replay of similar experiences in the future.

2. Management of Rebuilding Project Components

At the end of 1999 the state's obligation to finance reconstruction of the destroyed housing stock, dictated by the then-current provisions of the disasters law, amounted to an estimated $6 billion. This money was later raised partly through loans from the World Bank and European Investment Bank or other sources, and partly from national resources. The decision was reached that a two-sided management structure would be created for the complicated task for reconstruction and redevelopment of the region.

A short time before the earthquakes had struck, GoT had applied for and received an International Bank for Reconstruction and Development Bank (World Bank) loan to be executed under a program code-named TEFER (Turkey Emergency Flood and Earthquake Recovery). The program had been initiated following severe floods in the Western Black Sea Region during the Spring of 1998, and an earthquake that occurred on June 27, 1998, near Ceyhan in the Province of Adana in the south. The TEFER loan was augmented on December 5, 1999, when GoT and the World Bank signed a second loan agreement for the execution of a second program code-named MEER (Marmara Earthquake Emergency Reconstruction) worth $758 million. This agreement contained two parts as follows: a loan of $253 million under the "Earthquake Emergency Assistance Project" was provided as a general supplement to the Turkish national budget. This sum was targeted for expenses in project implementation as a general enhancement measure for the budget and to meet additional import requirements for the affected region.[4] This sum was disbursed by the "Fund for Promotion of Social Assistance and Solidarity" for assistance to victims who were not covered by any of the social security agencies in Turkey and by the three social security agencies in Turkey that cover salaried civil servants (Emekli Sandiği, the Retirement Mutual Fund for Civil Servants), workers on wages (Sosyal Sigortalar Kurumu, the Social Security Administration) and self-employed services people (Bağ-Kur, the Retirement Fund for Self-Dependent Employees), respectively. The money went toward covering obligatory expenses that arose in connection with family assistance toward burial of victims, disability payments for the injured and as perpetual payments for surviving family members.

The remaining $505 million was targeted for several rehabilitation projects under MEER. This component included physical reconstruction in the affected region that would be coordinated and executed by the Project Implementation Unit (PIU) that was made part of the Prime Ministry for this purpose. PIU was later also put in charge of managing a loan from the European Investment Bank (EIB) for reconstruction of urban and rural housing and its auxiliary infrastructure.

PIU had been created following the occurrence in 1992 of an earthquake in the eastern city of Erzincan. Negotiations with the World Bank were finalized with a $284 million loan, and it was agreed that this unit within the Housing Development Administration (HDA), an agency that normally lends loans to housing cooperatives for urban development, would be responsible for management of the reconstruction of Erzincan. By all accounts, the performance of PIU in Erzincan had been an exemplary success. A multitude of consulting and contracting parties were managed in accordance with World Bank rules and procedures that are similar to the internationally accepted FIDIC (International Federation of Consulting Engineers) rules. An example is shown in Figure 2 of the type of housing that was built in Erzincan in the mid-1990s.

Figure 2. Reconstruction in Erzincan: Government employee homes.

The loan agreement for TEFER was worth $369 million and was also managed by PIU. Major components of the project are shown in Figure 3. These activities covered a range of institutional mandates for risk mitigation.

The size and scope of MEER required a management change for PIU. It was detached from the Government Housing Agency and, for speedy implementation, made part of the Prime Ministry. The newly created General Directorate of Emergency Management, a replication of the Federal Emergency Management Agency in the US, was also connected with the Prime Ministry, with a deputy undersecretary charged with the task of providing executive oversight. The project components are summarized in Figure 4. Correct numbers for the units that have been constructed will be given subsequently. For both projects, Component C was for rebuilding new settlements, so some cross-tendering occurred in the contracts for the new sites.

GoT sought additional external resources for its needs to finance reconstructing the region. In Table I external credit information as of August 16, 2001, is summarized. The Undersecretariat of the Treasury, rather than the customary Ministry of Finance, served as the funnel for flow of the credits received.

The other major actor in the reconstruction of the Sea of Marmara region was the Ministry of Public Works and Settlement (MPWS) and its affiliated executive units. This is the ministry responsible for addressing needs and requirements in connection with all natural disasters. Besides earthquakes, this ministry is legally empowered to devise and enact all mitigation measures in urban areas for fires, floods, land-slides, rock falls, avalanches, etc., as well as to determine relief needs and their coordinated implementation in the post-disaster period. The three major service agencies of the ministry are described in Figure 5. Special units created

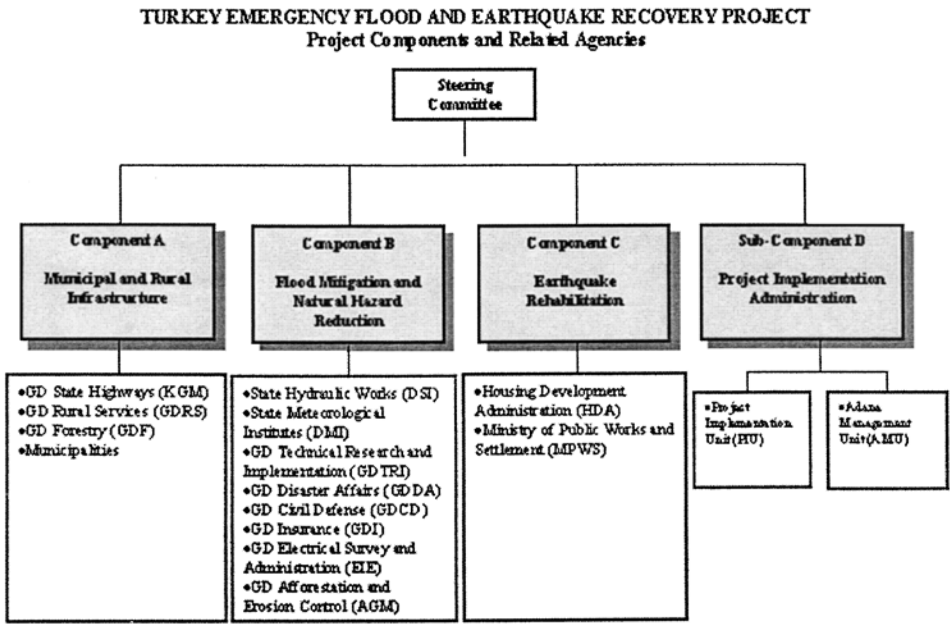

Figure 3. TEFER project components.

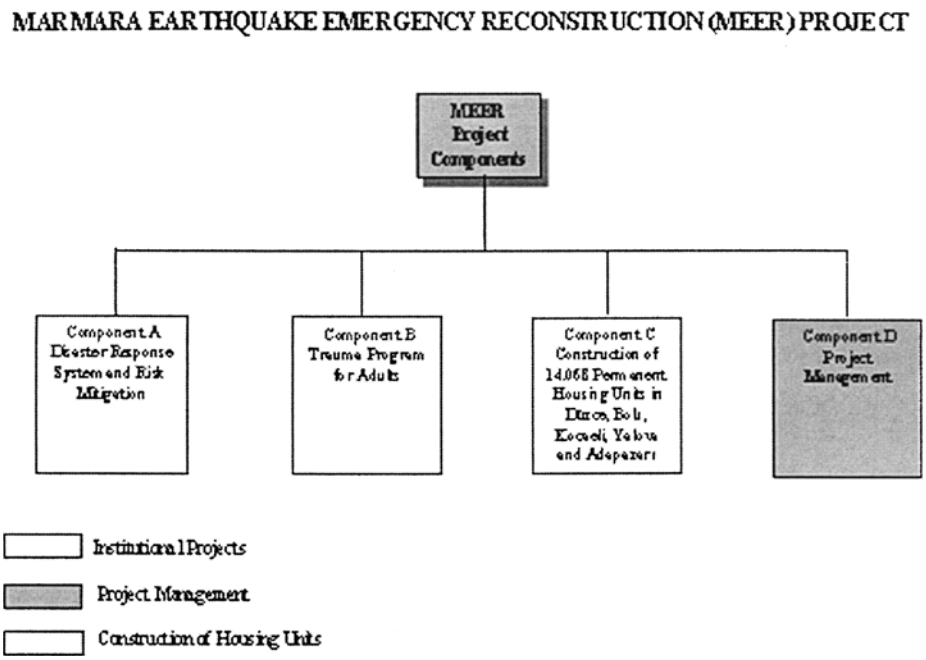

Figure 4. MEER project components.

TABLE I
Foreign credits received

Funding agency/country	Amount $M	Purpose
Japan	450	Credit for small and medium size enterprises and commercial wares
Spain	60	Demolition of collapsed buildings
S. Korea	30	Social Security Administration Hospital in K. Çekmece/İstanbul
Belgium	3.4	Basic education school construction
International Monetary Fund (IMF)	500	Supplement to national budget
World Bank	1,017	MEER Project and compensation of earthquake damages
Gulf Cooperation Council	400	Infrastructure
Islamic Development Bank	300	School and hospital reconstruction
European Council Development Bank	253	Permanent housing
European Investment Bank (EIB)	440	Infrastructure and permanent housing

pro tem for addressing the post-1999 requirements are shown in double-lined boxes.

3. Selection of New Land for Permanent Settlements

World Bank requested the Government of Turkey to assist in identifying quickly "suitable" sites where dwellings and businesses it would be financing would be constructed. The government relied on consultants (many of these were academics with earth science background) supported by Ministry of Public Works and Settlement personnel to come up with suitable sites for resettlement. In a number of cases it may have been the other way around. That is, the sites were selected by the ministry which was supported by the consultants. World Bank local country office and PIU also have employed their own consultants from, for example, the State Planning Organization or other academics, to provide quality control. But the task of determining where new settlements would be constructed, and surveying and assessing locations was carried out primarily by General Directorate of Disaster Affairs and PIU. Earlier, World Bank Turkey Office had commissioned a similar study immediately following the Kocaeli earthquake (Atik et al. 1999). These missions included site visits to affected families where surveys were conducted. These surveys sought to establish responses to the following pressing issues:

- Assessment of reconstruction needs and existing capacities for both temporary and permanent housing,
- Selection of sites suitable for reconstruction,
- Identification of engineering and design studies,

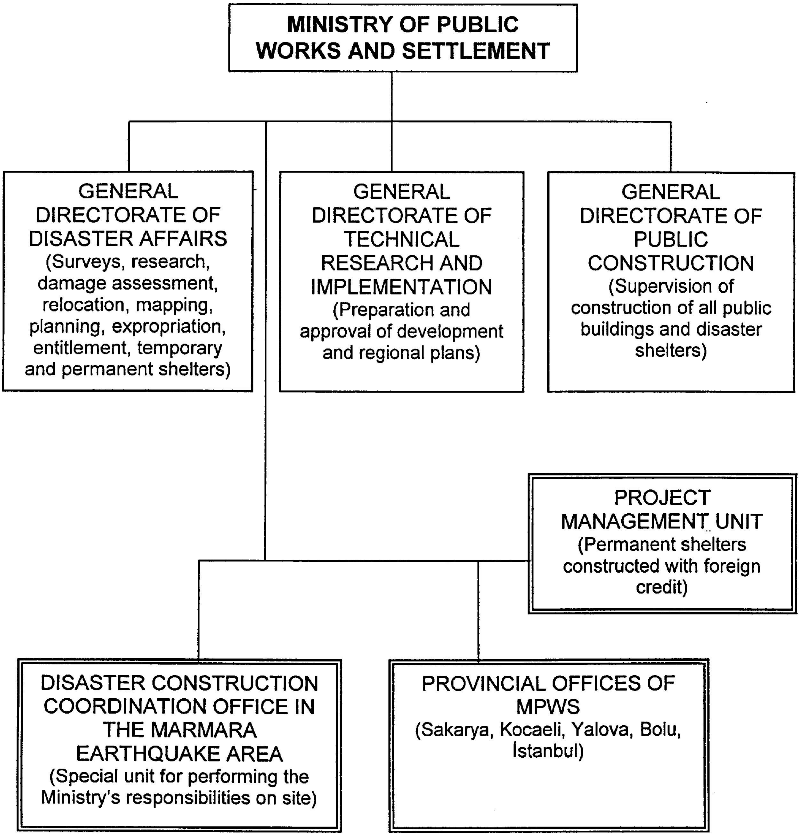

Figure 5. Organizational diagram for MPWS including specially created temporary units.

- Preparation of terms of reference; and
- tentative schedules for project preparation and implementation.

A wide array of parameters was taken into consideration besides geologic suitability for settlement. The new settlements needed also to constitute socially and spatially attractive centers, and serve as models for other settlements in their vicinity. Consultations with neighboring municipalities indicated that these hoped to see new settlements that were sufficiently removed from themselves and self-sufficient in terms of further development. Following the massive soil liquefaction-related damages in Adapazari, and at the largely unfounded urging of earth scientists, the new lands were generally selected away from any flat topography or alluvial formations. The result has been that most reconstruction has been confined to rolling hillsides and steep slopes. At the time, this also reflected the wishes of the victims who tended to blame everything on "wrong soils" rather than the true culprit of faulty construction practices and code enforcement (Gülkan 2000). In general, the site selection process was anchored to the following criteria:

3.1. Physical criteria

- Easily accessible land of size adequate to accommodate population.
- Suitable topography.
- Local geology suitable for building foundations.
- Suitable environmental factors permitting easy construction of infrastructure.

3.2. Economic criteria (probably more important in the long-term)

- Current ownership situation and ease of land acquisition.
- Ease of access to work places and central facilities such as hospitals and schools.
- Possibility of building infrastructure components inside and outside of settlement area.
- Growth potential.

3.3. Social and institutional criteria (established through interviews and surveys)

- Characteristics that promote social development and serve as model center.
- Acceptance by end users and their active support for promoting the settlement.

While these criteria are not unique for the Turkish urban recovery and reconstruction program, they were applied with some uniformity in a very short period of time. Each new settlement was then planned with the plans reported as in customary government procedures.

4. Regional Redevelopment

The large scale redevelopment and reconstruction has taken place over a 200 km long geographical area, and is now mostly completed. The global map is reproduced in Figure 6. Slight differences exist between the numbers entered on this map, which reflect the situation as at the end of 2000, and on Table II which is current.

The customary World Bank rules were implemented in the part of the contract work that was handled by PIU. Independent consultants were engaged to provide design review and to supervise contractors and report progress to PIU on a monthly basis. Turkish law for institutional contract work was followed in the contracts awarded by MPWS.

The quality of construction and the earthquake safety of the newly built settlements is very good. Visits to the many settlements have confirmed that none of the buildings represents a life safety compromise. A total of 797 rural houses were constructed and completed with assistance to owners by October 2001. Of these, 490 were in Kocaeli and 307 in Yalova. Tables III and IV provide a summary of the overall redevelopment activity. Buildings to accommodate small businesses and rural homes have also been included in the recovery program.

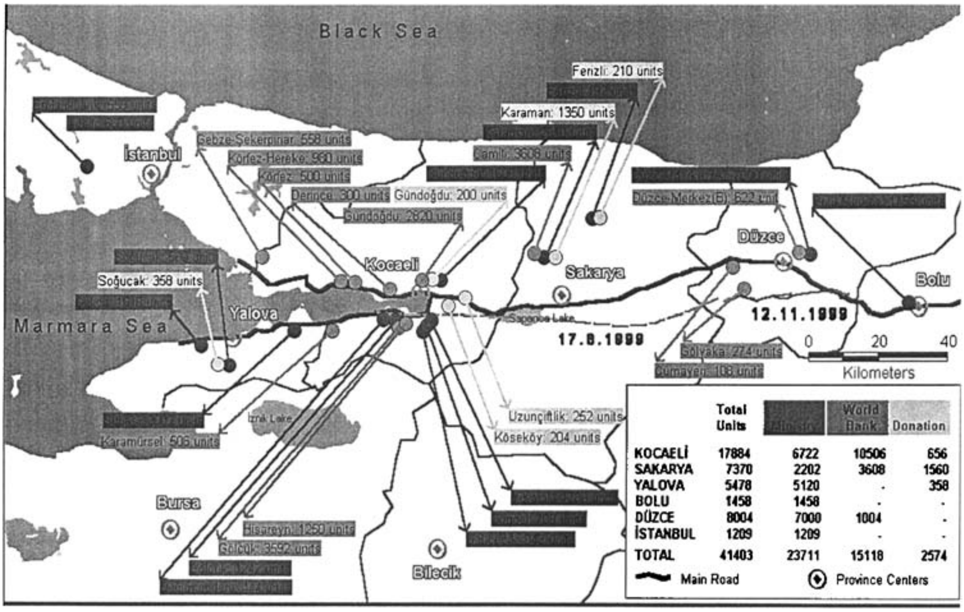

Figure 6. Sites for reconstruction in the sea of Marmara Region.

5. Timid Steps Toward Comprehensive Risk Mitigation

The overpowering impact of closely spaced earthquakes in Turkey since 1992 had many causative factors that prepared the stage: faulty construction practices tolerated for years, local governments ill-prepared for supervising construction and development, lack of design and land use plan supervision, and runaway developments in recently industrialized areas of Turkey. These have paved the way for disproportionate damages during not only major earthquakes such as in 1999, but during also "local" events such as in the province of Afyon in February 2002, or in Bingöl in May 2003. İstanbul, the largest metropolis and the country's financial and industrial center, is currently contemplating a massively expensive earthquake master plan. Societal memory is shorter than the return period of major earthquakes. The public pressure that had been brought to bear on the government in the period following the 1999 calamity to enact legislation and preventive measures to establish public authority to rule out its recurrence has now diminished. The meandering path of attempted improvements in the legal and administrative domains is described next.

The massive liquefaction that occurred in Adapazari, and the revelation that Gölcük and cities next to it had been sitting on major fault lines, pushed the "geology" of the event to the foreground. Many geologists and seismologists with no qualifications in earthquake resistant design matters became media celebrities,

TABLE II

Summary of permanent reconstruction units built and their funding sources

Province	Location	Donation	Contracted by PIU: World Bank	Contracted by PIU: EIB addtl. units	Contracted by MPWS: MPWS	Contracted by MPWS: EC Dev. Bank	Contracted by MPWS: EC Dev. B. Addtl.	Total number of units constructed
Kocaeli	Gölcük-Yeniköy			1120				1120
	Karamürsel		554					554
	Göcük		3568					3568
	Hereke		980					980
	Gebze-Şekerpinar		558					558
	Gündoğdu (B. Paşa)		2820					2820
	Gündoğdu (B. Paşa)					1606		1606
	Gündoğdu (B. Paşa)	200[a]						200
	Bahçecik					942		942
	Döngel					708		708
	Yuvacik					1780		1780
	Gölcük					1242		1242
	D. Dere					444		444
	U. Çiftlik	252[b]						252
	Köseköy	204[c]						204
	Derince						300	300
	Körfez						498	498
Sakrya	Camili			1000				1000
	Resuldivan		2572					2572
	Karaman						966	966
	Karaman					2010		2010
	Karaman	1278[d]						1278
	Ferizli					192		192
	Ferizli	210[a]						210
DÜZCE	Düzce A				7000			7000
	Düzce B		622					622
	Gölyaka		274					274
	Cumayeri		108					108
	Kaynaşli			466				466
Bolu	City					1458		1458
	City						276	276
İstanbul	K. Çekmece İkitelli				650			650
	K. Çekmece İkitelli						160	160
Tekirdağ	Çerkezköy	559[e]						559
Yalova	Soğucak					500		500
	Soğucak	358[f]						358
	Subaşi Çavuşçiftliği					3000		3000
	Çinarcik Çalica					1618		1618
Overall total		3,061	12,056	2,586	7,650	15,500	2,200	43,053

[a]Turkish Union of Textile Employers.
[b]Turkish Union of Chambers of Commerce and Bourses.
[c]Türk-İş (workers union).
[d]Financed jointly by: Governorate of Kayseri (120), Governorate of Konya (252), Governorate of Şirnak (108), Governorate of Karaman (36), Turkish Union of Chambers of Commerce and Bourses (528), Union of Mut (138), Türk-İş (96) for total of 1278.
[e]Purchased from Hazir Konut, a development concern.
[f]Financed jointly by: Turkish Union of Textile Employers (108) and Turkish Union of Chambers of Commerce and Bourses (250) for total of 358 units.

TABLE III

Summary of contracted dwelling units (including direct purchase)

Province	Total
Kocaeli	17,776
Sakarya	8,228
Düzce	8,470
Bolu	1,734
İstanbul	810
Yalova	5,476
Total contracted	42,494
Direct purchase (Çerkezköy)	559
Overall total	43,053

TABLE IV

Small business facility construction

Province	Total	Notes
Bolu	108	Stage-wise completion during 2002
Kocaeli	2,139	
Sakarya	1,300	
Yalova	422	
Düzce	1,873	
Total	5,642	

preaching relentlessly the simplistic message that “bad” soil (they may have meant “soft” soil) conditions spelled certain death and destruction. (To a lesser extent, the same simplistic message continues to be given today in relation to the anticipated, well-known, but yet-to-occur İstanbul earthquake. Where the fault rupture is supposed to occur, how many successive ruptures it will involve and which the victimized urban neighborhoods will be continues to draw viewer interest, and TV channels and earthquake experts continues to regale audiences with the arcane arguments of tectonics.) It appears that earth scientists have better access to the media, and they have a simpler, more easily understood message. It was through these simplified messages and the trauma of what the victims had suffered at the time of consultations that led to detached, new communities ringing Adapazari and Düzce. The satellite cities will no doubt experience growth and acceptance pains, and eventually become re-connected to their parent settlements over time.

The World Bank – or GoT – funded programs have been of good structural quality. Code enforcement and abidance have been exemplary. Until July 2001, private construction in the affected areas had been entrusted to the building construction supervision firms in accordance with decree No. 595. This caused some discomfort, and was rescinded by the Constitutional Court of Turkey because, in their view, this decree required the execution of municipal duties (of quality check of designs and of supervising actual construction) by private firms, and was thus inadmissible. I have written an article strongly critical of the court's misguided decision (Gülkan 2001).

Following the court's abrogation of the decree, parliament passed a new law, No. 4708, that serves as a tentative substitute of the strict requirements that the decree had contained. There has been a substantial rebuilding/rehabilitation activity for damaged buildings that did not need to be razed, but in general the quality of this work has been patchy.

Repair of damaged rural homes was funded by the MPWS, and executed under the "assistance to owner" scheme. Here beneficiaries are given design plans and technical guidance for self-built dwellings. MPWS engineers and technicians then visit these people regularly and ensure conformance with the guidelines. It may be surmised that owners have subcontracted some or all work to journeyman builders. In such cases assurance of quality remains questionable.

Assessment of satisfaction of disaster victims with the new houses handed to them seems to have been done sporadically in Turkey. Karanci and Akşit (1999) report on their survey findings from Dinar, a small town in west-central Turkey that was hit by a magnitude of 5.9 earthquake in October 1995. The recovery of Dinar was not a part of any World Bank loan agreement, but the reconstruction there was implemented in a similar way. Buildings that had been damaged superficially were repaired, and collapsed or irreparably damaged buildings were replaced. About one-third of the respondents were people who had just moved into newly constructed post-disaster houses and 23 percent were people whose homes had not been damaged at all by the ground shaking. The rest came from repaired buildings. The responses given to the queries in the questionnaire indicated that the degree of owner satisfaction in newly constructed units was much higher than in both of the other categories. Here government aid covered only the structural refurbishment of the damaged houses, but excluded expenses related to reinstatement of finishes that became unusable after the structural intervention was done. This seemed to have played a role in the recorded sentiments. Disaster houses were handed out to entitlement holders on a random basis, so there were also complaints that one's own neighbors could not be pre-determined. But the majority were quite satisfied with the houses and the social services that had been provided. Owner confidence in the quality of repairs done under government supervision was high.

6. Accompanying Measures and Absence of a Coherent Policy

GoT issued many decrees and legal guidelines in the wake of the 1999 earthquakes (Gülkan 2002). Many of these policy instruments were of a short-horizon nature, designed to address a given pressing problem. In a study completed shortly before the earthquakes struck,[5] a number of these decrees had been identified as general policy instruments for disaster mitigation that needed to be carefully crafted and tuned in harmony with other legislation. Surely, the continued laxity in the building construction medium will not help in improving quality that is so intimately linked to the groundbreaking compulsory insurance scheme, Turkish Catastrophe Insurance Pool (TCIP).[6] To date, parliament has not passed TCIP and its administrative entity into law. The pool is shrinking in terms of the number of policies it has sold.

The current planning system in Turkey, with its numerous regulatory mechanisms and actors, is far from a unified and singular body or authority of monitoring physical development in Turkey. Apart from the local authorities, separate and distinct powers of development planning, plan ratification and building construction are currently enjoyed and extensively exercised by a multitude of ministries and other public bodies. This brings vagueness in the identification of responsibilities and weaknesses in the control of development in an area demanding strict discipline in conduct, and clarity and coherence in authority. The responsibilities of enforcing the Development Law No. 3194 lies with the Ministry of Public Works and Settlement. The ministry itself is deprived of means of exercising control over municipalities, the real beneficiaries enjoying the powers given by the law in their daily practices. All powers concerning overseeing the administrative actions of municipalities, on the other hand, are delegated to the Ministry of the Interior, which in turn has no technical capacity to control plan-making and building.

The Development Law No. 3194 is solely a physical regulation instrument for development. It ignores the integral finance, organization, protection and management issues, or reciprocal requirements of all building activity. It has little power or incisive tools to manipulate or physically rearrange properties (and the sacrosanct rights of ownership), or to maintain the "public welfare," particularly monitor building activity in disaster areas. The law has no provision to cope with natural (and other forms of) disasters in itself, neither does it have an authentic interrelation with the Disasters Law No. 7269, apart from minor referencing between their respective by-laws. A draft replacement for Law No. 3194 has been issued by the Ministry of Public Works and Settlement.

The Disasters Law, currently also under review, pays only lip-service to pre-disaster preparations and control. Almost all of its provisions are concerned with the aftermath. It disperses public funds without necessarily ensuring their return, which makes it a highly popular mechanism with the political authorities. Throughout the Turkish practice with disasters, earthquakes in particular, powers provided in this law for technical decision-making have been transferred to the body politic, with *ad hoc* laws passed immediately after each disaster. This form of deprivation of powers of the technical body has been experience once again after August 17, 1999. Until and amendment recognizing TCIP was enacted the Disasters Law punished the building insurance policy-holders against disasters in its compensation of losses.

Furthermore, public credits were benevolently provided to all property owners without discriminating in any way against unauthorized building owners.

All planning and building supervisory action has been charged to the responsibilities of the municipalities (within their jurisdictional borders) and the provincial governors (in all areas external to the municipal boundaries). Even if they intended to, municipalities are in no position to carry out these functions of control simply for the reason of their incapacities in technical manpower, and the sheer size of the tasks involved. As if to complements this, municipalities are not liable to any serious extent for their failure to fulfill responsibilities of development control. This situation is aggravated by the fact that no legal countermeasures have been spelled out for those officials who fail to perform their duties in the spirit of the law. A law (No. 4708) passed on July 13, 2001, addresses the issues of project design and construction supervision, but represents a weakened version of the decree (No. 595) that had been enacted shortly after the earthquakes struck – originally an appeasement of the public outrage, fanned by the media, that so many buildings would be destroyed by ground tremors, killing tens of thousands of innocent people. Law No. 4708 is enforced in only about 19 pilot provinces, so a good appraisal of its impact is not likely to be visible for some time.

In a country with a strong centralistic tradition such as Turkey, an effective disaster mitigation strategy must depend on two basic premises. One is the crafting of an effective spatial planning system in which disaster occurrence is considered explicitly as a prime parameter. This includes strict building construction supervision as the other premise. Supervision of plans, the transparency of their preparation and accountability of public officials reinforce the safety considerations.

The basic objective of any proposed system must be to ensure coordination between general settlement and disaster policies with emphasis on pre-disaster mitigation and preparedness. It is proposed that integrated disaster maps (data information systems) should form the basis for physical development plans and disaster action programs for hazardous areas and settlements. It is to be hoped that revisions in the Local Governments Law, Development Law, Disasters Law, Building Construction Supervision Law, Law for TCIP and the Contracts Law will all speak the same language and present a workable, coherent and unified blueprint for disaster mitigation. Of equal importance are the steps required for the introduction of certification into technical services, and even professional liability insurance for classes of technical services that have a bearing on human life safety and protection of property. Regrettably, the building stones for a comprehensive risk mitigation policy framework have not yet been put in place.

7. Conclusions

The story related here has been about Turkey and the continued toll that this country pays for not having crafted a unified, singular system for disaster management.

Yet, the substitution of a different national polity's name might not have made the conclusions all that redundant. Examining the annual disaster statistics of the International Federation of Red Cross and Red Crescent Societies is a revealing exercise: certain disaster-prone countries habitually receive the brunt of nature's forces because their mitigation policies either do not exist or are so formulated that they simply do not work. The collective body of policies in Turkey that govern the way land is used and the housing stock is created are fraught with deficiencies that would require more than a patchwork of narrowly formulated legal instruments could possibly address. It is depressing that even the cataclysmic events of 1999, that seemed at the time to electrify the public opinion to the fact that "something needed to be done" to prevent a repeat, have failed to engender a broad stream of policies that would achieve that end. The country has quickly reconstructed the affected region at great cost but has failed to weave a system that would, over time, prevent recurrence of similar losses.

Notes

1. The cash value of assistance in camps was higher (including free health care, food, cooking utensils, clothing, counseling, skills training, schooling, and pocket money) which provided a strong incentive to go there. See: Bibbee A., et al., "Economic Effects of the 1999 Turkish Earthquakes: An Interim Report," OECD Economics Department Working Paper No. 247, June, 2000, Paris.
2. This is no longer true. As of Septemeber 27, 2000 each home owner must join the mandatory insurance scheme of Turkish Catastrophe Insurance Pool (TCIP). For a nominal premium this pool, administered by an entity referred to with its acronym of DASK, will provide ready cash to those who lose their property because of an earthquake, enough to purchase a no-frills replacement. Law No. 7269 has been amended so that the government's obligation no longer applies for dwellings located inside municipal boundaries. It continues to be valid for rural areas where no municipal building construction supervision exists.
3. A summary of all relief and assistance progams that have been implemented in the disaster area is given in: Emergency Management Center of the Prime Ministry, "Earthquakes 1999: Work Carried Out by Ministries and Public Agencies Following the August 17 and November 12 Earthquakes," August 2000 (in Turkish). The bulk of the work in redevelopment of the Sea of Marmara region was carried out by the Turkish Ministry of Public Works and Settlement (MPWS).
4. Akdağ, S.E., "Financial Structure and Auditing in Disaster Management," Turkish Court of Audits Publication No. 20, March, 2002, Ankara (in Turkish).
5. Earthquake Engineering Research Center, METU, "Revision of the Turkish Development Law No. 3194 and Its Attendant Regulations with the Objective of Establishing a New Building Construction Supervision System Inclusive of Incorporating Technical Disaster Resistance-Enhancing Measures," in two volumes available (in Turkish only) at: www.metu.edu.tr/home/wwwdmc.
6. For more on the Turkish Catastrophe Insurance Pool see: www.iiasa.ac.at/Research/RMS/dpri2002/Papers/guelkan.pdf.

References

Atik, S., Akyel, O., Yazgac, M., Uysal, O., and Serafettinoglu, F.: 1999, 'Marmara earthquake reconstruction project: Present situation and reconstruction needs for İzmit, Gölcük, Yalova and Adapazari', *Report submitted to World Bank*, Ankara, Turkey.

Gülkan, P.: 2000, ‘Building code enforcement at municipal level in Turkey: Failure of public policy for effective building Hazards mitigation?’, *Earthquake Spectra* **19** (Supplement A) 351–367.
Gülkan, P.: 2001, ‘An opinion on Abrogation of decree with power of Law No. 595 for building supervision and the enactment of Law No. 4708 as its replacement’, *Türkiye Mühendislik Haberleri*, Turkish Chamber of Civil Engineers **412**, 7–19.
Gülkan, P.: 2002, ‘Rising from the rubble: The costly rehabilitation of sea of Marmara Region in Turkey following the 1999 Earthquakes and mitigation policies they engendered’, presented to *NATO Committee of the Challenges of Modern Society, Natural Hazards Workshop*, 14–17 April 2002, Toronto, Ontario.
Karancı, N., and Akşit, B.: 1999, ‘Strengthening community participation in disaster management by strengthening governmental and non-governmental organizations and networks: A case study from Dinar and Bursa (Turkey)’, *Australian Journal of Emergency Management* **13**(4), 35–39.

CLIMATE CHANGE AND NATURAL HAZARDS IN NORTHERN CANADA: INTEGRATING INDIGENOUS PERSPECTIVES WITH GOVERNMENT POLICY

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(Received 25 November 2003; accepted in final form 8 April 2004)

Abstract. A study of the relationship between natural hazards and climate change in the international context provides the background for a discussion of the expected changes. In the context of this global discussion, this paper reviews the current perspectives of those natural hazards that are likely to be influenced by climate change, using northern Canada as a regional case study. The northern implications of the United Nations Framework Convention on Climate Change are examined, including the status of climate change action by the northern territorial governments, the evolving role of indigenous people, and the responsibility for climate change impacts. The difficulties surrounding natural hazards research in remote locations, and the approaches of indigenous people to natural hazards are then presented. The paper concludes with a suggested policy approach for climate change and natural hazards in northern Canada, underscoring the need for more comprehensive adaptive strategies to complement the current tendency to focus on the mitigation of greenhouse gases produced in this region.

Keywords: adaptation, climate change, indigenous people, local knowledge, mitigation, natural hazards, northern Canada, policy, traditional knowledge

1. Introduction

This study addresses four principal themes: (i) natural hazards and climate change research in northern Canada is limited and poorly linked; (ii) the contribution of indigenous people to this research area has also been limited, is primarily qualitative, and has been ignored or largely discounted by scientific investigations, though it is beginning to show substantial promise; (iii) the international and national climate change focus on greenhouse gas (GHG) reductions, while important, is misplaced for northern Canadian residents, yet the adaptation agenda here is nascent, despite the evident need; and (iv) connecting climate change research in the North (which has political profile) more closely with natural hazards research (which does not) could help diversity and bring closer both research agendas and in so doing influence the long term quality of life for northerners.

The risks of environmental disasters and the management of their impacts have long been a concern for natural scientists, engineers, and the humanitarian assistance community among others. Physical scientists led this exploration with intensive and wide-ranging research efforts from ice core analysis to permafrost studies.

Relatively, social scientists have been less active, though some community-focused studies of indigenous cultures address local and culturally specific behaviour related to risks of environmental disasters and their management. Anthropogenic and rapid climate change is a relatively new phenomenon that has challenged the ability of scientists and indigenous people to understand and predict future conditions with much certainty. Concurrently over the last two decades, climate change has emerged onto the international environmental agenda as a serious problem, which has international implications, the need for wide participation, and many unanswered questions[1].

This paper addresses the linkages and interactions between approaches to climate change in northern Canada and the views of indigenous people living in this region, more specifically the Dene Nation. Furthermore, we will explore, in a tentative manner, how natural hazards may be influenced by changes in climate and whether consideration of local knowledge is essential. Given the paucity of applied research surrounding climate change, natural hazards and traditional knowledge in the North the paper is exploratory in nature, underscoring the need for focused research efforts to support or refute the linkages suggested. In addition, it is anticipated that this exploration will be of interest to other northern circumpolar nations (see Figure 1) with similar climate change and natural hazard concerns.

Communities across northern[2] Canada are home to an indigenous population of First Nations, Aboriginal people, Inuit and Métis. The population of the three northern territories is approximately 100,000 in total – 30,000 in Yukon (21% indigenous), 42,000 in NWT (50% indigenous) and 29,000 (85% indigenous) in

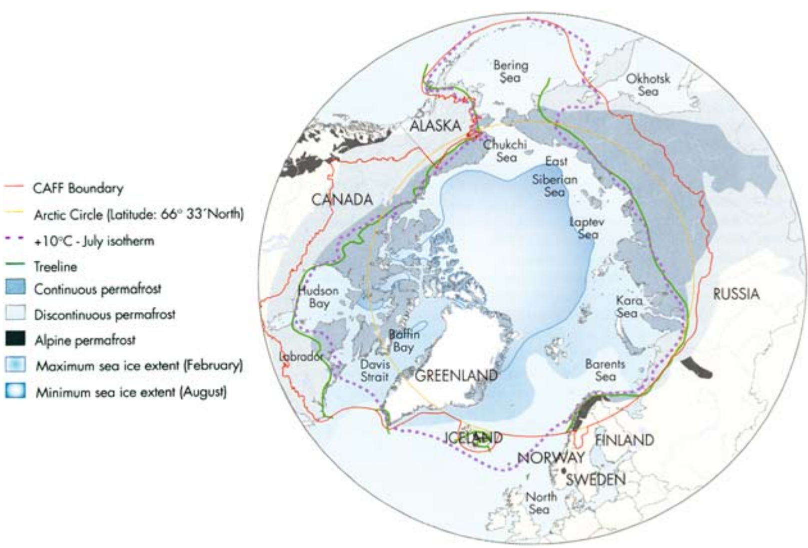

Figure 1. Northern Circumpolar Region. Source: CAFF: 2001, *Arctic Flora and Fauna: Status and Conservation.*

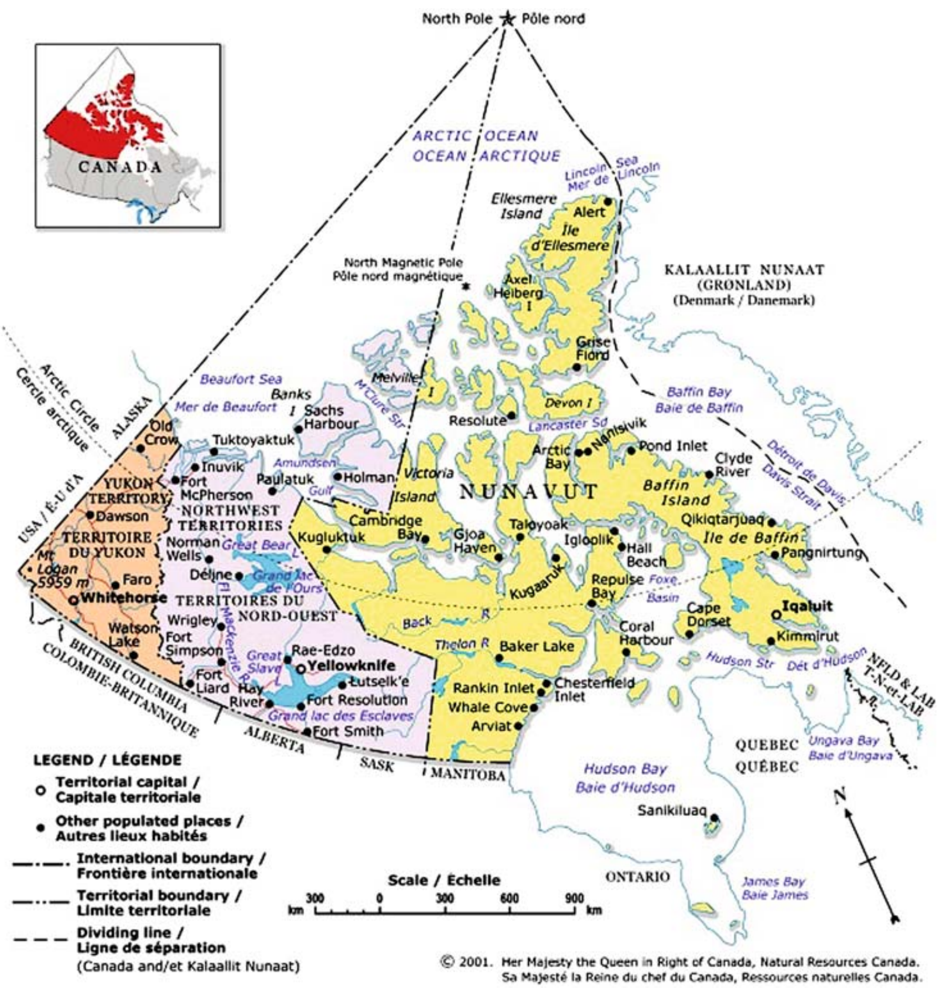

Figure 2. Northern Canada.

Nunavut according to territorial government figures available on the government websites. These three territories (see Figure 2) comprise the geographic focus of this paper. The region has a dual economy consisting of traditional First Nation communities heavily reliant upon government and social services supplemented by hunting and fishing, and a modern sector dominated by people of European origin engaged in mining, transport, administration, defence and service occupations.

Viewed from the perspective of northern Canada, especially First Nation communities, the emphasis on climate mitigation, while an acknowledged part of the national climate change agenda, will do little to affect the projected changes. Nonetheless, it represents the primary focus, due largely to national priorities and the availability of funding. At the outset we wish to clearly state, as will

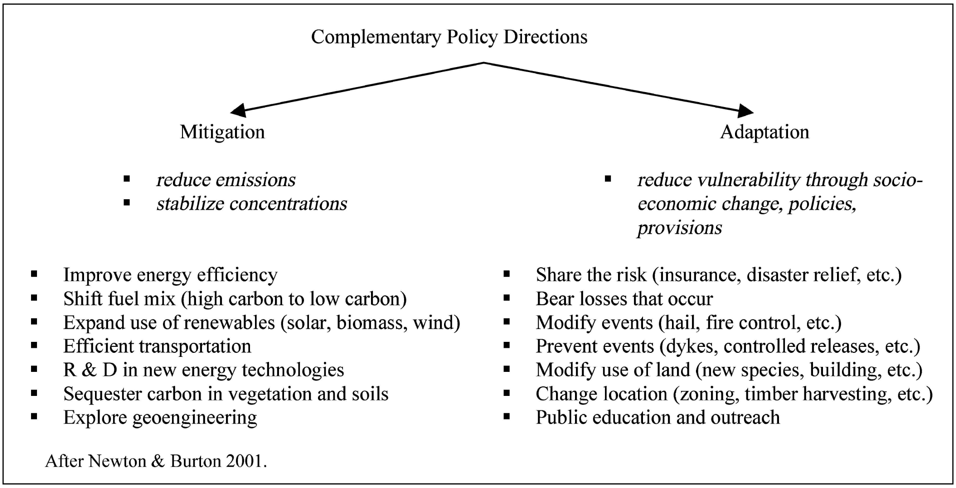

Figure 3. Potential climate change policy directions and measures.

be explored further in the subsequent discourse, that while GHG reductions are needed globally, the authors feel adaptation is a far more important, and in the long term, effective primary policy direction (see Figure 3) for the Canadian North. This situation presents a political and climate program conundrum for all jurisdictions, as the current overriding focus on GHG reductions fails to address the issue of vulnerability and to prepare communities to cope with unanticipated events.

2. Natural Hazards and Climate Change in the Canadian North

With projections of more extreme natural events occurring in northern Canada (IPCC 2001; Dotto 2000), research is crucial to shape climate change policies respectful of local indigenous wisdom and the aspirations of residents to share more fully in the growth and development of northern Canada. It is by no means an easy balance to achieve, but it must be done thoughtfully, guided by integrating a strong social dimension within the much-needed integration between hazards and climate research. To date these discourses have followed largely separate paths in the north and elsewhere.

It is virtually impossible to fully remove the risk associated with natural hazards; there will always be a slight residual risk. Survival (and progress) is learning to live *with* risk. However, steps can be taken to minimize damage from impacts (whether due to climate or natural sources). Response, particularly to such northern natural hazards as floods and forest fires, comes from a number of sources, as no single agency or level of government has the required resources. Forging partnerships between agencies that prepare for and cope with major natural hazards is an essential part of an effective response model, particularly for small, remote communities.

Partners must focus their efforts on the same goal and work towards the same result – safer more resilient communities.

As noted earlier, the annual rate of weather-related disasters is increasing globally (Loster 2003; IPCC 2001; McMichael et al. 2003). At the same time, given the increased investment and population in hazard-prone locations (e.g., ocean front, river edges, deltas, earthquake zones, etc.) the cost to respond and recover is growing. Munich Re reports insured losses from natural hazards were 15 times higher in the 1990s than in the 1960s (Hewitt 2003). To a significant extent, the global increase in the cost of natural disasters is due to increased population, asset values, wealth and expanded infrastructure, particularly in hazardous locations (e.g., coastal regions and earthquake zones). Such factors are only part of the answer, for climate change may influence the increase in the magnitude and frequency of disasters (Loster 2003). Are data available on the rate of occurrence of natural disasters in the North? Anecdotal information shows that more forest fires and potentially more flooding have occurred in the central Yukon over the past 10–15 years, but there is, as yet, no strong evidence that these increases are related to changes in the region's climate. Elsewhere, data is thin and inconclusive, although the global upward trend is likely to be reflected once northern data is compiled.

Nonetheless, if capacity is enhanced for individuals and communities to cope with current natural hazards, they will be better prepared for more frequent occurrences in the future. Increases in frequency will likely entail greater cumulative damages and costs to society, which may result in a more effective and efficient response as communities adapt to a new normal. With more advanced preparation to reduce impacts from extreme weather events and improved response and recovery due to actual events, eventually the costs should be less.

Regardless of whether or not climate change increases the magnitude and frequency of natural events, individuals, communities, and the institutions that govern them must take responsibility for being prepared to cope effectively. Building this capacity will require a better understanding of the linkages between climate change and natural hazards than we possess today, together with an appreciation of the evolving trends in global and Canadian climate change policy and thinking.

2.1. Coping with natural hazards in northern Canada

When considering the historical record of natural disasters on the North American continent, Canada, has experienced far fewer natural disasters than the United States, whether measured by frequency, magnitude, or economic impact. In recent memory, a few events do stand out: the 1997 Red River floods, the 1998 ice storm, and the 2003 British Columbia forest fires. Shifting the view to the situation within northern Canada, natural disasters are even more infrequent than in the rest of the country.

Predominant hazards among those living in isolated northern Canadian communities are flooding, forest fires, and severe winter storms. Landslides also occur in the north, though the impact on communities is infrequent. Avalanches are common to the mountainous areas of the northwest. The resilience of northern communities to such natural hazards is remarkable and underscores the adaptive capacity developed by inhabitants over generations of experience with the vagaries of the natural environment. However, only a few research studies published to date (Krupnik 2002; Berkes 1999; Newton 1995) have considered the more immediate natural hazards affecting northerners and indigenous people. Nonetheless, increased dependence on western-style community services, changes in social structures and reduced experience living on the land have caused a slow erosion of this historical coping capacity, to say nothing of changes to the frequency, intensity and expanded range of natural hazard events.

It is acknowledged that catastrophic disasters caused by these natural hazards have occurred (e.g., 1985 Winisk flood) and will continue to occur in the future. As discussed above, northerners and indigenous people have experience with such events, and while they can be devastating to those directly affected, the threats are largely known, localized to a single community or a few communities at most and ones they are able to cope with. In Aklavik, N.W.T., located in the Mackenzie River delta and known for being flooded during spring break-up, many residents have built houses on "stilts" or spend break-up at their outlying camps.

At the other end of the spectrum, we find natural hazards that are slow, incremental and almost imperceptible if one is not observing the change. Erosion in its many forms is constantly reshaping the landscape generally through the relentless movement of water. Similarly, amid the wide ranging annual climatic cycle in the north there is appearing variability that points to long term incremental changes whose source is now considered anthropogenic, but whose representation is seen in natural systems. Both catastrophic events and incremental shifts are of concern to northern residents, though from a human perspective, little can be said about how these conditions affect people living in the north, therefore, research in northern Canada and elsewhere is thin compared to physical science investigations. Why does this disparity in research focus exist? Is it driven by funding, national (regional priorities, or the global agenda explored above? Any answers to date, ours included, are speculative and without a solid research foundation. It may be that governments have traditionally put more funding into quantitative research, driven by a deterministic philosophy, and a desire to collect data and "facts" to hopefully lead to better decisions, rather than softer qualitative research efforts.

Salient literature of direct practical value to natural hazards research in remote regions is scarce. There have been assessments in developed nations with regional approaches (Cohen 1995), which have focused on ecosystems and economic impacts on mainly urban residents (Kenny et al. 1995; Knight 2000; Fisher et al. 2000). Where it does appear, reference to remote regions is often cursory, embedded in anthropological studies (Honigmann 1956, 1961), or mentioned in geographic overviews of national assessments (Mackay 1963; Dresler 1999). The anthropological literature on human adaptations to natural hazards in isolated locations comes from research such as that by Waddell (1983) in New Guinea and Morren (1983) in the Kalahari, or more commonly where the investigation of disasters is not the primary focus (Oliver-Smith 1986, p. 13). With few exceptions (generally government projects), research addressing natural hazards in remote regions, even tangentially, has been undertaken in foreign countries, but not in northern Canada. While the Arctic Climate Impact Assessment (ACIA) will address information gaps for the circumpolar north, hazards will not be a central focus.

Despite the logistical challenges of conducting research in remote locations in northern Canada, funding cutbacks and government downsizing over the past decade have resulted in a decline in research activity and training on northern issues at Canadian universities. The situation became so serious that in 1998, the northern science community was called upon by a group of alarmed researchers to alert the Canadian government to take action to secure the future of northern science before Canada's capacity to perform northern research collapsed (England et al. 1998). This situation effectively hinders the ability of those interested in pursuing large-scale research efforts that are essential to help northerners cope with extreme natural hazards as well as unprecedented social and economic challenges.

2.2. NORTHERN CLIMATE CHANGES AND RESEARCH

In the North, climate change is no longer an abstract idea. The North is demonstrating clear evidence of climate change that is consistent with what is expected to result from warming temperatures, and matches trends in the scenarios developed by global climate models (IPCC 2001). According to the most recent assessment carried out by the Intergovernmental Panel on Climate Change (IPCC), extensive land areas in the North show a 20th century warming trend in air temperature by as much as 5 °C accompanied by an increase in precipitation (IPCC 2001).

North landscapes have begun to reveal the impacts of climate change as well. Regions underlain by permafrost have decreased in extent. A general warming of ground temperatures and the thickening of the active soil layer has been observed in many areas, particularly at the southern margins of the North, close to and south of the treeline (IPCC 2001).

Important ecological changes that appear to have been triggered by warming are also beginning to be documented in terrestrial ecosystems across the North. Reduced nutritional value of caribou and moose browse and increased forest fire tendencies have been detected – a direct link to one of the dominant natural hazards in the region (Weller and Lange 1999). The North Transitions in the Land-Atmosphere System (ATLAS) program has recorded an advance and infilling of trees at the treeline, as well as an expansion of shrubs in the northern portion of the North (Chapin 2002). Currently, boreal forests are expanding northward at a rate of about 100 km/°C rise in temperature (Weller and Lange 1999).

Support for northern climate research is improving. The federal government has renewed support for the Northern Ecosystem Initiative, the Polar Continental

Shelf Program, and other northern research initiatives such as Arcticnet and the Aboriginal Northern Community Action Program. In September 2000, a task force established by the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), two of the primary funding agencies of university-based research in Canada, released a report that described the current situation as a crisis and urged Canada to rebuild its university-based northern research capacity. To explore this situation, NSERC-SSHRC and the Canadian Institutes for Health Research (CIHR) sponsored a northern dialogue on research in Whitehorse, Yukon, March 2004. There is considerable interest within the federal government in developing partnerships with institutions in the North to deliver climate change programs and services. For example, the Northern Climate ExChange (NCE), a partnership of the Government of Canada, Government of Yukon and Yukon College, was established in 2000 to enhance information exchange and facilitate research on climate change. The relative success of these institutional arrangements will depend on building successful partnerships with indigenous governments and their organizations. Clearly, challenges lie ahead for climate change research in northern Canada. It requires a long-term commitment to capacity-building and new flexible funding initiatives, which could well be driven by the mounting evidence (IPCC 2001) of the magnitude of the projected impact of GHG emissions on the North.

Government agencies, universities, and non-governmental organizations have already initiated many climate change research and monitoring projects in Canada and elsewhere. Individual communities, particularly in the North, are beginning to undertake their own projects related to climate change. The IPCC (2001) documented the global state of climate change research, and the NCE (2002) coordinated a major project aimed at assessing the current state of knowledge about climate change and its impacts in northern Canada. The Mackenzie Basin Impact Study (Cohen 1995), a six-year scientist-stakeholder collaboration to conduct an integrated regional impact assessment, contributed greatly to the state of knowledge of climate change impacts in northern Canada. As well, an international assessment of North climate impacts is currently underway, the North Climate Impact Assessment.

The substantial increase in climate change research in the past decade has made it difficult for researchers to keep track of all the various projects related to understanding, preventing, and mitigating climate change impacts. This situation has almost certainly led to overlapping research, unnecessary duplication of effort, and ineffective use of limited time and resources. In addition, there has been no overall vision guiding the allocation of efforts and resources.

Communication has been limited among the various groups and organizations involved in and concerned about climate change: researchers, communities, indigenous people, non-government organizations, industry, and all levels of government. This has made it difficult to exchange findings, to correlate scientific knowledge and local information, and to return the results of research to the people experiencing the effects of climate change most directly. Sharing information among all parties and interest groups can be a challenge, but it is essential. When knowledge is not shared, everyone's understanding of climate change and its impacts is diminished.

2.3. Projected Impacts of Climate Change in the 21st Century

Changes in northern climate are expected to continue throughout the 21st century and persist for many centuries to come, bringing with them major physical, ecological, sociological and economic transformations (IPCC 2001). The greatest changes in temperature are projected to take place during the winter months – extreme cold temperatures are expected to be less severe and occur less often. By 2080, the Global climate model output projects "large increases in the frequency of continuous days with extreme high temperatures" (Kovats et al. 2003, p. 56). Over land in the North, we expect temperatures to increase by 4.0–7.5 °C in summer, and by 2.5–14 °C in winter above present air temperatures (IPCC 2001).

Over the same period of time, precipitation in northern terrestrial ecosystems is projected to increase by 10–20% in summer months and by 5.0–80% in winter months (IPCC 2001). In almost all regions, these projections are well beyond the range of variability of the current climate patterns.

As warming occurs, there will be changes in species compositions with a tendency for a poleward and elevational shifts in species assemblages, the establishment of new assemblages of species, and the loss of some polar species (IPCC 2001). Vast areas of the North may develop entirely different ecosystems from those that exist currently (Everett and Fitzharris 1998). Ecosystem models predict that the area of tundra will decrease by two-thirds from its present size, due to an expansion of the boreal forest (Everett and Fitzharris 1998), which could be an asset to communities with a dependence on wood as a heating fuel.

The hydrology of the North is particularly susceptible to warming, since snowmelt drives virtually all of the major hydrological processes and related aquatic ecosystems in the North (IPCC 2001). Over the past decade, the Mackenzie GEWEX[3] Study (MAGS) has been studying the interrelationships between the atmospheric and hydrologic systems of the Mackenzie River Basin in northern Canada to evaluate the impact of both human-induced climate change and natural climate variability on Canada's water resources. The goal of MAGS is to improve the understanding of the water and energy cycle of the Mackenzie River Basin in particular and of cold regions in general. Because the ice cover on lakes and rivers will be thinner, freeze-up later, and break-up earlier, the rates of primary productivity in aquatic ecosystems will be affected (Rouse et al. 1997) as well as the use of winter roads to bring goods to isolated communities. Changes in freeze-up and break-up dates might also affect animal migration patterns in the North, especially the large-scale annual movements of ungulates. However, unless winter precipitation rates increase the amount of snow in mountainous areas, thus increasing river flows during break-up, the impact of a shifting timeframe may have little distinct change from a flooding perspective.

Northern landscapes are particularly sensitive to temperature changes because of the impact on surface albedo (reflectivity), permafrost distribution, active-layer thickness, and snowmelt (IPCC 2001). In areas where the temperature of the permafrost is only a few degrees below 0 °C, particularly at the southern margins, the permafrost is considered to be particularly vulnerable to warmer summer temperatures. Permafrost melting may substantially alter ecosystems where it causes soil subsidence and landslides, leading to poor water quality that is detrimental to fish and other wildlife. In communities where permafrost is susceptible to warmer summer temperatures, melting may cause building foundations to shift unevenly, pipelines and storage tanks used for water and sewage to rupture and buckle, and the structural integrity of older buildings, water supplies and waste disposal infrastructure could be threatened. Because of the way in which increased temperatures in the North may affect industrial activity, engineering designs will need to take climate change into account to minimize additional risk to the environment that is posed by these developments.

2.4. Is community vulnerability increasing?

In the natural hazards and climate change literature, the recognition of the importance of vulnerability reduction was not spontaneous. Natural hazards and disasters policies and institutional responses were long dominated by the urgent requirements of human safety, relief services, and humanitarian assistance. Similarly, climate change investigations placed emphasis on understanding the phenomena and seeking means to affect observed upward trends. By contrast, the historical record of survival shows that in indigenous northern communities efforts were focused on the avoidance of known hazards by minimizing vulnerabilities through reduced exposure and effective preparedness (Newton 1995). Residents of northern communities, especially the remote, isolated ones, had some economic and social incentives to change established behaviour patterns to protect family and scarce resources (e.g., firearms, camping kit, boats, etc.), however, this need dissipated in the later half of the 20th century with permanent communities and increased governmental involvement.

In more recent times, the rush of institutions to provide assistance and often evacuation (Indian and Northern Affairs Canada budgets millions for such needs each year) in response to disaster situations has enhanced the erosion of long-term cultural processes of reducing vulnerability. Moreover, such "assistance" might contribute to counter-productive tendencies such as the further expansion of human activities in high hazard zones, the lack of adequate building codes and design standards, or the lack of their enforcement, which could sometimes increase the vulnerability of northern residents. While these problems have by no means been fully overcome, the work of the International Decade for Natural Disaster Reduction

(IDNDR), 1990–1999, has done much to refocus the emphasis on the need for mitigation. Recent efforts by the International Strategy for Disaster Reduction (ISDR), the UN agency that evolved from IDNDR, continue this focus with the publication of *Living with Risk* (2002), an attempt to enhance understanding of policy and process through a global review of natural disaster reduction initiatives. Nonetheless, it would appear that, despite good intentions and significant efforts, the vulnerability of isolated northern communities could be increasing as a result of climate change, natural threats, and more disturbingly, the interaction of both phenomena in extreme natural events. While not proven, this latter condition is predicted and thus cause for concern throughout the north where temperature changes over the next century are among the highest projected.

How much attention to give to short-term disaster vulnerability and long-term climate change and how best to integrate them depends very much on local circumstances. In northern Canada both issues are important, and this region is a useful case study for considering how to cope with both climate change and natural disasters. The Canadian North shares some of the characteristics of both developed and developing countries. Although it is part of a developed country, it lacks the economic resources and embedded industrial engines characteristic of the southern Canadian regions and is thus relatively underdeveloped, despite the variable economic infusion from mining and energy projects.

2.5. Terminology and Language

Natural hazards and disasters have a long history of study and debate from early work by Gilbert White (1942) to the present day, and policies on managing the impacts have been in existence for decades. By contrast, climate change has only recently emerged on the international environmental agenda. Therefore, it is not surprising that different technical languages have developed. Prominent among the terms that cause confusion are the words adaptation and mitigation.

In the natural hazards community, mitigation is defined as the wide array of actions that can be taken to reduce vulnerability. Such mitigation actions can be considered either structural (e.g. diversion channels, fire breaks, etc.) or non-structural (e.g. awareness, information, policy, etc.). In the language of the United Nations Framework Convention on Climate Change (UNFCCC) established in 1992, the reduction of carbon dioxide and other GHGs and carbon sequestration in soils and biomass is referred to as "mitigation", thus potentially confusing communications between the natural hazards and climate change communities. Also, in the climate change world, the idea of vulnerability reduction is called "adaptation" which further affects the clarity of this discourse. Moreover, when considering natural hazards, many are now defining adaptation as "building resilience" and "increasing capacity" within human and natural ecosystems to cope with change (Berkes and Folke 1998; Folke et al. 2002; Holling 1973). Ecologists also define adaptation slightly differently – it is defined in the evolutionary sense – which can add to the overall confusion and demand a careful assessment of the context in which terms are used.

In addition, where the focus is on creating safer more resilient communities, discussions and documents routinely use such concepts as reducing risk, reducing vulnerability, natural disaster reduction, and hazard reduction without drawing distinctions and assuming understanding (ICLR and EPC 1998a, b). Such terms and concepts expand the lexicon of risk management and can provide helpful distinctions, if they are well explained and placed in context. The purpose here is not to discuss these terms in detail, but rather to note the need for clarity in literature addressing issues related to hazards and the risks they pose to humans. Underlying all such terms is the desire to better understand human exposure and, from this knowledge, influence decisions towards achieving safer communities throughout the North for all populations groups.

While many key words in the natural hazards/climate change dialogue are similar in meaning, disaster mitigation is an exception as it refers to all kinds of disasters, including non-natural disasters and those natural disasters that are not climate related such as earthquakes, tsunamis, and other geophysical events. Such definitional differences and subtleties are an integral part of the research landscape, whatever the subject. However, it is worthwhile underscoring such anomalies, when we endeavour to shed light on complex issues and potential linkages between different, but related, fields of research. In this paper, the terms will be used as they apply and are understood, in their respective climate change and natural hazards fields of research.

3. The Contribution of Traditional Knowledge

The effects of climatic warming on local environmental conditions have been registered by the indigenous people living in the North. Elders report that they are seeing species of birds and animals farther north than previously recalled, and new species are appearing that have never been seen before. Elders also note that the weather is more unpredictable that it used to be (Krupnuk and Jolly 2002)[4].

3.1. Dene approaches to natural hazards

Indigenous people have a long history of survival in vulnerable environments, using their mobility to find needed resources. Traditional indigenous cultural systems, for example, adapt housing to local conditions, representing sensitivity to environmental risks. Moreover, their oral history speaks to avoidance of locations associated with natural hazards (Tetso 1989, p. 8). In part, this attention and the ability to assess risk are cultural mechanisms, which have enhanced group survival under often difficult, but predictable conditions. We will illustrate the general view, noted as indigenous, by making specific reference to Dene. This approach has the usual strengths and weaknesses. For example, not all indigenous people behave as the Dene, just as not all Dene are consistently the same over time. The particular actions of each indigenous culture do not necessarily reflect what other indigenous people have done. Given this inherent variability within cultures, it is important to be careful not to generalize to a pan-generic "Indigenous." Most indigenous people themselves, for example the Sami, will make specific reference to how people cope with natural hazards, down to the level of particular families or noted individuals. Having said this, there is value in making general comments about the relationship between natural hazards and indigenous people, to illustrate the problems related to the influence of climate change on how indigenous people interact with the natural hazards they must cope with.

Some indigenous people traditionally avoided locations such as those high in naturally occurring heavy metals and radionuclides, for example the Sahtu Dene avoided the mine site of Port Radium before mines were established there (Blondin 2002, p. 13). Indigenous people found various ways to minimize risk, as risk avoidance was embedded in their cultures and cosmologies, as much as was the maximization of benefits (i.e., harvesting species at times of peak concentrations, such as spawning). In many cases though, particularly the location of communities, the avoidance of natural hazards is limited and requires effective adaptive strategies and lately some structural mitigation. Attawapiskat, Ontario, a Cree community slightly upstream from James Bay on the Attawapiskat River, was situated, as were many other communities in northern Canada, where trading, religion and later education and medical services were provided. Organizations were drawn to such locations as they functioned as traditional summer gatherings spots, in part due to adequate food sources, often fish. Thus over time, temporary meeting places became permanent settlements, with little or no consultation or consideration of local knowledge about devastating spring floods caused by ice jamming. Recently, amid much controversy, dykes have been built around Attawapiskat to cope with the flood hazard, though success is questionable and the visual impact disturbing to some. The sad implication of the location choice of many northern communities is a significant exposure to flooding. Indigenous people throughout northern Canada continue to live with this risk, which could well be exacerbated by extreme weather resulting from global climate change.

Risk assessment can be found in traditional and sacred stories. For example, one of the traditional stories told about the creation of the Dehcho (Mackenzie River) is that the spring came and then the snow returned before there was summer (Tetso 1989, p. 8). The snows returned and the people suffered greatly. Eventually the Dehcho was created and the Dene were able to find much food and dry meat along the great river. Telling this story would remind the people to always maintain a supply of food, even when there was the assumption that spring and summer would lessen the hardships of winter, bring greater availability of game, ease travel on the land, and bring expected conditions. The stories would teach where the highest opportunity to find food was, but they would caution Dene to show respect for the land, whose climate could change from the usual conditions to being unexpectedly cold. Are such approaches adaptive or purely cultural in achieving enhanced resilience to change? Either way, indigenous people have a heritage to draw on that has the potential to mitigate the impacts of unusual conditions, though the capacity will be constrained by reduced transmission of traditional stories, the value the stories are given as communities modernize, and the conditions indigenous people have inherited with permanent communities. To reiterate an earlier point, the inherent adaptive capacity of indigenous people, for example spring flooding, can be romanticized, when in fact it may be eroding. If this is so, then we risk encouraging the belief that adaptive skills remain strong, while vulnerability to more extreme events may be increasing. Put another way, should climate change lead to more extreme events then the 1:500-year flood could become the 1:200-year flood and the 1:25 the 1:10, creating an increased return period of events of the same magnitude? Few have asked these questions, and fewer still have presented answers, however tentative.

3.2. Indigenous involvement in climate change research

Indigenous people had to adapt to constant environmental changes and have consistently employed coping actions, such as temporarily shifting camps, to reduce their vulnerability to hazards and disasters (Newton 1995). Life in the North demanded such capacities, just to survive. Traditionally, indigenous people have been highly resilient to the forces of change, and consequently, did not consider themselves, their families or their communities to be vulnerable. Survival skills were handed down from generation to generation and became part of everyday life. However, the rapidity of recent changes in the North makes it more difficult for Indigenous people to maintain this way of life, eroding some coping skills. Similarly, southern Canadians, especially urban dwellers, have few of the adaptive coping skills of their forefathers. The cumulative effects of climate change and other forces of change affecting the region – such as globalization, oil and gas development, population expansion, diamond mining, and wilderness tourism – has resulted in many communities taking steps to ensure that their culture and ways of life continue to be sustained in the long term.

Variation of climatic conditions is integral to how indigenous people have lived, making change common and thus accepted. In general, they have both local information and sacred stories that speak about the way climate was and is meant to be. Recently, Tampere Polytechnic initiated a multi-year education oriented project to document indigenous observations of climate change in the northern regions (www.snowchange.org). The phenomenon of general atmospheric warming and accumulation of greenhouse gases following industrialization is influencing how indigenous people are thinking about climate change, in particular, discourse from international discussions of greenhouse gas emissions and global warming (Brown et al. 2000, pp. 5–6). For northern communities, changes in climate are being lived as locally specific impacts, often due to extreme or unusual natural hazards, as well as being felt through policies and programs aimed at mitigation and adaptation. The latter often has little to do with the local or even regional realities.

In 2002, Dene began to document their observations and knowledge of climate change, keeping pace with other indigenous people who had contracted academics, students, and environmental NGOs to do this work (Paci et al. *in press*). These projects contributed to larger policy initiatives around the Kyoto Protocol, UNFCCC, and the Arctic Council's Arctic Climate Impact Assessment (ACIA). Furthermore, the way that international agreements are implemented by national governments, and in turn initiated at the provincial/territorial or other regional or local level has had a profound impact on how indigenous knowledge is, if at all, entering the climate change discourse. A good example of this is the establishment of Arctic Energy Alliance in Yellowknife and the Northern Climate ExChange in Whitehorse. Indigenous people created neither institution, however, both have relied on indigenous knowledge, anecdotally, to implement climate change programming designed south of 60° latitude. Another example is the Government of the Northwest Territories Greenhouse Gas Strategy, a strategy that negates indigenous knowledge by focusing solely on measures that reduce greenhouse gas emissions. To some extent the development of national government policy and programs frame indigenous understanding of climate change.

Since the 1980s, for example, the Canadian government has developed various programs for dealing with climate change in northern Canada. In particular, Canada developed the North Environmental Strategy (AES) and Canadian Climate Action Fund (CCAF). These two examples of government policy had a profound influence on how the response to climate change is being shaped for northern Canada. The diverse interests of academics and scientists have been driving northern climate change research independent from local communities. In addition, several government departments have dedicated climate change programs and policies, which continue to follow the trajectory of the North as hinterland or colony (Innis 1956).

The problem with many of the Canadian national programs and policies are that they are largely divorced from real and meaningful public participation by northern citizens. For example, the Canadian Climate Change Secretariat is engaged in a number of initiatives, most notably the modelling of climate change impacts. The 2002 national roundtables, which were part of Canada's Climate Change Plan, "commits to ongoing collaboration with Aboriginal and northern Communities to build capacity to address their particular priorities" (Markbek Resource Consultants 2002). However, to date collaboration has not occurred. Part of the salve to this weakness is to set priorities in consultation with Aboriginal and northern communities and the federal, provincial, and territorial governments.

At the circumpolar level, indigenous people are approaching climate change independently and as a result there has been an uncoordinated input of their views, needs, and priorities in the international discourse. The value of bringing forward indigenous views and knowledge and of including local knowledge of climate change is a significant issue (Nunavut Tunngavik Incorporated, Kitikmeot Inuit

Association and Qikiqtani Inuit Association 2001; Dene Nation 2002, 2003). It will be equally important to continue to examine how traditional knowledge is interpreted and communicated to people who may lack the historical and anthropological knowledge necessary to understand what indigenous people are saying (Krupnik and Jolly 2002). This problem of translation is particularly pronounced in climate change because of its heavy reliance on physical scientists who may make scientifically sound, but locally inappropriate recommendations and decisions. One method used in the Canadian North has been for the national and regional indigenous organizations to host workshops to share, document, and protect local and traditional knowledge as an efficient way of contributing to national and international discussions on climate change. For example, Dene Nation has hosted two climate change meetings of the Denendeh Environmental Working Group.

Climate change impacts on food security are a significant concern for most indigenous people in the North. This area of concern has lead to a research project (by H.M. Laurie Chan at the Center for Indigenous Nutrition and Environment (CINE) at McGill and Chris Furgal of the University of Laval), which is currently in the data collection phase and anticipates results towards the end of 2004. The research is being undertaken in partnership with Dene Nation (Chris Paci), Council of Yukon First Nations (Cindy Dickson), and Inuit Tapariit Kanitami (Scot Nickels). In Denendeh (NWT) Deh Gah Got'ie Dene Council (Fort Providence) is participating in the research to establish potential vulnerabilities and opportunities of climate change in relation to the traditional Dene food system. One objective of this research project is to understand the potential health impacts of climate change. Health impacts vary from physical health of individuals to the mental and spiritual health of families and communities. Climate change may be a threat to traditional cultural practices, for example warming may decrease the ability of hunters to find species, such as caribou, as other species, such as deer, migrate in from southern regions. Other implications of climate change may include decreasing the reliability of traditional knowledge in decision-making around understanding and predicting local weather patterns. Such negative feedback may lead to rejection of traditional knowledge and elders in the overall social structure of Dene communities. Consequently, climate change may have more impacts than the physical vulnerabilities and hazards leading to increased rates of land and water-based accidents. Village life and access to harvest sites can be disrupted by the melting of permafrost which can also damage roads, pipelines, and infrastructures, leading to sanitation and contamination concerns, and even the need to relocate entire communities. Climate change may result in new and increased rates of infectious disease, including those found in wildlife that can be transmitted to humans. Plants used in traditional medicine may be more difficult to find. The migration patterns of some wildlife may be changed, thus influencing the diet of local residents with important direct and indirect implications to health.

Deh Gah Got'ie is participating as a "case study" representing a Dene community with strong ties to the land, in particular hunting, trapping, berry picking, and fishing.

Researchers are looking to document the adaptive strategies based on Dene knowledge of climate change with the goal of finding ways to minimize potential impacts on food security. A research agreement has been developed to protect the community and to share with the academic community important traditional knowledge. The project will take three years and should be complete in 2007. The research team is now gathering documentary sources specific to the question of climate change and food security. The research team hopes to develop a comprehensive resources management scheme that will respect Dene traditional knowledge, wildlife biology, information on toxicology of environmental contaminants, food composition and nutrient requirement, food availability and effects of environmental changes, cultural and socioeconomic factors. In each year, education and communication initiatives are planned to assist individuals in making informed decisions about their food choices. The research strives to be participatory and to ensure community members' involvement and/or training at all stages of research, including the initiation, planning, implementation, and communication of research findings.

4. The Northern Implications of the UNFCCC

Under the United Nations Framework Convention for Climate Change (UNFCCC), emphasis was placed for most of the 1990s almost exclusively on the need to reduce GHG emissions with the ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere. From a northern perspective, a fundamental concern with the UN Convention is that the level of discourse, as has traditionally been the case, is at the international level between nation states. The current operational focus on national state-to-state dialogue and negotiation leaves the most pressing problems of climate change in the circumpolar north – the regional affect of greenhouse gas emissions – without a direct, strong voice at this table. Consideration of northern issues is indirect, through Canada's designated representatives. The interest of the three territories becomes only one aspect of a national agenda with many other important, though different, considerations. Nonetheless, it is extremely important for the international dialogue between nation states regarding climate change to be strengthened, as this is the primary hope for the North in terms of reducing the projected impacts. However, largely because the international process has not yet succeeded in stabilizing greenhouse gas emissions, adaptation actions by northern governments and residents are now becoming an immediate and necessary component of the northern climate change agenda, though unfortunately not yet a central, strong part of the national policy. This need is not expected to subside given the degree and magnitude of climate change that is projected for this region and the challenges of mobilizing concerted global actions, at a scale sufficient to realize even the initial reductions in GHG emissions proposed within the Kyoto Accord.

Both indigenous people and national/regional governments in the North are reliant on fossil fuels to heat homes, power transportation, and drive industries. Fossil fuel is enabling the development of northern urban centres, such as Yellowknife, NWT, and to a lesser extent, Inuvik, NWT, which are contributing to GHG emissions, though to a very small degree when compared to the rest of Canada. Further compounding this problem is that over the last 50 years most indigenous communities in the north became more established and dependent on the available technologies of the day (e.g., diesel generated electricity, air access, electric heating, energy-efficient housing, etc.). Such technologies were, and still are, based on a southern model which indigenous communities were encouraged to embrace, and in their own way, felt a right to have. Improvements have been made to respect the harshness of the winter environment, particularly in better housing, although the application is uneven and a large backlog of old housing stock remains throughout remote communities.

Not all indigenous people living on the land willingly accepted the move to permanent locations. As mentioned earlier, the provision of health care and education drew families to settle in trading centres, which in most cases evolved into today's communities that exist primarily as isolated off-grid settlements of 800–3000 people, accessible by air, winter roads, and occasionally major water ways. Today, some elders are questioning the wisdom of this path, although the momentum towards urban style housing, electricity, and motorized transport has become culturally integrated, encoded in policies and programs, and increasingly viewed as part of everyday life. Such inverse logic represents part of the hidden, and thus largely unaddressed, contradiction between the historical indigenous capacity to cope with hazards and the evolution of permanent communities in a manner that may inadvertently undermine that capacity – witness the tragic destruction of Winisk, Ontario (located a few kilometres from Hudson's Bay on the Winisk River) in 1985 by raging flood waters that swept away over 100 buildings, though miraculously caused only two deaths. After much debate, the community was rebuilt further upstream on higher ground and renamed Peawunack.

Northern development is trapped in an escalating cycle of use and impacts caused by reliance on fossil fuels that can be mitigated somewhat by adopting less damaging (from a GHG perspective) technologies such as wind, solar, hydro, and photovoltaics. However, whether these technologies will be made available in the North and to indigenous people, once development catches up, remains to be seen. Demonstration projects during the 1980s, such as the Fort Severn wind-powered generation or the Big Trout Lake photovoltaic installation, were encouraging but have not translated into widespread application. More encouraging advances have been made in energy efficient building construction and high efficiency wood stoves, perhaps due to the resultant improvements in quality of life as well as energy saving.

Since 1999 emphasis is beginning to be given to the reduction of vulnerability to climate change, called "adaptation". Adaptation is in fact recognized in the UNFCCC as a necessary part of the portfolio of responses to climate change and provision is made for the developed country parties to the Convention to assist the most vulnerable (developing country) parties in meeting the costs of adaptation.

While the global stabilization and reduction of GHG is the best long-term solution for the North to reduce climate change impacts, adaptation will be, by default, a necessary strategy to allow northern communities, industries and ecosystems to cope with projected impacts until international greenhouse gas emission reduction programs take effect (Rosentrater and Ogden 2003). The magnitude and diversity of pressures facing the North are unprecedented in human history, and the pace at which change is occurring in the North leaves no room for delay in developing a fuller understanding of the coping capacity needed over the next 10–30 years.

4.1. Regional status of climate change action

Each of the three territories – Yukon, Northwest Territories (NWT) and Nunavut – are at different stages striving towards the concurrent tasks of: (1) developing strategy and action plans, and (2) initiating the implementation of those plans, or where that is premature, identifying the climate change components of existing programs and initiatives. As well, the various components of each territory's climate change policy vary in focus, and have yet to attain an operational balance between impacts and adaptation initiatives and GHG mitigation actions. Some would argue that the recent emphasis on promoting oil and gas developments in the Yukon and NWT would indicate that northern governments have not yet achieved a balanced energy strategy (CARC 2003). The Mackenzie Valley natural gas pipeline, a large-scale energy development project, has the potential to dramatically alter the emissions projections from the North, not to mention the associated economic, environmental, social and cultural impacts.

The largely singular focus on the stabilization of GHG is natural, but must be augmented to deal with the time lag of even the most optimistic timing of global GHG reductions. The tendency to place emphasis on mitigation activities evolves from the global attention to the reduction of GHG and a history of off-oil and energy conservation efforts. By comparison, tangible policy options for adaptation are harder to grasp, seem to address a less immediate need, and are less of a focus in national policy. However, on an international scale, adaptation is gaining wider support. It is well recognized that many long-standing programs and initiatives, particularly in the areas of energy efficiency and alternate energy, will help northern jurisdictions address their climate change objectives. The high cost of transporting fuel to northern communities makes the argument compelling, though as the federal Remote Community Demonstration Program found in the 1980s, there are many challenges to achieving energy reduction in northern communities. The challenge here, which has been taken up in collaboration with sectorial and national programs, is to integrate the territorial components of these programs into the evolving national strategies and action plans. Progress has been made and more will follow in the coming years. On the climate change file, the three territories are cooperating to deliver their message in Ottawa and international fora.

4.1.1. *Northwest Territories*

In March 2001, a draft Greenhouse Gas (GHG) Strategy (GNWT 2001) was approved by Cabinet to guide the stabilization and reduction of GHG emissions in the Northwest Territories (NWT), however, a companion adaptation strategy remains to be developed in order to achieve a balanced approach. The strategy included an action plan structured according to the five national theme areas: (1) enhance public awareness and understanding; (2) government leading by example; (3) encourage action across and between sectors; (4) promoting technology development and innovation; and (5) investing in knowledge/building the foundation (GNWT 2001). Initiatives were identified under each theme. Some initiatives have been started while others await implementation in coming years as specific activities are structured, approved, and funded. In the NWT there are three primary sources of emissions: electrical generation (diesel), space heating (fuel), and transport. The North Energy Alliance plays a key role in the emissions reduction strategy through education, awareness and community consultations.

To reach their objectives, greenhouse gas considerations will need to be integrated into NWT projects in all sectors. The strategy is viewed as a "living document" and will therefore be revised in future years as more information becomes available. Following the schedule of the National Implementation Strategy on Climate Change, the NWT Greenhouse Gas Strategy has three year rolling business plans that will be updated by January 2004. An advisory panel oversees the implementation of the strategy under the direction of the Minister of Resources, Wildlife and Economic Development.

In light of energy efficiency activities already underway, the initial thrust of the strategy is to slow emission increases. Progress on climate change in the NWT will be dependent on funding levels and the need to consider the implications of a recent upswing in the oil and gas industry. Moreover, the NWT will need to re-assess subsidies to remote communities, and provide stronger support for community efforts to reduce greenhouse gas emissions. A complementary approach directed towards assisting residents, businesses, and other organizations adapt to future changes in climate is under consideration. Over the long term an effective strategy for the Northwest Territories must incorporate both approaches. Given the pulse of gases already in the atmosphere from international sources, it is evident that some form of adaptation will be required, no matter what reduction efforts are made in the NWT, across Canada, or globally.

In July 2003, the Government of NWT released the NWT Energy Strategy (GNWT 2003). The document outlines the directions the NWT can take to reduce the cost of energy, the use of imported fossil fuel and the impact of energy development on the natural environment.

4.1.2. *Nunavut*

Since the establishment of Nunavut in 1992, strategies and action plans to address climate change implications have been under development. The two-part Nunavut

Climate Change Strategy was initiated in 1999. It was developed to reduce increases in emissions, and address adaptation to anticipated impacts, with a business plan to meet the goals and objectives of this strategy, modelled after the national plan. Expanding and updating the database of key information is a crucial task. Nunavut must collect and document information on climate change, and this knowledge must be effectively communicated between science and government. In addition, the government of Nunavut will continue to support its energy management and renewable energy projects.

The challenges faced by Nunavut, including climate, size and population distribution, complicate climate change action, as does community dependence on diesel-generated electricity. Equally problematic for Nunavut are the challenges associated with adapting to a changing climate where the options are few and the projected impacts appear to be severe, though not as dramatic as the models projected for the western North. As well, economic activity has increased because of industrial development. The government has approved a climate change strategy for Nunavut that acknowledges the dependence of a significant portion of the population, who live in small isolated communities or camps on the natural environment for food and sustenance through hunting, fishing and trap lines. Nunavut's strategy also includes initiatives to reduce greenhouse gas emissions and raise awareness of climate change, though the small dispersed population, harsh climate, and long travel distances make meaningful reductions, in the Canadian context, impossible.

4.1.3. *Yukon*

The Yukon government has played a major role at national and international meetings on climate change, including the recent Sixth Conference of the Parties to the Kyoto Protocol (COP 6), insisting that Canada highlight Northern concerns at these conferences and in day-to-day negotiations in the future.

The Yukon Government is working towards completing a climate change strategy for the Yukon. A key element in that plan is the Northern Climate ExChange (NCE) at Yukon College, designed to act as a catalyst for climate change action and as a hub for public education and outreach in the North. One of NCE's initiatives is to increase awareness of climate change issues and responses through community workshops and the compilation and dissemination of research information. Other initiatives are the Energy Solutions Centre and an inventory of climate change actions. In the Yukon, immediate climate change action will focus on the development of a climate change action plan, reviewing provincial and territorial plans, and refining the greenhouse gas inventory.

4.2. Broadening the Context of Climate Change

Losses from natural disasters and the impacts of climate change both depend to some degree on the way and extent to which people and their governments have chosen to expand industrial activities, develop settlements, and guide economic growth. Economic factors, such as transportation, often directed the location of human activities close to high hazard zones, and minimal building and design standards contributed to increases in vulnerability. Whether in the North or elsewhere, all governments have contributed to the vulnerability of their populations, often knowingly so, by their own policy choices and development practices. Perhaps the main difference is the ability of wealthy nations to more easily sustain the economic impact of hazards (e.g., earthquakes in Japan or hurricanes on the American east coast) without international aid.

Similarly, the vulnerability of all countries to natural hazards and to the implications of climate change depends to some degree on their own domestic or internal policies and on their international context (e.g. net providers or recipients of wealth). Nobody, either person or country, can be said to be entirely without responsibility for their own circumstances, nor can they be said to be entirely independent. No person is truly isolated, however no person, or country, is without some isolationist characteristics. And indeed, some possess a greater isolationist tendency than others, which often hampers effective discourse on issues such as climate change, and the natural hazard extremes this change can create, as these conditions transcend borders.

It is our observation that in the post IDNDR era the situation has dramatically changed. Not only has the disaster community come to realize the importance and the potential advantages of linking their efforts to climate change and the UNFCCC, it has also become apparent to the climate change community that the significance of climate change to those impacted will not be only or even primarily in changes in mean temperatures, but much more in the changing pattern of climate variability and extreme climatic events at specific localities. The interests are converging, and the search is on for ways of bringing the climate change and disaster communities into closer cooperation for their mutual benefit.

The delay in arriving at this understanding is due in large part to the different social construction placed upon natural disasters and climate change, and their historical evolution described above. There is another regional (north-south) factor that has also played a role. Severe natural disasters are most prominently the concern of developing countries, as their development can be hindered or set back years when a major disaster strikes. By comparison, long-term changes in mean temperatures seem much less significant. The industrialized countries also suffer losses from major natural disasters, but the losses are a relatively small fraction of their GDP, and the countries are sufficiently wealthy to be able to recover very rapidly. Therefore, developed countries are more interested in the prospect of longer-term changes in climate norms and the potential threat to their well-established socio-economic development model to which, since the Bruntland Report (WCED 1987), the word "sustainable" has increasingly been applied. While developing countries are still inclined to the short-term view and the pressing problems of development, developed countries have become more aware of the short-term as well, particularly as losses rose exponentially during the 1990s. Moreover, widespread media reporting of extreme events (the 2002 floods in eastern Europe and the 2003 heat waves in western Europe, for example) enhanced interest and stimulated discussion of linkages to climate change, even though atmospheric scientists tend to deny a direct attribution and say only that more variability and extreme events are what one might expect with climate change (Reinhart 2003).

Economic imperatives, often combined with physical attraction, have often spawned significant efforts to control the natural hazards threatening a location. Most communities on rivers and coastal locations, including those in northern Canada, are examples of this tendency towards trade dominating, and driving enhancements to achieve a minimum level of safety. Conversely and historically, indigenous people avoided fixed locations, thus reducing vulnerability while maximizing resources wisely. Development (such as fur trading posts, settlements, and churches) had no such concern. Over the last 50 years many people have been drawn to permanent though vulnerable locations (e.g., flood plains), because it was economically advantageous to locate in such places, or because property rights or goods trans-shipment hubs were established there. Too often the exposure to such hazards was not factored into individual or collective decisions.

Over time, the transition in northern Canada from a gathering and hunting lifestyle to one dominated by living in a permanent location has, and will continue to have, implications for who will be impacted by climate change, and how those impacts will be felt by northern citizens. How is responsibility to be distributed and who is to decide? Under the UNFCCC this question is a matter of contentious and ongoing debate. But at least there is a forum where the matter can be debated and there is agreement in principle that responsibilities have to be shared. In the language of the Convention, there are "common but differentiated responsibilities". No such forum exists for natural disasters, especially the linking of such disasters to the evolving influence of climate changes. And while the Decade (IDNDR) led to the creation of the International Strategy for Disaster Reduction (ISDR) this, and its Secretariat, carry nothing approaching the weight of the Climate Convention. This circumstance has led to a growing recognition in the natural disaster community that there is much to be gained by linking natural disaster vulnerability to climate change vulnerability. The UNFCCC might be used as a vehicle to go beyond what the IDNDR and the ISRD have achieved and to make more rapid progress, especially in making international funds available for disaster mitigation on a non-charitable/humanitarian basis.

Consideration of any such linkage was nascent, and has only just begun to emerge in the post-IDNDR era. At the time the IDNDR was getting underway in the late 1980s, those involved gave little attention to climate change. The negotiation of the UNFCCC in 1992 came as a surprise to many in the disaster community. Similarly in the climate community, the priority problem was seen as the need to bring under control the long-term problem of atmospheric pollution by greenhouse gasses. The Convention was justified by the global nature of the threat (disasters were seen as local), and the recognition that it would take decades of concerted action to bring GHG emissions under control. Consequently, politicians and advisors viewed the climate change issue as long-term and requiring board-based engagement, action, and institutional frameworks.

The activities within each country designed to assist indigenous communities, such as those in northern Canada, to cope with the projected impacts of climate change have yet to enter significant national and international discussions. The UNFCC reference to traditional and indigenous knowledge, and the resulting adaptation capacity, has been given little attention because of the dominant focus on the reduction of GHG emissions. However, it is important to note that the climate change initiative should be viewed in the larger context of Agenda 21 (United Nations 1992), which embraces a much wider range of community-focused initiatives.

The existence of funds for adaptation under the UNFCC highlights another important difference between hazard mitigation and climate adaptation. Action at the international level to promote adaptation to climate change has been agreed in principle as part of the UNFCCC. Assistance to developing countries is being suggested as a mechanism to mitigate development, which will lead to greater GHG emissions. Some level of "rent" to assist developing countries is seen as a means to pay for valuable environmental services. The provision of financial assistance is in principle, mandatory, although the level has not been specified, and there is currently no agreement about it. There is no such Convention for natural disasters and the funds that are provided for both humanitarian relief and disaster mitigation are therefore in the form of charity/humanitarian assistance. The rationale for this difference is that the developed industrialized countries have accepted the point that they are responsible historically for the overwhelming part of the greenhouse gasses now resident in the atmosphere, and that this makes them collectively responsible for climate change in a way that they are not for natural disasters. The pattern of GHG emissions is set to change as energy production and consumption grow rapidly in the developing countries, especially from a few of the larger ones, such as Brazil, China, and India, although there is still debate about the rate and distribution of changes. No developing countries have yet agreed to manage their own emissions in the way that the overwhelming majority of the developed countries have done by ratifying the Kyoto Protocol to the Convention.

Global circulation models (GCMs), sometime also called global climate models, have been developed to generate scenarios of world climate patterns in the latter part of the 21st century when GHG concentrations have been projected to reach double (or later triple) their pre-industrial levels (IPCC 2001). The projections have been translated into expected increases in global mean temperature (IPCC 2001). While the global distribution of mean temperature increases was reported, little or nothing was said about climate variability in this Third Assessment Report (IPCC 2001). The spatial coarseness of the models was also such that little could be said about the specifics of climate change in particular localities. Consequently, advising policy makers how much impact climate change would have in the long-term and therefore how much urgency should be given to getting on with the process of GHG "mitigation" presented a difficult scientific challenge.

5. Current and Future Policy Implications

Every so often international bodies create a point of departure for an issue that can become a benchmark. In 1997, the Bruntland Commission (WCED) issued *Our Common Future* and placed 'sustainable development' in our lexicon. In 1992 the Earth Summit in Rio sought to address global issues creating hope but delivering little more than good intentions. In 1997 the Kyoto Accord provided a global policy context for action on climate change, the realization of which remains in question. History will show that these efforts to address complex global issues were helpful, even necessary precursors to actions yet to be taken, but not sufficient to move leaders and populations from their path of perceived progress. Such initiatives focus attention, momentarily, and provide a point of departure as well as much needed reference points to chart progress, or lack thereof, on issues of import. Reflection on the past 15 years shows a political ineptness to grapple successfully with the complexity of these issues in a concerted manner, leaving the way forward murky, uncertain, and inconsistent.

The inability for climate change to be managed effectively by international dialogue is to be expected despite good intentions, given the divergence of national agendas and the tendency for local interests and domestic protective policies to take precedent. With over a decade of regional and national initiatives to investigate and address sustainability, climate change, and natural hazards in Canada, and to a more limited extent in the Canadian North, the hope placed in the continuation of these efforts is questionable and calls for a reassessment and exploration of different approaches. Perhaps a course similar to the *Disaster by Design* (Mileti 1999) approach proposed for natural hazards in the United States should be considered. No route will be free of setbacks and challenges that in the best of situations redirect effort and energy on new, more fruitful paths where small, incremental steps begin to achieve complementary objectives. However, unless such concerted efforts are integrated at the community, regional, national, and on the more difficult international scale, progress will be limited, resulting in further climatic shifts in northern Canada and the subsequent increase in extreme natural hazards. To move towards results that are meaningful to individuals and communities, an increasing effort must be placed at the local, community level, not just to use energy more efficiently but to also grapple more directly with an understanding of these extremes and how individuals and communities might cope better. Placing emphasis on the local community level allows citizens to assume responsibility and can empower them to act in their own best interests as a more cohesive group. This approach bears investigation. To stimulate thinking and discussion, we present some preliminary ideas with respect to a framework of action, tools needed for implementation, and indicators of progress.

The framework we propose is organic in character; a coarse integration of three ideas that build on concepts yielding progress elsewhere. First, any step that is taken must possess the integration among immediate benefit and longer-term regional, national and global implications. This builds on the holistic character of indigenous knowledge and reinforces that, to engage people, the benefit must be local and improve their quality of life. Second, a concerted effort is needed to identify and reduce local threats through an assessment of vulnerability and actions that minimize the potential of loss should the threat be realized. In taking such local actions, which in the climate change lexicon would be considered adaptive strategies, sustainability is enhanced and safer communities created. Third, to achieve a modicum of success with the first two areas requires a better understanding of how people cope with changing conditions, in this case an increased frequency of natural hazards (Newton 1995), for the foundation of progress is change, which has been exceedingly rapid in northern communities. The results of people's capability to mould themselves to changing conditions and environments are evidenced by the tenaciousness of human survival in the Canadian North and elsewhere. Yet more extreme events will test this resolve, and extract a high economic and human price if individuals and northern communities are not better prepared to cope. Only through embracing the inevitability of climate change, and drawing on their strength and knowledge to cope, will residents have a hand in shaping the emergence of the future face of northern Canadian communities.

Efforts to cope with more frequent extreme weather conditions affecting northern communities will need simple, intermediate technologies, hands-on methodologies, and the incorporation of local indigenous knowledge applied through local government and institutions (e.g., Band Councils, schools, churches, businesses, etc.). Such approaches must have the ability to interpret each community's context, and evolve relative to the vulnerability caused by extreme conditions. For example, the food security study previously mentioned involving Fort Providence has recently been initiated in a Yukon First Nation community. As well, Nunavut and northern Quebec are modelling a decision-making matrix, plugged into various climate change scenarios to explore the nature and contribution of related traditional knowledge.

In keeping with the dominant approach adopted under the UNFCCC, Canada, has focused most of its attention on climate change mitigation. By ratifying the Kyoto Protocol, Canada has made a commitment to reduce greenhouse gas emissions six percent below the 1990 level by 2010. Most effort at the Federal level is currently directed to developing the means of achieving this goal. This has little relevance to the Canadian North, which is now the source of only a minute fraction of Canada's greenhouse gas emissions, though this could increase if widespread thawing of the permafrost results in substantial methane emissions. However, such conditions result from changes in natural systems, not by actions of residents. The primary cause is still global.

Consequently, the Premier of Nunavut stated in a speech at the Arctic Climate Workshop (CFCAS in press) that the focus of his government is on GHG mitigation, however, they also need to address adaptation now, and will certainly have to in the future. Unfortunately, such actions do not fit the current national and international policy position and there is concern that any deviation towards adaptation might undermine the constant message of GHG reductions. Moreover, any indication that northerners and indigenous people can adapt successfully may cause others to consider their adaptive capacity and raise disturbing questions about the necessity of taking costly and difficult actions to reduce GHG. Nonetheless, as has been noted (Rosentrater and Ogden 2003), adaptive strategies, if implemented in the north, may do little more than "buy time" while broad based international mitigation measures take effect and recalcitrant nations are encouraged to participate.

The intent of the Whitehorse Declaration on Northern Climate Change (n.a. 2001) was to present a balanced perspective of the need for both mitigation and adaptation, as reflective of the political and policy framework at the time. This balanced approach was deemed to be necessary because conference delegates recognized that northerners are, per capita, the largest emitters of greenhouse gases in Canada, although the volumes are a minute percentage of Canadian GHG emissions and the result of unique environmental and transport conditions. Moreover, regardless of the efforts of northerners reducing emissions, adaptation measures (see Figure 3) are deemed essential to help the region prepare for the inevitable impacts of climate change, quite possibly resulting from more severe natural disasters. Current Government of Canada initiatives, including the Climate Change Action Fund, continue to reinforce the emphasis on emissions reduction rather than a more diversified agenda respectful of the conditions and needs of northern Canada.

In the North, a shift of emphasis toward adaptation is required as there is very little northerners and indigenous people can do about GHG levels because they contributes so little to global emissions. More consideration should be given as a matter of priority to how to move the adaptation agenda forward in the North, including how to develop synergy between climate adaptation, sustainable development, and mitigation of GHG emissions, and how to link and integrate climate change adaptation with natural disaster reduction. In conclusion, we would argue that northern jurisdictions should insist that emissions in southern Canada and globally be reduced to limit the significant changes projected. Concurrently, northerners require financial assistance to understand adaptation better, explore the climate change – natural hazard linkage, and implement adaptive strategies relevant to all northern residents. Only through a comprehensive, coordinated program of policies and actions will northern communities attain improved capacity to cope with projected changes, thus creating over the long term safer, more resilient communities in which to live.

Notes

1. The authors would like to thank Ian Burton, Ph.D., Scientist Emeritus, Meteorological Service of Canada, for his assistance and contribution to early drafts of this paper.
2. For the purposes of this document "Northern Canada", or simply the "North" is defined as the combined jurisdictional boundaries of the Yukon, the Northwest Territories and Nunavut, the Hudson-James Bay lowlands of Ontario and Manitoba, northern Québec, and Labrador. It is, however, recognized that other perspectives of "the North" exist based on geophysical, ecological and cultural characteristics.
3. For further information on this initiative see www.gewex.org.
4. The publication *The Earth is Faster Now: Indigenous Observations of North Environmental Change* documents observations of change from the perspective of 23 indigenous communities in the North (Krupnik and Jolly 2002).

References

Berkes, F.: 1999, *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*, Philadelphia, Taylor and Francis.

Berkes, F. and Folke, C.: 1998, *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*, Cambridge University Press, Cambridge, UK.

Blondin, G.: 2002, 'Need for Community Healing', in *Action Plan. To Address Concerns Raised by the Community of Deline About Risks to Human and Environmental Health from Exposure to Radiation and Heavy Metals from the Former Port Radium Mine, Great Bear Lake (NWT)*, Canada-Deline Uranium Table, 2nd edn., for the Deline Band Chief and Council and the Minister of DIAND.

Brown, L.R. et al.: 2000, *State of the World 2000*, New York, W.W. Norton and Company.

Burton, I.: 1998, 'Adapting to climate change in the context of national economic planning and development', in *Africa's Valuable Assets – A Reader in Natural Resource Management*, World Resources Institute, Washington, pp. 195–222.

Burton, I.: 1996, 'The growth of adaptive capacity: Practice and policy', in *Adapting to Climate Change: An International Perspective*, New York, Springer-Verlag, pp. 55–67.

CAFF: 2001, *Arctic Flora and Fauna: Status and Conservation*, Edita, Helsinki.

Canadian Arctic Resources Committee (CARC): 2003, *NWT Gas Pipeline Briefing*, Ottawa, Ontario.

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS): in press, *Proceedings of the February 20–21, 2003 Arctic Climate Workshop*, Ottawa, Ontario.

Chapin, T.: 2002, *Vegetation Feedbacks Explain Recent High-Latitude Summer Warming in Alaskan Arctic and Boreal Ecosystems*, Eos. Trans. ATU 83(47), Fall Meet. Suppl., Abstract U71A-08.

Cohen, S.: 1995, 'Mackenzie Basin impact study final report', in S. Cohen (ed.), Environment Canada, Ottawa.

Dene: 2002, *The Denendeh Environmental Working Group: Thebaghche Workshop*, Environment Canada Report.

Dene: 2003, *The Denendeh Environmental Working Group: Liidlii Kue Workshop*, Environment Canada Report.

Dotto, L.: 2000, *Storm Warnings: Gambling with the Climate of Our Planet*, Doubleday Canada, Toronto.

Dresler, P.: 1999, *US National Assessment: The Potential Consequences of Climate Variability and Change*, Mara Advisory Committee Meeting, May 2–3, 1999, Pennsylvania State University, University Park.

England, J.H., Dyke, A.S. and Henry, G.H.R.: 1998, 'Canada's crisis in arctic science: The urgent need for an arctic science and technology policy; or, "Why work in the Arctic? No one lives there"' *Arctic*, **51**(2), 83–190.

Everett, J.T. and Fitzharris, B.B.: 1998, 'The Arctic and the Antarctic', in R.T. Watson, M.C. Zinyowera, R.H. Moss and D.J. Dokken (eds.), *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, A Special Report of IPCC Working Group II, Cambridge University Press, Cambridge, United Kingdom and New York.

Fisher, A., Neff, R. and Barron, E.J.: 2000, 'The Mid-Atlantic regional assessment: Motivation and approach', in *Climate Research*, Vol. 14, pp. 153–159.

Folke, C. et al.: 2002, *Resilience for Sustainable Development: Building Adaptive Capacity in a World of Transformations*, International Council for Scientific Unions (ICUS), Rainbow Series No. 3, Paris.

Government of the Northwest Territories: 2001, *Northwest Territories Greenhouse Gas Strategy*, Department of Resources, Wildlife and Economic Development, Yellowknife.

Government of the Northwest Territories: 2003, *Northwest Territories Energy Strategy*, Department of Resources, Wildlife and Economic Development, Yellowknife.

Habiba, G. et al.: 2003, 'Climate change and biodiversity: Observed and projected impacts', in *Interlinkages Between Biological Diversity and Climate*, Secretariat of the Convention on Biological Diversity (SCBD), Montreal, pp. 30–47.

Hewitt, R.: 2003, 'What climate change?', in *Topics*, Munichener Ruckversicherungs-Gesellschaft, Munich, Vol. 2, pp. 18–19.

Holling, C.S.: 1973, *Resilience and Stability of Ecological System*, Annual Review of Ecology and Systematics, Vol. 4, pp. 1–23.

Honigmann, J.J.: 1956, 'The Attawapiskat Swampy Cree: An ethnographic reconstruction', in *Anthropological Papers of the University of Alaska*, Vol. 5, pp. 23–82.

Honigmann, J.J.: 1961, *Foodways in a Muskeg Community: An Anthropological Report on the Attawapiskat Indians*, Indian and Northern Affairs Canada, Ottawa.

Innis, H.: 1956, *The Fur Trade in Canada*, Toronto, University of Toronto Press.

Institute for Catastrophic Loss Reduction (ICLR) and Emergency Preparedness Canada (EPC): 1998a, *A National Mitigation Policy*, Ottawa.

Institute for Catastrophic Loss Reduction (ICLR) and Emergency Preparedness Canada (EPC): 1998b, *Better Protecting Canadians from Natural Hazards*, Ottawa.

IPCC: 2001, *Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge.

IPCC: 1996, *Climate Change 1995 – Second Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge.

ISDR: 2002, *Living with Risk: A Global Review of Disaster Reduction Initiatives*, Preliminary Version – July, United Nations, Geneva.

Kenny, G.J.R. et al.: 1995, 'CLIMPACTS: An integrated model for assessment of the effects of climate change on the New Zealand environment', *Journal of Biogeography* **22**, 883–895.

Knight, C.B.: 2000, 'Regional assessment', in *Oxford Encyclopedia of Global Change*, Oxford University Press, New York.

Kovats, S. et al.: 2003, *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change*, World Health Organization, Health Canada and United Nations Environment Programme, Copenhagen.

Krupnik, I. and Jolly, D.: 2002, 'The Earth is faster now: Indigenous observations of Arctic environmental change', in I. Krupnik and D. Jolly (eds.), *Arctic Research Consortium of the United States*, Arctic Studies Center, Smithsonian Institution, Washington, DC.

Krupnik, I.: 2002, 'Watching ice and weather our way: Some lessons from Yupik observations of sea ice and weather on St. Lawrence Island, Alaska', in I. Krupnik and D. Jolly (eds.), *The*

Earth is faster now: Indigenous observations of Arctic environmental change, Arctic Research Consortium of the United States, Arctic Studies Center, Smithsonian Institution, Washington, DC, pp. 156–199.

Lonergan, S. and Woo, M.: 1988, *Climate Change and Transportation in Northern Canada – An Integrated Impact Assessment*, Environment Canada, Downsview.

Loster, T.: 2003, 'Facts, data, trends', in *Topics*, Munichener Ruckversicherungs-Gesellschaft, Munich, Vol. 2, pp. 20–24.

Maxwell, B.: 1997, *Responding to Global Climate Change in Canada's North, Volume II of the Canada Country Study*, Climate Impacts and Adaptation, Environment Canada, Ottawa.

Mackay, J.R.: 1963, *The Mackenzie Delta Area, N.W.T.*, Menoir 8, Geographical Branch, Mines and Technical Surveys, Ottawa.

Markbek Resource Consultants: 2002, *National Stakeholder Workshops: Summary Report*, National Stakeholder Workshop on Climate Change, June 2002, National Climate Change Process (NCCP), Ottawa, Ontario.

McMichael, A.J. et al.: 2003, 'Climate change and human health: Risks and responses', in A.J. McMichael, et al. (eds.), World Health Organization, Geneva.

Mileti, D.S.: 1999, *Disasters by Design – A Reassessment of Natural Hazards in the United States*, Joseph Henry Press, Washington, DC.

Morren, G.E.B., Jr.: 1983, 'A general approach to the identification of hazards and responses', in K. Hewitt (ed.), *Interpretations of Calamity from the Viewpoint of Human Ecology*, Allen & Unwin, London, pp. 284–297.

National Climate Change Process (NCCP): 2000a, *Canada's National Implementation Strategy on Climate Change*, NCCP, Ottawa.

National Climate Change Process (NCCP): 2000b, *A Compendium of Canadian Initiatives National Taking Action on Climate Change*, NCCP, Ottawa.

Natural Resources Canada: 2001, *The Territories*, Online: http://atlas.gc.ca/site/english/maps/reference/provincesterritories/northern_territories/referencemap_view_image.

Newton, J.: 1995, 'An assessment of coping with environmental hazards in northern aboriginal communities', in *The Canadian Geographer*, Vol. 39, No. 2, pp. 112–120.

Newton, J. and Burton, I.: 2001, *An Exploration of Potential Directions for Climate Change Policy in Northern Canada, The Northern Review*, Yukon College, Whitehorse, Vol. 24, pp. 126–141.

n.a.: 2001, *Whitehorse Declaration on Northern Climate Change, The Northern Review*, Yukon College, Whitehorse, Vol. 24, p. 120.

Northern Climate ExChange (NCE): 2002, *Gap Analysis Project: An Assessment of the Current State of Knowledge about the Impacts of Climate Change in Northern Canada*, Northern Climate ExChange, Northern Research Institute, Yukon College, Whitehorse, Yukon.

Nunavut Tunngavik Incorporated, Kitikmeot Inuit Association and Qikiqtani Inuit Association: 2001, *Elder's Conference on Climate Change*, Report to Indian and Northern Affairs Canada.

Oliver-Smith, A.: 1986, 'Disaster context and causation: An overview of changing perspective in disaster research', in Sutlive et al. (eds.), *Natural Disasters and Cultural Responses*, Department of Anthropology, College of William and Mary, Williamsburg, Virginia, No. 36, pp. 1–34.

Paci, C.D. et al.: in press, 'Indigenous observations', in H. Huntington, F. Berkes and Samantha Fox (eds.), *Arctic Climate Impact Assessment*, Arctic Council, Iceland, pp. 21–27.

Polsky, C. et al.: 2000, 'The Mid-Atlantic Region and its climate: Past, present, and future', *Climate Research* **14**, 161–173.

Reinhart, J.: 2003, 'Generate data – Create transparency', in *Topics*, Munichener Ruckversicherungs-Gesellschaft, Munich, Vol. 2, p. 24.

Rosentrater, L. and Ogden, A.E.: 2003, 'Building resilience in Arctic ecosystems', in L.J. Hansen, J. Biringer and J.R. Hoffman (eds.), *Buying Time: A User's Manual for Building Resistance* *and Resilience to Climate Change in Natural Systems*, World Wildlife Fund for Nature, Gland, Switzerland.

Rouse, W.R. et al.: 1997, 'Effects of climate change on the freshwaters of Arctic and sub-Arctic North America', *Hydrological Processes* **11**, 873–902.

Tetso, J.: 1989, 'The creation of Dehcho, the Big River', in *Dehcho: "Mom, we've been discovered!"*, Dene Cultural Institute, Yellowknife, p. 8.

United Nations: 1992, *Earth Summit Agenda 21: United Nations Conference on Environment and Development (UNCED)*, United Nations Commission on Sustainable Development, New York.

Waddell, E.: 1983, 'Coping with frosts, governments and disaster experts: Some reflections based on a New Guinea experience and a perusal of the relevant literature', in K. Hewitt (ed.), *Interpretations of Calamity from the Viewpoint of Human Ecology*, Allen & Unwin, London, pp. 33–43.

Weller, G. and Lange, M. (eds.): 1999, *Impacts of Global Climate Change in the Arctic Regions: Report from a Workshop on the Impacts of Global Change, April 25–26, 1999, Tromso, Norway*, International Arctic Science Committee, Center for Global Change and Arctic System Research, University of Alaska Fairbanks, Fairbanks, Alaska.

White, G.F.: 1942, *Human Adjustment to Floods: A Geographical Approach to the Flood Problem in the United States*, Ph.D. Dissertation, Department of Geography, University of Chicago. Reprinted in 1945 as research paper no. 29, Department of Geography, University of Chicago Press, Chicago.

World Commission on Environment and Development: 1987, *Our Common Future*, Oxford University Press, Oxford.

Yukon Climate Change Coordinating Committee: 2001, *An Inventory of Yukon Climate Change Initiatives*, Yukon Climate Change Coordinating Committee, Whitehorse.