Extreme Environmental Events Induced by Climate Change: Communicating Risk with Rural Communities in the Canadian Prairies

by

Graham Smith

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

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Winnipeg, Manitoba, Canada

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Of

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Abstract

In the Canadian Prairies, climate change is predicted to increase the intensity and frequency of extreme environmental events, like flood and drought, this century (IPCC, 2007A; Schindler, 2006; Warren, 2006; Francis *et al.*, 1998). The 1997 Red River flood demonstrated that reducing risk and vulnerability at the local level are less likely to be successful if (expert) decision makers perceive risk differently than the public (Haque, 2000; Rasid, 2000; Buckland and Rahman, 1999). Unfortunately, risk communication has traditionally adhered to a one-way, top-down approach, resulting in messages that are often either too complex or too general to be effective (Wagner, 2007). This research attempts to locate the gap in expert/public knowledge and identify the required elements of a two-way risk communication tool that will empower the public with the knowledge that they need in order to increase their coping capacity to climate change-induced extreme environmental events. The findings from this research revealed that the greatest gap between expert and public knowledge, concerning climate change-induced extreme environmental events, exists in relation to the more scientific/technical based knowledge, and in particular the relationship between greenhouse gases and climate change. In addition, it was revealed that middle-aged, white males with a post-secondary education were primarily correlated with this gap in knowledge. These findings reinforce the need to concentrate future research towards understanding how social power affects different societal group's ability to 'act' based on their knowledge.

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1.0 Chapter 1 – Introduction

1.1 Problem Statement

Over the past two decades, climate change has emerged as the leading global environmental issue. The negative impacts associated with climate change are already well documented throughout the world and in Canada (Lemmen *et al.*, 2008; Van Aalst, 2006). Research by the Inter-governmental Panel on Climate Change (IPCC) has shown that climate change will have far-reaching and severe consequences that will affect not only the earth's physical and biological systems but also the social and economic sectors as well (IPCC, 2007B). As climate change progresses, the balance of impacts are predicted to become increasingly negative with more irreversible impacts (Van Aalst, 2006). This problem is unprecedented in scale and complexity, and requires governance efforts beyond contemporary global models (Drexhage, 2007).

In the Canadian Prairies, climate change is predicted to increase the intensity and frequency of extreme environmental events (EEEs), like flood and drought, this century (IPCC, 2007A; Schindler, 2006; Warren, 2006; Francis *et al.*, 1998). An increase in EEEs, although not always associated with a high degree of mortality, is likely to lead to a range of various chronic and acute stresses that occur during a disaster and throughout recovery (Flynn 1999; Freedy *et al.*, 1994). An increase in these events, as well as an inclusion of events in regions where previously rare or absent will cause critical coping thresholds to be exceeded, posing serious economic, societal, and health related risks to communities (Mehdi *et al.*, 2006; Warren, 2004; Francis and Hengeveld, 1998). It is therefore crucial to explore the various adaptation strategies that can increase the capacity of rural prairie communities to cope with these challenges.

Responding to climate change requires a multi-faceted approach involving both *mitigation* and *adaptation* (Warren, 2004). *Mitigation* implies taking preventative measures to minimize the release of greenhouse gases (GHG's) into the atmosphere. This may occur through either technical innovations (i.e. electric cars, solar and wind power), or it may be through large-scale societal conservation and efficiency measures (i.e. locally grown produce, public transit, and energy efficient homes). *Adaptation* is directed at taking initiatives that increase the resiliency of society to buffer the various detrimental impacts of climate change. However, even the most effective mitigation efforts cannot avoid all impacts of climate change over the next few decades, which makes adaptation unavoidable (Klein *et al.*, 2007). Accordingly, the United Nations Framework Convention on climate change (UNFCCC) and the Kyoto Protocol both identify adaptation as a necessary requirement to combat climate change (Warren, 2004).

Adaptation strategies must reflect the numerous ways that climate change will affect the range of regions throughout the country and with varying degrees of severity (Roberts *et al.*, 2006). This may include, for example, drought resistant crops, hurricane-proof homes, or community flood strategies. While it is imperative that Canada pursues both options, the focus of this thesis is towards the latter, and specifically towards how to increase community coping capacity of climate change-induced extreme EEEs through risk communication.

It is asserted that once the public is aware of the risks, they will take more effective means of addressing the problem, including demanding policy change (Moser, 2007). However, amongst climate change communicators, advocates and scientists, there is a growing frustration that politicians and the public have not adequately prioritized the issue. As a consequence, the general reaction by climate change communicators has been to 'ring the alarm bell' more loudly in what has been described as 'fear appeals', in hopes that if the public understands the urgency of climate change they will act or demand more action. Moser (2007) argues that this approach has ultimately divided the public's opinion regarding climate change and further suggests that a more positive communication strategy is needed. Despite this inherent need, there have been very few attempts to examine how to more effectively communicate the risks of climate change to the public.

The 1997 Red River flood demonstrated that divergent perceptions of risk between the public and the expert decision makers can lead to increased vulnerability to hazards (Haque 2000; Rasid 2000; Buckland and Rahman 1999). There is therefore a distinct need to bridge the knowledge gap that occurs between experts and the public so that citizens can make better choices to mitigate their risks (Longstaff, 2003). However, traditional approaches to risk communication have conventionally followed a one-way, top-down approach which has typically resulted in messages that are often either too complex or too general to be effective (Wagner, 2007).

This thesis attempts to identify the gap that exists between expert and public knowledge and identify the required elements of a risk communication tool to engage the public in a two-way process of bridging the knowledge gap and increasing the coping capacity of rural prairie communities to climate change-induced EEEs. This was achieved through a multi-disciplinary four-step methodology involving the creation of an expert knowledge model, face-to-face interviews, confirmatory questionnaires, and an expert feedback workshop.

1.2 Background

The research included in this thesis is a portion of the larger research project entitled "Impact of Climate Change and Extreme Events on Psychosocial Well-Being of Individuals and Community, and Consequent Vulnerability: Mitigation and Adaptation by Strengthening Community and Health Risk Management Capacity". This study was coordinated as a portion of a collaborative Climate Change Initiatives and Adaptation Program (CCIAP) research project funded by Natural Resources Canada (NRCAN). The project involved the partnership of the Public Health Agency of Canada (PHAC), Manitoba Red Cross, and the Natural Resources Institute (NRI) at the University of Manitoba. This project commenced in early 2005 and was completed in March 2007. Its specific goals were to identify factors that strengthen the resiliency of people to cope with stressors in a changing environment, as well as to examine what motivates people to take proactive preventive and mitigation measures. This research was therefore a specific attempt to address the first goal through the application of risk communication.

1.3 Organization of Chapters

The thesis is organized into 7 chapters. This first chapter describes the basis and background for this research. The second chapter consists of a literature review relevant to this research, with particular emphasis directed towards climate change-induced EEEs, the vulnerability of the rural Canadian Prairies and risk communication. The third chapter describes the methodology that was used for this research. Chapter 4 reveals the results from the first three objectives, and identifies the gaps between expert and public knowledge. Chapter 5 attempts to explore the nature of these gaps by using variables associated with worldview to determine what factors are correlated with the occurrence of a gap with the public. Chapter 6 examines the expert feedback concerning the findings from the previous two chapters and identifies the required elements of a risk communication tool. Chapter 7 concludes the thesis with some final perspectives regarding the relevance of these findings to disaster management policy as well as some recommendations for future research.

1.4 Purpose

It is the purpose of this research to enhance practices in risk communication by identifying the required elements of risk communication a tool based on the results of this research in an attempt to increase community coping capacity to climate change-induced EEEs in the rural Canadian Prairies.

1.5 Objectives

The objectives of this research are to:

1) determine the status of knowledge concerning climate change-induced EEEs in the expert community;
2) determine the status of knowledge concerning climate change-induced EEEs in the rural public community;
3) identify the gap in knowledge between the expert and public domains concerning climate change-induced EEEs; and
4) identify the required elements of a risk communication tool in an attempt to increase the community coping capacity to climate-change-induced EEEs

1.6 Methods

The '*mental model approach*', developed by Morgan *et al.* (2002) has emerged in the field of risk communication as an effective methodological framework for identifying the gap between public and expert knowledge. This framework was adapted to the '*knowledge model approach*' to meet the objectives of this research which included the following methods: (1) an expert workshop, (2) face-to-face interviews, (3) confirmatory questionnaire surveys, and (4) an expert feedback workshop.

1.7 Study Area

The research focuses in the context of rural communities in the Canadian Prairie region. The rural communities used in this research where selected based on some predisposition to a particular hazard (either flood or drought) and the willingness of the municipality to be included in the research project. Subsequently, the rural municipality (RM) of Stuartburn (south-east) was chosen to represent rural communities in regards to flooding and the RM of Cornwallis (south-west) was chosen in regards to drought (Figure 1).

The geography of Cornwallis is characterized by a semi-arid climate, fertile farmlands, and the Assiniboine River which meanders west-to-east through the heart of the RM (Manitoba Community Profiles, 2006). In amongst the vast expanse of prairie landscape Cornwallis also features the Blue Hills of Brandon to the south and Spruce Woods Provincial Forest to the east. The Blues Hills were formed as a result of an end moraine and glacio-fluvial deposits during the late Wisconsin period, and elevate 92 m above the surrounding plains (Dawson, 2006). The vegetation in the region consists of aspen-oak parkland with sections of mixed grass prairie. Spruce Woods Provincial Forest is the remnant of an ancient river delta and consists of aspen parkland, which is dominated by trembling aspen groves intermixed with mixed-grass prairies in amongst recent invasions of white spruce and creeping juniper (Wang *et al.*, 2006).

In the west, Stuartburn is generally flat with sandy soils and patches of ash, poplar and oak dotted throughout the landscape (Manitoba Community Profiles, 2006). In the east, the RM transitions into evergreen forest and Sandilands Provincial Park. The primary river in the RM of Stuartburn is the Roseau River which runs from its headwater in northern Minnesota through south-eastern Manitoba and into the Red River. The river's tendency to flood during spring runoff, as well as the regions historical abundance of marshes which have mostly since been drained, has led to a prevalence of flooding in the region.

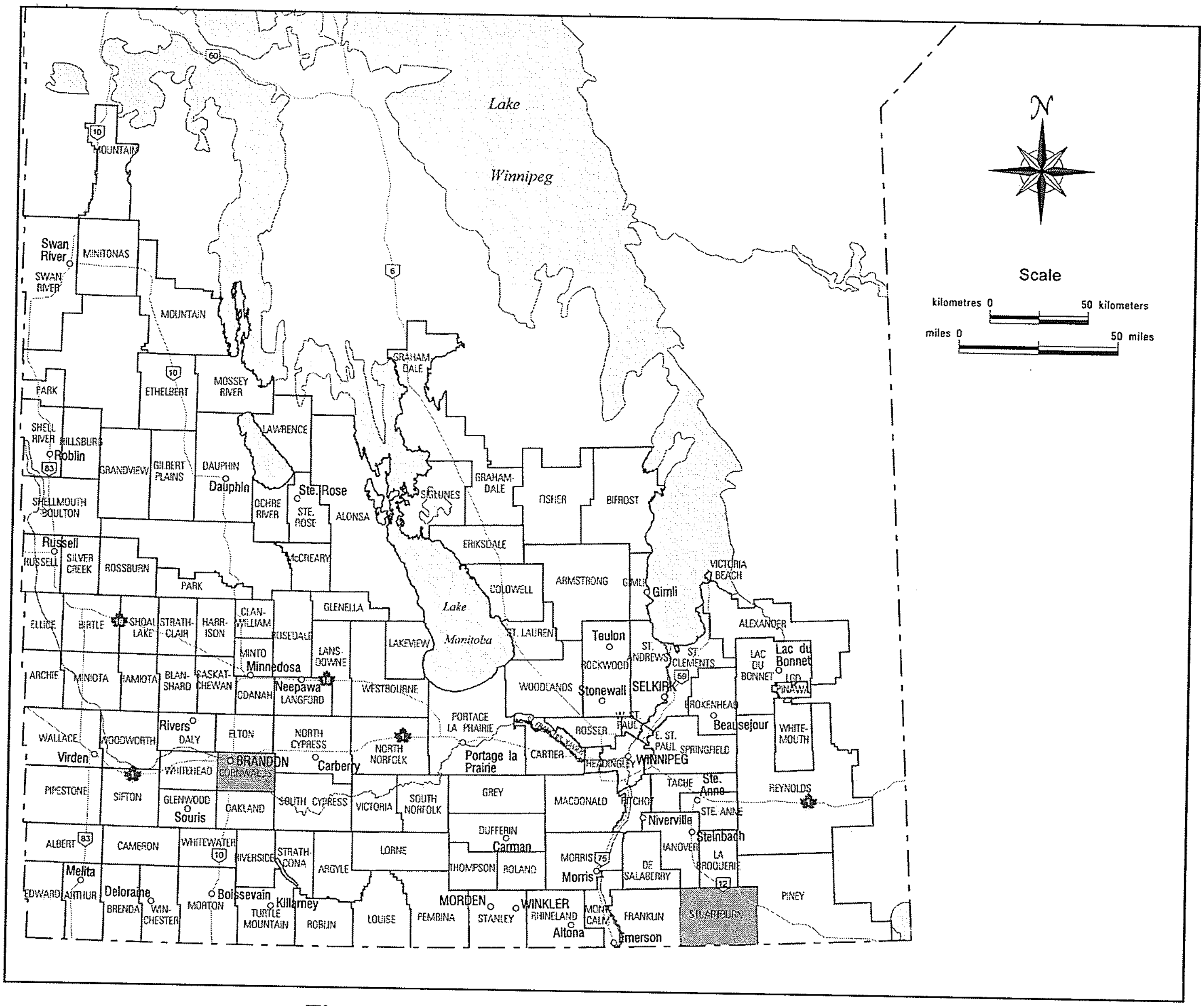

Figure 1: The RMs of Cornwallis and Stuartburn

2.0 Chapter 2 – Literature Review

2.1 Climate Change and Extreme Environmental Events

2.1.1 Introduction

Climate change is caused by variations in the atmospheric abundance of GHG's, including carbon dioxide ($C0^2$), methane, and nitrous oxide (N^2O), which increases the intensity of the 'greenhouse effect' and alters the incoming and outgoing levels of solar radiation, increasing the earth's temperature. A warmer climate caused by global warming also changes the physical processes that generate different types of weather in our atmosphere (IPCC, 2007A). More specifically, a warmer climate leads to a considerable increase in the amount of water and energy that moves through the hydrological system by increasing evaporation, transpiration, and the capacity of the air to hold moisture (Francis and Hengeveld, 1998).

These circumstances, combined with a more unstable atmosphere due to increased convection over warmer surfaces, are attributed to an increase in the frequency and intensity of EEEs (IPCC, 2007A; Van Aalst, 2006; Groisman *et al.*, 2005; Laprise *et al.*, 2003; Schindler, 2000; Francis and Hengeveld, 1998). Overall, the human, ecological, and economic costs of a long-term increase in EEEs is likely to be substantial. Unfortunately due to a lack of research, there is currently a lack of clear, concise and pragmatic adaptation strategies; primarily because we do not understand how climate change-induced EEEs will affect our vulnerability (Wheaton *et al.*, 2007).

Global atmospheric concentrations of GHG's have increased considerably since 1750 and now far exceed pre-industrial levels. The concentration of $C0^2$ in the atmosphere has increased by around one-third, from 280 parts per million (PPM) in 1750 to 368 PPM in

2000, representing the highest level in the atmosphere in at least the last 420,000 and likely the last 20 million years (IPCC, 2007A). This significant rise of atmospheric $C0^2$ concentration has been accompanied by a rise in average global temperature, which in the last 50 years has doubled its rate of increase compared to that of the first 50 years of the 20^{th} century. Concurrently, eleven of the last twelve years rank among the 12 warmest years in the instrumental record of global surface temperature (IPCC, 2007A).

Since human emissions to date have already initiated substantial global climate change and because most GHG's remain in the atmosphere for at least several decades, global climate change is likely to continue, regardless of any substantial reductions of emissions (IPCC, 2007A). However, anthropogenic emissions are steadily increasing and are unlikely to decrease in the near future suggesting that the effects of global climate change will accelerate and intensify (Van Aalst, 2006). The irony is that society's ongoing ignorance to the problem is likely to result in costs that dramatically exceed the costs of prevention (Bazerman, 2006).

There is high confidence that a warming of up to 2°C above 1990-2000 levels would increase the risk of many extreme weather events, including floods, droughts, heat-waves, and fires, with increasing levels of adverse impacts as temperatures increase (Schneider *et al.*, 2007; Kharin and Zwiers, 2000). Although it is difficult to empirically link the occurrence of any one particular extreme weather event specifically to climate change (Cannon, 1994), the number of hydro-meteorological disasters has increased significantly over the past few decades. It is now asserted with a high confidence that climate change has already and will continue to lead to changes in the frequency and intensity of extreme weather throughout the world (O'Brien *et al.*, 2008; IPCC, 2007A; Van Aalst, 2006).

Extreme weather implies a specific hydrological event in time where weather occurs outside the normal parameters of commonality in that region (Francis and Hengeveld, 1998). The research uses the term 'extreme environmental event' as opposed to 'extreme weather' to include other climate change-induced environmental phenomena, such as disease, pandemics, and infestation which occur outside the domain of weather. This scope is a more holistic scale of investigation because it examines multiple dimensions of the environment affected by climate change, over a longer period of time.

During the 1990s alone, at least half a dozen floods of epic proportions occurred in Canada, the United States, central Europe, and southern China, while intense droughts occurred throughout Africa, Asia, Peru, Chile, north-eastern Australia, northern China, northern Vietnam, North Korea, and southern Europe (IPCC, 2007A; Francis and Hengeveld, 1998). North America, despite its strong resilient capacity, has experienced a significant increase in both economic and ecosystem loss, in addition to prominent indications of social and cultural disruption, caused by recent EEEs, including hurricanes, severe storms, floods, droughts, heat-waves and wildfires (Field *et al.*, 2007).

The 2004 World Disasters Report indicates that the number of people directly affected by natural disasters in Canada has risen steadily in recent years, increasing by 7 times from 79, 066 (1984-1993) to 578, 238 (1994-2003) (International Federation of Red Cross and Red Crescent Societies, 2004). Notable examples of this phenomenon include several large tornadoes, including in Barrie, Ontario (1989, 12 deaths), Edmonton (1987, 29 deaths) and Pine Lake, Alberta (1989, 12 deaths). In 1996, extreme rainfall led to major flooding in the Saguenay region of Quebec, causing $1.5 billion in economic losses and the evacuation of 15,000 people. The following year the 1997 Red River Flood forced over

25,000 people to evacuate and caused nearly $1 billion in damages. A year later, the ice storm in Eastern-Ontario, Quebec and New Brunswick resulted in 28 deaths and economic losses totaling $5 billion (Public Safety and Emergency Preparedness Canada, 2005).

2.1.2 Extreme Environmental Events in the Canadian Prairie Region

The Canadian Prairie region is considered to be particularly vulnerability to the effects of climate change (Sauchyn and Kulshreshtha, 2008). Accordingly, most climate models project the highest warming to occur in the high latitudes of the Northern Hemisphere (Cubasch *et al.*, 2001). Accompanying this warming is an anticipated increase in precipitation which when combined with increased water loss through evapo-transpiration will place tremendous stress on the coping capacity of the region and in particular rural communities where agriculture and resource based activities are significant contributors to the local economies (Laprise *et al.*, 2003; Cubasch *et al.*, 2001).

The Canadian Prairies contain approximately 17% of Canada's population and account for 20% of its area (Natural Resources Canada, 2001). The region also accounts for around 50% of all Canadian farms and 80% of its farmland (Sauchyn and Kulshreshtha, 2008). In 2004, the Canadian Prairies contributed $202 billion in value-added activities to the Canadian gross domestic product (GDP) in total, while agriculture in the region accounted for 3% of the GDP, making it one of the largest sectors in the country (Sauchyn and Kulshreshtha, 2008; Harker *et al.*, 2004).

The Prairies have always been associated with a high degree of uncertainty regarding large fluctuations in the local agricultural economy, and with the threat of an increase in climate change-induced EEEs, there remains serious questions surrounding the resiliency of

Canadian prairie agriculture and its ability to sustain the livelihood of a region (Cubash *et al.*, 2001; Kharin and Zwiers, 2000).

Traditionally government subsidies have allowed Canadian agriculture to remain sustainable, accounting for 114% of all net farm income from 1985-92 (Brinkman, 2002). Low interest rates have allowed Canadian agriculture to buffer the affects of low commodity prices in the past. However, interest rates are expected to eventually increase and with more frequent and intense EEEs the ability of the Canadian agriculture to cope, particularly in the case of rural communities, may be exceeded (Brinkman, 2002).

These projections for the next century indicate that the number of hot and very hot days will continue to rise, while the number of cold and very cold days will continue to decrease over nearly all land areas (IPCC, 2007A). It is predicted that by the middle of the 21st century the Canadian Prairies will have increased in temperature by between 2 to 4 °C from late 20th century averages (Nyirfa and Harron, 2002). When the dry and wet years of the 20th century are compared with the degree of warming of the earth's surface there appears to be a correlation with recurring droughts and an increasing temperature (IPCC, 2007A; Kharin and Zwiers, 2000). In addition to more frequent and intense drought, an increase in temperature will also likely to lead to an increase in the intensity of precipitation events including floods (Groisman *et al.*, 2005; Laprise *et al.*, 2003; Schindler, 2000; Francis and Hengeveld, 1998; Frederick *et al.*, 1997). It is important to consider that an increase in the frequency and intensity of EEEs as well as a greater range of yearly averages from traditional climatic conditions, represent a greater risk to the sustainability of the Canadian Prairies than a simple shift in mean temperatures (Sauchyn and Kulshreshtha, 2008).

2.1.3 Drought in the Canadian Prairies

Historically throughout the 20th century, a rise in temperature has been correlated with increased drought (IPCC, 2007A). Accordingly, temperature in the continental interior of North America is predicted to sharply increase and therefore lead to an increase in the frequency, intensity, and scale of drought in the future (IPCC, 2007A; Wheaton, 2007). This is especially true in regions where climate circulation changes cause rainfall to decrease, however drought could become more frequent in regions that also see an increase in precipitation (IPCC, 2007A). In a warmer climate, increased evaporation from soils and transpiration from plants may offset any additional increase seen in rainfall. Furthermore, an increase in extreme precipitation events means that most of the rainfall in a region will come in fewer days, resulting in more dry days. Heavy precipitation events are inefficient at recharging soil moisture, because they happen so quickly, and often result in surface runoff. This scenario is likely to lead to an increase in both flooding and droughts in regions such as the Canadian Prairie region (Francis and Hengeveld, 1998).

In the context of this research in the RM of Cornwallis, drought does not immediately threaten human life; however extended droughts can trigger disastrous socio-economic impacts in terms of the severe disruption of grain, food, and water supplies as well as having a serious impact on the local and even national economy (Khandekar, 2004). These impacts, though indirect in nature, are likely to produce a wide range of social and economic impacts in the community which may also transpire into many secondary effects, such as drug and alcohol abuse, chronic stress and suicide.

Since most human activities and ecosystem health are dependent on reliable, adequate water supply, droughts present a serious national threat to Canada and in particular the

Prairies (Bonsal *et al.*, 2004). Large-scale droughts have major impacts on a wide range of water-sensitive sectors including agriculture, industry, municipalities, recreation, and aquatic ecosystems. They often stress water supplies by depleting soil moisture reserves, reducing stream flow, lowering lake and reservoir levels, and diminishing groundwater supplies. Although most regions in Canada have experiences drought, the Canadian Prairies are more vulnerable mainly because of its high variability of precipitation in both time and space (Bonsal *et al.*, 2004).

Droughts are described as a 'creeping' hazard because unlike most other natural hazards they develop slowly over time and can last for prolonged durations. Droughts can be grouped into 3 main categories, including meteorological drought, hydrological drought and agricultural drought. Meteorological drought is defined as a deficit in precipitation, while hydrological drought is specific to a decline in the water table, effecting lakes, rivers and aquifers. An agricultural drought, which is the focus of this research, is defined as a deficiency in water as to inhibit the production of agriculture. Agricultural drought occurs in the domain in which the hazard of drought and the human/social element come into direct contact. Agricultural drought results in the direct loss of income to agriculturally based families and businesses and is therefore the most significant type of drought worth examining in regards to climate change-induced EEEs in the Canadian Prairies (Khandekar, 2004).

Drought occurs in all regions of Canada, but in the Prairies precipitation can cease for more than a month, surface waters can disappear for entire seasons, and water deficits can persist for a decade or more, making the region potentially vulnerable to desertification (Sauchyn and Kulshreshtha, 2008). In this century, examples of severe droughts in the Prairies include 1936-1938, 1961, 1976-1977, 1980, 1984-1985, 1988, and 2001-2002

(Khandekar, 2004; Gan, 2000). Paleo-climatic data shows that the Prairies have experienced droughts far more severe over the past 500-1000 years than in this century, and in particular the worst drought occurred roughly between 1791 and 1800 (Case and MacDonald, 1995). Many serious droughts also occurred in the nineteenth century, particularly in the late 1880's and early 1890's (Godwin, 1986).

The nation-wide 2001-2002 drought is considered to be one of the worst in Canadian history and comparable, if not exceeding, those of the dust bowl years in the 1920s and 1930s (Wheaton 2007; Schindler 2006; Khandekar 2004). The drought severely tested the economic and social resiliency of the Prairie agriculture (Wheaton 2007). The Canadian Wheat Board reported that the spring wheat, barley, oats and canola yields during this period ranged from 8% to 22% below average (Garnett 2005). The resounding message that this drought emphasized was that if these conditions were exacerbated, agriculture, and in particular the cereal and grain sectors, would face considerable coping challenges.

Even in these periods of relatively low-intensity drought of the 20th and 21st centuries, the effects on agriculture has been severe. In the 1930s droughts affected 7.3 million hectares of agricultural land and forced a quarter million people to migrate out of the region (Godwin, 1986). The 1984-1985 drought affected agricultural production throughout the majority of the southern Prairies and resulted in an estimated loss of over one billion Canadian dollars in GDP (Ripley, 1988). Similarly, the 1988 drought caused a loss of four billion dollars in exports of agriculture, and forced 10% of all farmers to leave the agricultural business (Arthur, 1989). Despite these notable examples of loss, it has been argued that adjustments through institutions, policies and management practices have largely mitigated, or at least buffered, the social and economic impacts of most droughts in recent years (Sauchyn, 2005; Liverman, 1990; Hewitt, 1983). This further suggests that with more severe and frequent drought conditions in the future, Canadian prairie agriculture may surpass its coping capacity threshold.

2.1.4 Flooding in the Canadian Prairies

Due to the widespread geographical distribution of river valleys and low-lying coastal areas, combined with their attraction for human settlement, flooding is the most frequent and economically disruptive of all environmental disasters in the world. Over the last century, damages in Canada have exceeded $2 billion with over 198 deaths (Brooks *et al.*, 2001). Flooding can directly cause death or injury as well as indirectly cause a variety of delayed and long-term health impacts. This usually manifests itself through individual and community displacement, exposing individuals to a range of indirect stressors, such as social disruption, loss of possession, disrupted livelihoods and family life. These conditions also lead to ill-health effects through: unsafe sanitary environments, inadequate nutrition, and increased exposure to infectious diseases. Therefore floods are considered significant hazards because of their cumulative impacts on both individuals and communities (Hutton, 2004).

Flooding is primarily caused by hydro-meteorological conditions, including excess snowmelt, rain, snow, ice-jams, or natural dams (Andrews, 1993). Anthropogenic causes can also lead to flooding, or exacerbate natural flooding conditions, through changes in drainage patterns or dam-breaks (Pietroniro *et al.*, 2004). Structural measures such as dams, dykes and diversions have been utilized in the Prairies as a means of mitigating flood risk; however these measures have also disrupted riparian habitat and sometimes given the public a false sense of security. Non-structural approaches, such as floodplain regulation and forecasting, have become increasingly favorable ways of mitigating flood risk and reducing damage

(Pietroniro *et al.*, 2004). Therefore flood prevention strategies should reflect the vulnerability/resilience paradigm (see Haque and Etkin, 2006), which stresses that societal dimensions are equally or more important in coping with disasters like floods, than solely trying to control nature with technology.

In the context of the Canadian Prairies, the Red River has been the archetype of prairie river flooding, having consistently flooded throughout its history. The Red River originates in Wahpeton, North Dakota with the convergence of the Bois de Sioux and Ottertail Rivers and flows north into Lake Winnipeg with a drainage area of 116 500 km^2. Flows in the river are erratic and highly variable, ranging from periods of minimal flow in the summer and fall to periods of extreme flow during the spring. The risk of flooding is heightened in this region because the floodplain's clay soils diminish its absorptive capacity, its northward flow increases its potential for ice jams, and because it is the remnant of glacial Lake Agassiz, the landscape is extremely flat (IJC, 2000).

The severity of the impacts of flooding in the region became apparent in 1950 when the Red River Valley, including large portions of Winnipeg, was inundated. This event forced the evacuation of nearly 80, 000 people in Winnipeg and resulted in more than 9, 000 damaged buildings (Bumsted, 1993). Following the 1950 Red River flood, the federal and provincial governments established a fact-finding commission to appraise the damages and make recommendations. The commission recommended the construction of the Red River Floodway (completed 1966), the Portage Diversion (completed 1970) and the Shellmouth Reservoir (completed 1972). This Red River flood protection system was designed to provide protection for the City of Winnipeg for a 1 in 160 year flood with a capacity of 4 786 cubic meters per second (m^3/s) at Redwood Bridge (Simonovic and Li, 2004). The floodway channel has a design capacity of 1 700 m^3/s and an emergency capacity of 2 830 m^3/s. It is 46.7 km long with an average depth of 9.1 m and an average bottom width of 137.2 m (Topping, 1997). In addition, a series of ring dikes were built around rural communities, as well as financial aid programs encouraging rural inhabitants to raise their homes and create individual dikes around their properties.

As previously noted, climate change is expected to increase the frequency and intensity of flooding (IPCC, 2007A; Francis and Hengeveld, 1999; Hurd *et al.*, 1999). The 1997 Red River flood is an example of what future conditions may prevail in the region. The flood was caused by a combination of highly saturated soils, heavy winter snowfall, and a rapid spring melt. It was the province's largest flood in 135 years, forcing the evacuation of 28,000 people and causing over an estimated $500 million in damages (Lemarquand, 2007; Farlinger *et al.*, 1998). The flow at Winnipeg in 1997 was 4,580 (m^3/s), while the next largest flood in 1950, peaked at 3,050 m^3/s (Lemarquand, 2007). Although the city of Winnipeg managed to avoid severe flooding, the southern Manitoba was devastated.

The factors that lead to flooding in Manitoba include: (1) soil moisture at freeze-up time; (2) total winter precipitation; (3) rate of snowmelt; (4) amount of spring rain; and (5) timing factors (Warkentin, 1999). Temperature and precipitation are the two major variables that affect the above parameters and ultimately influence the starting time, magnitude and frequency of floods. Global warming is expected to cause the flood starting time and peak flow to occur earlier and for an overall increase in annual precipitation and annual stream flow in the Red River basin (Simonovic and Li, 2004). Although the current flood protection capacity of the Red River infrastructure (including the expansion) is sufficient under traditional flood scenarios, it may not be reliable under future conditions (Simonovic and Li, 2004).

2.2 Rural Prairie Communities and Vulnerability

2.2.1 Introduction

Hazards and risk exists within a complex and dynamic system that varies in both space and time and therefore yields different results in different situations (Haque and Etkin, 2007). A major concern in the developed and developing world is how vulnerability can be affected more or less drastically by social changes and patterns of development (Hewitt, 1997). Vulnerability implies the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of a hazard (Haque & Burton, 2005). Expressed systematically, Blaikie *et al.* (1994) view risk as a complex combination of both vulnerability and hazards, with disasters representing the result of the interaction of both. Accordingly it is contended that there is no risk if there is a hazard but the population is not vulnerable, or if there is a vulnerable population but no hazard (Blaikie *et al.*, 1994).

Since the early 1980s, there has been a growing emphasis towards the significance of social systems and their relationships to risk from hazards (Haque, 1997). Vulnerability has thus been characterized as a pre-existing condition or state defined by a set of negative attributes that cause people or communities' susceptibility to hazards. In other words, disasters do not happen, they unfold (Blaikie *et al.*, 1994). It is therefore imperative for risk managers to identify who is vulnerable in order to prioritize capacity building initiatives, as those who are most vulnerable usually possess the fewest resources to cope (Kasperson and Kasperson, 1998).

Research has shown that the most vulnerable groups are often the poor, women, racial and ethnic minorities, as well as those who are members of other disenfranchised groups (Mileti & Gailus, 2004; Hewitt, 1997). These groups exhibit increased vulnerability because they lack access to livelihoods and resources, and secondly because they are more likely to be a low priority for government mitigation initiatives (Blaikie *et al.*, 1994). In addition, individual's living in rural regions compared to urban areas, tend to have a shorter life expectancy, higher death rates and higher infant mortality rates (PHAC, 2005). The poorer health status of Canadians living in rural areas cannot be linked to one specific problem. Rather, it is a combination of personal, social, economic, and environmental factors and conditions that influences health, such as income, employment and working conditions, education and training, personal health practices, equipment and the physical environment (PHAC, 2005; Haque, 2000).

There are additional implications to rural Canadians living in remote regions who are spatially dispersed. Their geographic isolation makes them particularly more vulnerable to disasters and their effects because rural inhabitants often lack the same infrastructural support systems that buffer urban dwellers from the threats and impacts of disasters. The *direct* social support systems that are in place, such as Post-Acute Home Care (PAHC), the Regional Health Authority (RHA), the Public Health Agency of Canada (PHAC), and the Canadian Red Cross, are largely contained within urban centers and are much more difficult to access for remote populations. Also, *indirect* social support systems (i.e. social capital) are largely dependent on geographic proximity, in order for one individual to provide emotional or physical support to another.

In terms of climate change-induced EEEs, the impacts are likely to result in a number of stressors that may be either acute (i.e. injury, panic) or chronic (i.e. displacement, loss of livelihood) in nature (Hutton, 2004). For example, events that occur suddenly and have destructive impacts can overwhelm the coping capacity of communities, causing heightened levels of psychological stress that manifests itself through anxiety, depression, and acute stress disorders (Staab *et al.*, 1999; Green and Lindy, 1994). In events that occur gradually, more typical with floods and drought, psychological stress is likely to reflect the additive and interactive stressors that occur throughout recovery; such as, rebuilding delays, financial losses, and social disruptions (Flynn 1999; Freedy *et al.*, 1994). Research has indicated that the cumulative stress caused by such events tends to manifest primarily through the persistence or recurrence of previously existing disorders (Smith *et al.*, 1990), as well as through the immediate psychological impacts associated with disasters (Hutton, 2004; Rubonis and Bickman, 1991).

2.2.2 The Socioeconomic Status of Cornwallis

The RM of Cornwallis is located in south-western Manitoba, surrounding the city of Brandon, and is contained within the agricultural heartland of Manitoba. It was officially incorporated in 1884 and currently has a population of 4,055 people in an area of 500.82 square kilometers (Statistics Canada, 2006).

Contrary to many other surrounding municipalities in south-western Manitoba, Cornwallis has seen significant growth in recent years, increasing its population by 7.4% in five years (2001-2006) (Manitoba Community Profiles, 2006). Much of this growth can be attributed to the 2001 relocation of 700 military personnel and their families from the Kapyong Barracks in Winnipeg to the Canadian Armed Forces Base Shilo in the south-eastern portion of the RM. Accompanying this growth in population is a strong labour force and a low unemployment rate with an average household income of $68.084, well above the Canadian average (Table 2.1).

Although the region was formally dependent on agriculture as an economic base, it has since diversified with health care, social services, and business services emerging as major contributors to the local economy. The workforce consists of a young educated population, with a median age of 33 and with 43% having a post secondary education (Statistics Canada, 2006). Cornwallis also shows strong marital status indicators with a high marriage rate, and low divorce and widowed rates compared to the national average. These statistics were also reflected in the RM's high proportion of 'married couple families', well above the national average.

Overall, Cornwallis shows strong socioeconomic indicators, suggesting that its vulnerability to EEEs and specifically to drought should be low. However, the effects of extreme drought, although with the potential to devastate the agricultural sector, would likely manifest through the cumulative chronic and acute stress induced by social disruptions throughout the community (Flynn 1999; Freedy *et al.*, 1994).

Table 2.1: Socioeconomic statistics of Cornwallis, 2006

Population and Age	**Total**	**Male**	**Female**
Total Population	4,055	2,095	1,960
Median Age	33	33	33
Total Population aged 15 and over	78.0%	78.0%	78.0%
Income	**Cornwallis**	**Canada**	

Median Income (2005) for All Private Households	$68,084	$44,136	
Labour Force	**Total**	**Male**	**Female**
Total population 15 years and over	3,160	1,625	1,535
In the labour force	2,470	1,340	1,130
Employed	2,390	1,320	1,070
Unemployed	75	20	55
Not in the labour force	690	285	400
Participation rate	78.2%	82.5%	73.6%
Unemployment rate	3.0%	1.5%	4.9%
Industry	**Total**	**Male**	**Female**
Total experience labour force 15 years and over	2,445	1,335	1,110
Agriculture and other resource-based industries	205	150	55
Construction industries	50	40	15
Manufacturing industries	160	100	60
Wholesale trade	70	55	20
Retail trade	190	70	115
Finance and real estate	70	15	55
Health care and social services	245	20	225
Educational services	190	40	150
Business services	330	215	110
Other services	930	630	305
Education	**Total**	**Male**	**Female**
Total Population 15 years and over	3,160	1,625	1,530

No certificate, diploma or degree	725	400	325
High school or equivalent	1,070	585	485
Apprenticeship or trades certificate or diploma	440	265	175
College degree	580	215	360
University degree below bachelor level	120	55	70
University degree	225	110	120
Marital Status	**Cornwallis**	**Canada**	
Total Population 15 years and over	3,155	26,033,060	
Never legally married (single)	915 (29%)	9,087,030 (35%)	
Legally married (and not separated)	1,915 (61%)	12,470,400 (48%)	
Separated; but still legally married	60 (2%)	775,425 (3%)	
Divorced	195 (6%)	2,087,390 (8%)	
Widowed	70 (2%)	1,612,815 (6%)	
Family Characteristics	**Cornwallis**	**Canada**	
Total number of census families	1,225	8,896,840	
Number of married-couple families	930 (76%)	6,105,910 (68%)	
Number of common-law-couple families	190 (15%)	1,376,870 (15%)	
Number of lone-parent families	105 (8%)	1,414,060 (16%)	
Number of female lone-parent families	90 (7%)	1,132,290 (13%)	

Adapted from: Economy and Rural Development Knowledge Center, Manitoba Agriculture, Food and Rural Initiatives, 2008; and Statistics Canada (Census 2006)

2.2.3 The Socioeconomic Status of Stuartburn

Stuartburn is located in south-eastern Manitoba, 120 kilometers south of the city of Winnipeg, on the Canada-United States border. In 2005, 1,630 people lived in the municipality which covers an area of 1,162 square kilometers. The municipality was initially formed in 1902 but went bankrupt and was disbanded in 1944. Stuartburn then became a local government district, until 1997 when it was re-established as a municipality. Many of the current inhabitants of the municipality are of Ukrainian decent, who settled in the region throughout the late 19th century (Manitoba Community Profiles, 2006).

Stuartburn is more typical of rural prairie communities and exhibits an outward migration of youth and retention of the aging, retired population. As a consequence, when compared to Cornwallis, Stuartburn has a significantly higher average age of 44 years old (Statistics Canada, 2006). In addition, although the unemployment rate is low, at 3.1%, it still exhibits a low workforce participation rate at 63% compared to Cornwallis at 78%.

These demographics are reflected in the local economy where the average household income in 2005 of $37,622 was significantly lower than the national average of $44,136 (Statistics Canada, 2006). Stuartburn's economy also appears to be more dependent and concentrated on agriculture when compared to Cornwallis (Table 2.2). In addition, the proportion of individuals with a post secondary education is nearly half in Stuartburn (24%) when compared to Cornwallis (43%). Although Stuartburn exhibits a low divorce rate, it exhibits a substantially high widow rate (10.5%) compared to the national average of 6% (Statistics Canada, 2006). Stuartburn still however displays a high proportion of married-couple families when compared to the rest of country.

Overall, Stuartburn shows the typical socioeconomic indicators of a small rural community, with an aging population and a dependence on agriculture and resource-based activities as an economic base. This suggests that Stuartburn may be particularly vulnerable to the effects of EEEs and specifically flooding. Similar to drought in Cornwallis, it is not necessarily the acute effects of flooding that pose a long-term threat to the community, but rather the cumulative stress from the social disruption that would result from an increase in extreme flooding induced by climate change (Flynn 1999; Freedy *et al.*, 1994).

Table 2.2: Socioeconomic statistics of Stuartburn, 2006

Population and Age	**Total**	**Male**	**Female**
Total Population	1,630	815	810
Median Age	44	44	44
Total Population aged 15 and over	79%	80%	77%
Income	**Stuartburn**	**Canada**	
Median Income (2005) for All Private Households	$37,622	$44,136	
Labour Force	**Total**	**Male**	**Female**
Total population 15 years and over	1,270	645	620
In the labour force	800	455	340
Employed	775	440	335
Unemployed	25	15	10
Not in the labour force	470	190	275
Participation rate	63.0%	68.2%	54.0%
Unemployment rate	3.1%	3.3%	2.9%

Industry	Total	Male	Female
Total experience labour force 15 years and over	785	455	335
Agriculture and other resource-based industries	315	210	105
Construction industries	50	45	0
Manufacturing industries	95	55	35
Wholesale trade	35	25	0
Retail trade	80	25	55
Finance and real estate	0	0	0
Health care and social services	70	10	65
Educational services	45	20	20
Business services	30	20	0
Other services	65	35	35

Education	Total	Male	Female
Total Population – 15 years and over	1,270	645	620
No certificate, diploma or degree	685	370	315
High school or equivalent	275	105	165
Apprenticeship or trades certificate or diploma	80	35	40
College degree	155	90	65
University degree below bachelor level	10	10	0
University degree	70	35	30

Marital Status	Stuartburn	Canada
Total Population 15 years and over	1,285	26,033,060
Never legally married (single)	300 (23%)	9,087,030 (35%)

Legally married (and not separated)	730 (57%)	12,470,400 (48%)	
Separated; but still legally married	40 (3%)	775,425 (3%)	
Divorced	75 (6%)	2,087,390 (8%)	
Widowed	135 (10.5%)	1,612,815 (6%)	
Family Characteristics	**Stuartburn**	**Canada**	
Total number of census families	450	8,896,840	
Number of married-couple families	350 (78%)	6,105,910 (68%)	
Number of common-law-couple families	35 (7.8%)	1,376,870 (15%)	
Number of lone-parent families	65 (14%)	1,414,060 (16%)	
Number of female lone-parent families	40 (9%)	1,132,290 (13%)	

Adapted from: Economy and Rural Development Knowledge Center, Manitoba Agriculture, Food and Rural Initiatives, 2008; and Statistics Canada (Census 2006)

2.2.4 Increasing Community Coping Capacity

In order to reduce vulnerability it is imperative that individuals and communities are well prepared to deal with EEEs, especially in the context of an increasing risk due to climate change-induced drought and flooding in the rural Canadian Prairies. In order to cope with these hazards disaster management has traditionally followed a three step process of:

1) *preparedness*, which involves all actions designed to minimize loss of life and damage, and to prepare for timely and effective rescue, relief and rehabilitation;
2) *prevention*, which includes measures taken to prevent phenomena from causing or resulting in hazards; and

3) *mitigation*, which includes minimizing the effects once the phenomena has occurred (WHO, 1992).

The ways in which these objectives are most effectively achieved are a source of continuous debate. However, the past decade in disaster management has seen a movement away from focusing on the hazards as the element to be managed or controlled towards an increased emphasis on managing the risks (Mileti & Gailus, 2005; Buckle and Cole, 2004; Blaikie *et al.*, 1994). This shift towards the vulnerability/resilience paradigm, has largely replaced the technocratic hazards paradigm within disaster research and much of the professional emergency and disaster management departments, but unfortunately still not policy (Haque and Etkin, 2007). This approach dictates that mitigation strategies should be increasingly based on long-term social, economic and environmental adaptation strategies and should draw upon assessments of risk, vulnerability and resilience within communities, rather than relying on scientific and technological intervention as the primary strategy in disaster management. The goal of this approach is to build institutions and structures in such a way as to minimize the effects a hazard in a preventative manner. Buckle and Cole (2004) contend that this is achievable by:

1) building a comprehensive capability for anticipating major incidents to prevent them or take action in advance that will mitigate their effects;
2) ensuring that planning for response and recovery is geared to the risk therefore ensuring preparedness; and
3) promoting a culture of resilience including business continuity thus helping to reduce the disruptive effects of a hazard.

Another movement that has been gaining attention in disaster management is increasing the public's role in decision making or participatory approaches. The ongoing debate between researchers and decision makers has thus focused on how to effectively involve public participation in the decisions making process. It is increasingly argued that the empowerment of citizens associated with a collaborative approach is more effective when compared to the one-way, top-down communication that has characterized past approaches. Mileti and Gailus (2005) contend that in order to achieve sustainability in disaster management, communities must become more active in determining the nature of future practices. Therefore, public involvement is increasingly becoming a more common method in the decision making process (Diduck and Sinclair, 2002). In addition, increased participation as well as early involvement of citizens has been found to lead to more successful mitigation and preparedness measures (Bruby, 2001). However, disaster management has yet to acknowledge and include that direct training and persuasion by professionals and health workers, as opposed to indirect methods, has proven to be a more effective approach towards generating behavioral change and enhancing risk perception (Ferrier and Haque, 2003). It is generally contended that by making the right choices about citizen participation in mitigation strategies, emergency managers can build an informed constituency for mitigation and develop a real commitment among elected officials to take action.

There is also increasing evidence that suggests increased community cohesion may develop following a disaster (Anderson-Berry and King, 2005). However, other research has also suggested that this tends to vary according to pre-existing social support systems but that community social stratification, economic viability, political motivation and structural features most often eventually return to pre-disaster conditions (Anderson-Berry and King, 2005). This tendency to return to previous conditions has been noted as an opportunity to increase the capacity of communities to deal with future losses, but 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 make meaningful changes.

In the context of rural regions like the Canadian Prairies, where communities are traditionally considered to be more cohesive, there can be no assumptions that residents are of 'like mind' or are 'not in conflict' (Marsh and Buckle, 2001). For example, research on rural Canadian communities by Haque (2000) focused on the strain on volunteer capacity due to the lack of human resources available, as many community members already perform multiple roles. The capacity of even the idealized small rural community, with its perceived strong social cohesion and high social capital, may present difficulties to further development of community capacity building efforts due to a lack of general enthusiasm and commitment. This is compounded with the additional strain on community resources that are already coping with emergency preparedness tasks along with the rest of the social and community duties already performed. While there is a reasonably high level of awareness of general risks and their associated response, the awareness of rare events, such as disasters not common to the region, are generally over-looked. Evidently there is a deficit of strong organizational structure at the community level, suggesting that an all hazards risk reduction approach may prove to be inadequate (Haque, 2000).

2.3 Risk Communication

2.3.1 Introduction

Risk is an inherent characteristic of life and our ability as individuals to make decisions based on risk assessment is fundamental to our survival. Therefore, the ability for government to effectively communicate risk to the public is a very useful skill towards ensuring a safe, healthy, and productive population. Risk communication has thus emerged as the dominant framework from which government and other bureaucracies communicate complex risk information to the public so that they can make well- informed, independent decisions (Morgan *et al.*, 2002; Rowan, 1991; Gow and Otway, 1990; Otway, 1987; Plough and Krimsky, 1987). The ultimate goal of risk communication is to give people the ability to make informed decisions that minimize their risk (Longstaff, 2003). Unfortunately, the last three decades of risk communication have primarily focused on short-term, urgent, emergency warnings in which implementation is often *ad hoc* with typically no clear analysis of what needs to be communicated or any evidence that messages were successful (Blanchard-Boehm, 2008; Morgan *et al.*, 2002). However, recent advances in the field are focusing more on the social context of risk communication and the interpretive process that ensues (Blanchard-Boehm, 2008). The following section attempts to explore some of the important ideas in the field of risk communication relative to this thesis.

2.3.2 Risk Perception

Establishing a successful risk communication message requires an identification and understanding of risk perception. Not only is risk perception a crucial component of determining how to target a specific audience in order to communicate a message but it is also what allows the public to make informed decisions about the risks they encounter.

However, the prevailing attitudes surrounding the risk communication message is likely to affect what information is believed and responded to by the audience (Frewer, 2004; Douglas & Wildavsky, 1982). Similarly, the state and nature of risk perception, interest and access to information, and psychological preparedness to respond, have a profound effect upon the quality of emergency and disaster preparedness (Haque, 2000; 1997). It is therefore imperative that the risk perception of the target audience is properly understood and considered as a critical aspect in the risk communication strategy.

For almost 25 years social scientists have conducted studies concerning risk perception, yet there has still been no consensus to what drives public attitudes (Slovic, 2000). The earliest studies of risk perception focused on describing the idiosyncratic ways human minds think about probability, uncertainty, and risk (Slovic *et al.*, 1974). This approach embraced the theory of 'bounded rationality', which asserted that people commonly display a systematic misperception regarding risks and tend to deny questions of uncertainty. Research by Tversky and Kahneman (1982, 1974, and 1973) built on this concept by establishing the idea that people don't tend to follow the principles of probability theory in judging the likelihood of uncertain events. Instead, people tend to replace the laws of chance by intuitive heuristics, which suggests that experience with a particular hazard should increase an individual's knowledge of associated risks. Although this sometimes produces good estimates of risk, such as in flood prone regions, it all too often yields large and systemic biases which can lead to severe consequences. These theories led to the general belief that human cognitive limitations require decision makers to construct a simplified model of the world in order for messages to effectively influence the public (Slovic, 2000).

By the late 1970s the 'psychometric model' was developed by Fischhoff *et al.* (1978) and quickly became the most common platform for risk perception research. The model attempts to explain why various people perceive risk differently by using psychophysical scaling and multivariate analysis techniques to produce quantitative representations of risk attitudes and perceptions (Sjoburg, 2004). Numerous studies carried out within the psychometric paradigm have seemingly demonstrated that perceived risk is quantifiable and predictable (Slovic, 2004).

With the introduction of the psychometric paradigm, many key findings emerged that have had major impacts in the field of risk perception research. One of these key findings is the theory that people often overestimate the risks of dramatic causes of death (i.e. airplane crashes) (Covello & Johnson, 1987; Lichtenstein *et al.*, 1978). These overestimates are thought to reflect the greater 'memorability' and 'imaginability' of these events. These distorted risk perceptions are also believed to be reinforced by more recent events and those receiving intense media coverage (Lichtenstein *et al.*, 1978).

Secondly, the psychometric paradigm has also led to the prevailing belief that the public often has difficulty understanding and interpreting probabilistic information, especially when the probabilities are small and the risks are unfamiliar (Slovic *et al.*, 1980; Covello, 1984). A third significant concept identified in the literature is that the way in which risk is presented often exerts a powerful influence on an individual's risk selection, perceptions, and concerns (Kahneman & Tversky, 1984). Finally, one of the most important ideas in risk perception has been that individuals take a large number of factors into consideration in evaluating the seriousness of a risk (Covello & Johnson, 1987; Slovic et al, 1980; Covello, 1984). Therefore, an individual's perception of risk is likely to reflect a myriad of qualitative factors including familiarity, dread, catastrophic potential, and voluntariness; as opposed to only expected mortality rates.

2.3.3 The Traditional Top-Down Approach

Risk communication has traditionally seen a disjuncture between those who make risk decisions on a day-to-day basis and those who make decisions concerning risk messages (Morgan *et al.*, 2002; Fischhoff, 1990). Accordingly, research has shown that the public tends to evaluate risk based more on a 'worst-case-scenario' basis, while experts tend to relate risk as a statistic or numerical probability, such as an expected annual mortality (Slovic *et al.*, 1979). This reflects a common theme throughout risk communication, and is emphasized in this research; that the public and scientific/technical experts do not often share similar perceptions of risk (Slovic, 2000; Okrent and Pidgeon, 1998; Plough and Krimsky, 1987).

Despite this knowledge, the risk communication process has typically followed a top-down approach, with the delivery of messages ascending from the expert down to the public. Risk communication strategies have traditionally neglected the concerns or beliefs held by the public, leading to a general distrust and lack of confidence in the activities and programs devised for public protection (Frewer, 2004). The process has been described by Hilgertner (1990) as the 'deficit model', which assumes that the public is deficient in their understanding of risk and of science in general.

However, recent advances in the field are focusing more on the social context of risk communication and the interpretive process that ensues (Blanchard-Boehm, 2008). Work by Slovic (1974; 1979; 2000) has continually argued that the gap between 'expert' and 'public' must be eliminated in order for the public to trust the judgments made by informed (expert) decision makers. Risk communication has subsequently begun to focus more towards understanding public views of risk, particularly in an attempt to increase the public acceptance of prevailing expert opinion and policy.

2.3.4 The Social Elements of Risk Communication

A successful risk communication is seen to be dependent on the characteristics of the risk, the nature of the message, how the message is communicated, and how the recipients process the information (Mileti and Fitzpatrick, 1991). At the individual level, the recipient of the risk message must (1) receive the information, (2) understand the information, (3) understand that the message applies to them, (4) understand that they are at risk if they do not take protective action, (5) decide that they need to act on the information, (6) understand which actions need to be taken, and (7) be able to take action (Blachard-Boehm, 2008; Glik, 2007). If anyone of these sequences is interrupted it is contended that it will result in a failure of the intended risk message (Tierney, 2000). Research has also shown that socio-demographic characteristics of the recipients of the risk messages are significantly related to their ability to receive, cognitively process, and act on warning information (Tierney, 2000).

Research now largely supports the concept that risk communication strategies must take societal concerns and values into account in order to improve the desired outcome of the process (Okrent & Pidgeon, 1998). Research has also shown that these factors are more important determinants in public response to communication messages than technical risk information alone (Frewer, 2004). Therefore, there is a need to understand the extent and nature of the public's perceptions of risk to hazards and how this knowledge differs from the expert community. This information is essential should there be a coordinated emergency response to a hazard, and to identify the factors that motivate people to take preventative actions that result in decreased personal risk and decreased economic losses (Siegrist and Gutscher, 2006). This knowledge can then be applied towards developing the best possible practices in risk communication by directly targeting misconceptions and divergent views into the risk communication process.

Trust is also found to be a very fundamental necessity in the risk communication process, particularly since there has been a broad-based loss of trust from the public in institutions and their leadership over the past three decades (Kasperson & Kasperson, 1998). Research by Sjober (2001) also reveals that the public is generally concerned with the limitations of scientific knowledge, particularly in its ability to determine risk. It is therefore important to recognize that when an audience has serious concerns or negative impressions, one must begin by listening to them before any new information is given (Frewer, 2004). Attempting to convey new information before understanding which concerns are important to one's audience may suggest to them that those concerns are not being taken seriously, and disregarded.

As a result, increasing societal and political pressure has been to maximize transparency in the risk communication process as well as the use of participatory approaches discussed previously. This concept is widely supported today based on the belief that experts often have an incomplete picture of the important, frequently intangible, factors that influence the risk perception of the public (Bier, 2001).

2.3.5 Cultural Theory, Worldview and Risk Perception

The last 20 years has seen the emergence of cultural theory as the primary method of examining how broader belief systems affect individual views, including risk perception. Cultural theory was first introduced by Douglas and Wildavsky (1982) who hypothesized that our society, like any other, uses "worldviews" to perceive the world around them. The risk perception literature generally defines worldview as the 'cultural lens' or 'cognitive filter' from which we view the world (Etkin and Ho, 2007; Slovic, 1999; Jenkins-Smith, 1993). It is contended that worldviews are generalized attitudes toward the world that manifest through social organizations which 'orient dispositions' that serve to guide people's responses in complex situations (Dake, 1991 and 1992). It is therefore contended that an individual's worldview acts as a gauge towards their attitudes concerning political, economic, and social relations (Peters and Slovic, 1996).

In the risk perception literature worldview is seen as instrumental in determining a person's risk attitudes and perceptions (Peters and Slovic, 1996). Accordingly an individual's worldview is influenced by the social relations in different groups which influence attitudes and beliefs according to the cultural bias of the specific group. This hypothesis affirms that various groups hold different worldviews that reflect their varying values and beliefs into their risk judgment that cannot necessarily be explained by individual psychology or by the scientific analysis of objective risks (Royal Society, 1992).

The literature identifies four basic worldview groups that exists throughout society, including hierarchical, fatalistic, individualistic, and egalitarian (Peters and Slovic, 1996). Those with a *hierarchical* worldview are believed to be more group-oriented and understand that different strategies corresponding to different groups of people. The *fatalist* also believes that different strategies should be applied to different groups of people, but is more isolated and tends to focus on individual as opposed to groups. The *individualist* is hypothesized to be more individual-oriented and to believe that few rules are necessary to govern behavior. The egalitarian is more group-oriented, but also believes in few rules in order to govern.

In the context of this research, the concept of worldview is applied as a mental or cognitive lens through which individuals perceive, understand, and make decisions about the world around them. For example, an older aged religious man, who is well-educated and wealthy, would probably see the world fundamentally different than a young atheist woman who is a high school dropout, and poor. Worldview is therefore used as an indicator, based on numerous variables, including age, gender, and socio-economic status, which ultimately orients an individual's belief system.

Accordingly, the risk perception research has grown to support the importance of worldviews as one of the fundamental factors involved in understanding different perceptions of risk (Lima and Castro, 2005; Lorenzoni *et al.*, 2005; Peters and Slovic, 1996). Research by Brier (2001) suggests that people with an egalitarian worldview tend to be 'anti-nuclear', while those embracing a fatalistic, hierarchist or individualistic worldview tended to be 'pro-nuclear'. In relation to climate change, three main groups of worldview were identified by Lorenzoni *et al.* (2005), including:

1) individuals who think of climate change as a low or nonexistent risk;
2) individuals who perceive climate change as a real and high threat; and
3) people who conflate global climate change with stratospheric ozone depletion.

However, even within a specific worldview there still tends to be a variation in which individuals either hold extreme 'fringe' positions or 'middle-of-the-road' views (Bier, 2001). Some members of the targeted audience may already hold misconceptions about the topic in question, and hence may find the information being conveyed implausible or difficult to understand. Therefore assessing what the intended audience already knows or believes about a particular issue is clearly important in designing effective risk communication messages.

Thus, when a significant misconception is identified, it is important to address it explicitly, rather than merely presenting the correct information. While it may be impossible to gain agreement from everybody in the target audience, it is imperative to clearly identify which worldview you are attempting to communicate with. Risk communication messages are however too often designed with only one target audience in mind and not enough consideration is given to who is vulnerable and who needs to know (Morgan *et al.*, 2002).

2.3.6 Risk Communication and Climate Change

There is a range of fundamental risk perception and risk communication issues associated with the ways in which the public might respond to current discussions about dangers posed by climate change (Dessai *et al.*, 2004). Americans, for example, tend to view climate change as a moderate risk, affecting other populations or places removed in space and time. In addition, they tend not to link climate change with direct health impacts, indicating a clear gap between public and expert risk assessments (Lorenzon *et al.*, 2005).

Therefore, current public opinion and knowledge concerning climate change suggests that the public lacks a clear understanding of the precise nature, causes, and consequences (Lorenzon *et al.*, 2005). Indeed, research by Bostrom *et al.* (1994) indicates that the public commonly displays a variety of misunderstandings and confusions about the causes and mechanisms of climate change, and that even very well-educated individuals tend to conceptualize climate change issues very differently than do scientific/technical specialists.

The main obstacle concerning climate change is that it requires a strong grounding in climate-science, economics, and policy to fully capture the scope and interdisciplinary nature of the problem (Lorenzoni *et al.*, 2005). The *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC, 2007B) emphasizes this concern, indicating that while the sciences should be the source of information and evidence on anthropogenic climate change and impacts, the danger that these may represent will ultimately be judged by sociopolitical processes, as well as aspects of uncertainty and risk.

The problem of climate change can be linked to the risk concepts of *amplification* and *attenuation*, in which some people have erroneously perceived a particular risk as exceptionally high while others perceive the same risk as exceptionally low. Recent communication, particularly in the media, regarding climate change has emphasized 'fear appeals', essentially attempting to scare the public into action. Moser (2007) argues that this approach has ultimately divided the public's opinion regarding climate change, with some people perceiving the concept of global climate change and its anticipated outcomes as unbelievable, while others find it alarming and fearful. The result is a scenario where *amplification* and *attention* have consequently misguided the public's perception of risk. The current public perception that surrounds climate change has not yielded sufficient action, which is typical of threats that are perceived as frightening, ill understood, difficult to control, and overwhelming (Moser, 2007). Furthermore, Weber's (2006) "finite pool of worry" hypothesis attempts to explain human behaviour as being preoccupied with current salient risks (e.g. how to make money), and thus tends to neglect perceived distant risks (e.g. rare hazards).

Climate change is also an example of a risk that exhibits a rather significant degree of uncertainty. More specifically, the genuine degree of uncertainty that prevails throughout the scientific community is based on future global climate predictions that are currently predicted by powerful climate model computers. Historically there has been little emphasis on the communication of uncertainties of risk in communication. This was primarily because it was assumed that the public was unable to conceptualize the scientific uncertainties associated with technical risk estimates (Frewer, 2004). There has however been increasing evidence that suggests that the public is capable of understanding scientific/technical risk assessment and that the acknowledgement of uncertainty works to inform an individual's perception of risk through increasing the credibility of the communicator (Frewer, 1999; 2004).

The very complex nature of the climate change presents problems that require coherent, cohesive, and concerted action in order for risk to be effectively communicated. The most logical approach must be based on the guidance of scientific knowledge and shaped by a multitude of societal perspectives elicited through various methods and techniques. This approach broadens the knowledge base in the climate risk policy process by moving away from traditional notions of risk characterization and one-way communication (Lorenzoni *et al.*, 2005). In particular the provision of knowledge should commence with an empirical assessment of what people already know about climate change (Bostrom *et al.*, 1994).

3.0 Chapter 3 – Methods

3.1 Introduction

This chapter identifies and explains the methods that were used to fulfill the objectives for this research. *The mental model approach* was chosen as the methodological framework because of its proven effectiveness at identifying gaps in knowledge and applying the findings towards forming two-way risk communication messages. This methodology was developed by Morgan *et al.* (2002) at the Center for Risk Perception and Communication at Carnegie Mellon and reflects over a decade of work on the use of mental models in risk communication.

3.2 Mental Models

Mental models were first introduced in the 1940s by the Scottish psychologist Kenneth Criak who was interested in the cognitive mechanisms of the human learning process. The fundamental basis for Craik's work was founded on the theory that the human mind constructs small scale models of reality that are used to anticipate events, reason, and explain phenomenon. Over time mental models evolved to incorporate various other dimensions of human cognition and became a tool used to understand how knowledge is influenced by perception and behavior (Borgman, 1984). By the 1980s, after having been largely ignored in the literature following Craik's death, mental models began to be used by cognitive scientists throughout many disciplines in order to explain the various ways in which the human mind solves problems, learns, and understands how complex systems work (Johnson-Laird, 1983; Gentner, 1989). Mental models at this time however were still more focused on understanding objective measurements of the human mind. It was not until the

1990s that mental models began to be applied as tools for risk communication, in which they were specifically used to explain and educate the public about various risks. From the mid-1990s forward, mental models have been increasingly used in risk communication as a way of developing open-ended two-way dialogues, creating partnerships, and aiding in decision-making (Hill, 2005).

Despite the progress that mental models made in regards to promoting two-way communications, traditional risk communication has still typically relied on experts to determine what the people should be told. It is suspected that the failure to effectively communicate risk to the public is a reflection of the lack of systematic procedures for finding out what people know and need to know, and for confirming empirically that a communication has been effective (Morgan *et al.*, 2002).

Bier (2001) suggests that risk communication messages based on mental models are more effective at conveying both general knowledge as well as information regarding risk reduction strategies because message are tailored to the knowledge-set of the targeted audience and take individual differences in both attitudes and knowledge concerning risks into consideration when creating a message. Therefore, by understanding people's mental models (e.g. knowledge, beliefs, perception), effective risk communication messages are crafted to directly help them understand complex or unfamiliar phenomena.

In order to build on the work made on mental models in the last 20 years, Morgan *et al.* (2002) developed a five-step method called the '*mental model approach*', designed to create and test risk messages in a way that is faithful to the sciences of risk and communication. The *mental model approach* provides a necessary condition for establishing a partnership with the public and laying the foundations for mutual trust through a two-way communication process. According to the *mental model approach*, effective risk communication is dependent on determining: (1) what we know, (2) what we really know, (3) what we are doing, and (4) what we can do. This approach ultimately aspires to communicate risks to the public that they need to know but do not already (Morgan *et al.*, 2002).

The fundamental prerequisite of this approach involves determining the gaps in knowledge between the public and experts. By targeting the specific gaps in knowledge it is the intention of this risk communication approach to empower and motivate people with the knowledge that they need in order to take preventative actions that will decrease their overall risk to potential hazards (Siegrist and Gutscher, 2006). For the purpose of this research, the name '*mental model*' has been replaced by '*knowledge model*' to reflect the specific pursuit of documenting expert and public knowledge in this study.

3.3 Theoretical Framework

In adhering to the *knowledge model approach*, this research followed a mixed-method methodology embedded within a critical social science (CSS) paradigm. The philosophical basis underlining a mixed-methods approach is that all methods have limitations, and thus by triangulating data sources, both qualitative and quantitative, there is convergence of data that can either help develop or inform the other method or provide insight into different levels or units of analysis (Green et al, 1989; Jick, 1979). In particular Creswell (2002) identifies two general strategies that are fundamental to the mixed-method approach:

- *Sequential procedures* – in which the researcher attempts to elaborate on or expand the findings of one method with another; and

- *Concurrent procedures* – in which the researcher converges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem.

CSS is founded on the principle of conducting research to critique and transform social relations. This is achieved by revealing the underlying sources of social relations and empowering people, especially marginalized people. According to this philosophy, reality is seen as constantly changing by social, political, cultural factors. CSS thus focuses on changes and conflict, particularly in problems that are inherent in the very way social relations are organized. While a positivist researcher will typically attempt to solve problems according to the constraints imposed by political or corporate elites, as not to 'rock the boat', a CSS researcher will typically identify problems and raise issues that conflict with the mandate of the elites. By uncovering myths, revealing hidden truths, it is the objective of the CSS researcher to ultimately empower the public and the individual.

3.4 The Knowledge Model Approach

This research employed the *knowledge model approach*, an adaptation of the *Mental Model Approach* developed by Morgan *et al.* (2002), in an attempt to fulfill the following objectives:

1) determine the status of knowledge concerning climate change-induced EEEs in the expert community;
2) determine the status of knowledge concerning climate change-induced EEEs in the rural public community;
3) identify the gap in knowledge between the expert and public domains concerning climate change-induced EEEs; and

4) identify the required elements of a risk communication tool in an attempt to increase the community coping capacity to climate-change-induced EEEs.

In order to fulfill these objectives, the *knowledge model approach* utilized four main methods. These methods included:

- Two expert knowledge models
- 20 face-to-face interviews
- 400 confirmatory questionnaire surveys
- Expert feedback workshop

3.4.1 The Expert Knowledge Models

The first step of this methodology involved creating an expert knowledge model. The knowledge model was designed to be used as a tool that can help identify the gap that exists between 'expert' and 'public' knowledge. The knowledge model uses an *influence diagram*, which is a directed graph, with nodes connected by arrows, to illustrate the sequential relationship for climate change-induced EEEs to lead to individual-level effects.

Influence diagrams were first developed by decision analysts as a convenient way to summarize information about uncertain situations, allowing effective communication between experts and decision makers as well as to conduct information-related analyses (Shachter, 1988; Howard & Matheson, 1981). *Influence diagrams* were used in knowledge models because they can be applied to virtually any risk, are compatible with conventional 'scientific/technical' ways of thinking, are easily understood and readily subjected to peer-review, and fit within a decision-making perspective (Morgan *et al.*, 2002).

The knowledge models for this research were created through a full-day 'inter-disciplinary' workshop on October 16^{th}, 2006 in Winnipeg, Manitoba. The workshop included the participation of 12 experts from various organizations and institutions including NGOs, the federal and provincial governments, and academia (Appendix 1). The experts were chosen based on their recognition as leaders in their respected fields, including climate change, human health, and disaster management, as well as their willingness to participate.

The workshop focused on creating two expert models which illustrate the complex, sequential relationships in which climate change-induced flood and drought lead to individual-level effects. The workshop used the 'Assembly Method', which included identifying the key relationships involved and organizing them into *influence diagrams*. With the aid of a professional facilitator, the expert participants were able to express their opinions openly and discuss them with others until a general consensus was reached concerning each relationship. The final output from this process were two expert knowledge models which clearly illustrate the sequential relationship between climate change and the individual-level effects exacerbated by increased flood and drought.

3.4.2 Face-to-Face Interviews

The second step in the knowledge model process involved conducting 10 face-to-face interviews within each community throughout January and February 2007. The individuals asked to participate in these interviews were identified as key stakeholders in their communities and were primarily associated with either the local administration, or were involved in community organizations. These individuals were seen as 'active' or 'leaders' within their respective communities and were chosen because they represented a sample of local decision-makers and encompassed a broad knowledge-set of the various issues associated with the region.

Initial contacts were made within each of the RM's administration whereupon additional participants were identified and contacted through the 'the snowball method'. This method involved asking the participants to refer any individuals who met the requirements listed above, and who may be interested in an interview. This process was continued until the desired outcome of 10 interviews in each community was fulfilled.

The interviews were open-ended and designed to elicit people's beliefs, ideas, and perspectives concerning the hazard by eliminating bias or leading questions from the interview process. This was achieved by opening the interviews with very general, non-leading questions and then following up with more specific questions in what is described as a 'funnel design' (Morgan *et al.*, 2002). These interviews were designed to capture a conceptual 'community knowledge model' which can be compared to the scientific/expert knowledge model' to provide insight into the second objective and specifically identify community knowledge concerning climate change-induced EEEs. Each question was specific to an explicit topic assigned to a key node within the expert knowledge model, in order to directly compare the two different knowledge sets. The interviews typically lasted for between 45 minutes and an hour.

3.4.3 Confirmatory Questionnaire Surveys

The third step in the knowledge model process involved creating and distributing confirmatory questionnaires asking questions related to the beliefs expressed in the expert model and face-to-face interviews in March 2007. This step is concurrent with Creswell's (2002) *sequential* and *concurrent* procedures, in which the researcher attempts to elaborate on or expand the findings of one method with another and in which both quantitative and qualitative data is compared in order to provide a comprehensive analysis of the research problem.

Knowing how frequently different beliefs are held by the public allows the risk manager to focus communications on the most widely held misconceptions, as well evaluate their potential impact. This included a comprehensive assessment of public knowledge concerning important beliefs (as determined in the expert model) and significant misconceptions (as identified in the face-to-face interviews) (Morgan *et al.*, 2002).

This step employed a distribution of 200 survey questionnaires within each community. The questionnaires were randomly distributed by Canada Post throughout each rural municipality as to ensure a true random sample. The response rate was 23% ($N^3 = 46$) in Cornwallis and 20.5% in Stuarturn ($N^3 = 41$). Analysis of these questionnaires was carried out through the use of SPSS which was used to calculate non-parametric statistics on the prevailing beliefs held by individuals in each community. The findings from both the questionnaires and interviews were then used as a framework to determine the status of public knowledge and thus allowed for public and expert knowledge to be directly compared in order to identify the gaps in knowledge.

3.4.4 The Expert Feedback Workshop

The fourth and final step of the *knowledge model approach* included a half-day expert feedback workshop at the Manitoba Health office in Winnipeg on July 17th 2008. The workshop involved the presentation of the findings to a group of experts who then engaged in a discussion regarding its relevance to disaster management policy in Manitoba. Leading questions, which were identified previous to the workshop, were then posed to the experts in order address specific issues pertaining to the research, including:

- What is the current risk communication policy regarding EEEs in Manitoba?
- Does the *knowledge model approach* have a potential application in Manitoba?
- What are some potential challenges to implementation?
- Based on the research findings, what would be the most effective risk communication tool?
- Do you have any other policy recommendations regarding climate change-induced EEEs?

The feedback from these questions was recorded through both group and individual-level documentation, in which participants could either openly discuss their ideas which were documented on a large sheet of paper, or could write their ideas on a personal sheet of paper. This allowed for the facilitation of a discussion as well as the opportunity for ideas to be expressed that may be controversial. The purpose of this workshop was therefore not only to discuss the implications of the findings to disaster management but to also identify the required elements of a risk communication tool and its potential application in Manitoba.

4.0 Chapter 4 – The Knowledge Gap

4.1 Introduction

The goal of this chapter is to present the findings obtained through the first three steps of the *knowledge model approach* which also fulfill the first three objectives of the research. These findings include an examination of expert knowledge pertaining to climate change-induced risk for both flooding and drought in Manitoba. Outcomes of this process are represented by two expert knowledge models which illustrate the sequential relationship in which a rise in mean atmospheric temperature leads to climate change-induced EEEs and subsequently to human related effects. Public knowledge regarding these specific relationships was then obtained through a series of face-to-face interviews and a round of mailed-out confirmatory questionnaires, which provided both qualitative and quantitative data. The results from all three steps were then compared in order to determine the existence and or extent of a gap that exists between both knowledge sets.

The key findings from this chapter include:

- the expert/public gap is largest concerning scientific/technical information (earlier parts of the models) related to climate change-induced EEEs;
- the gap is smallest regarding human/social aspects (later parts of the models) related to climate change-induced EEEs;
- expert and public knowledge is most divergent concerning the relationship between GHG's and a rise in the earth's temperature;
- Cornwallis respondents did not associate a rise in temperature with a reduction in soil moisture deficit; and

- Stuartburn respondents overwhelmingly believed that floods are caused by changes in the hydrological condition.

4.2 The Expert Knowledge Models

The purpose of the expert knowledge models was to fulfill the first objective which required determining the status of knowledge concerning climate change-induced EEEs in the expert community. In order to achieve this, a workshop was organized consisting of 12 experts representing different stakeholders from various disciplines. The experts provided their input regarding climate change-induced flooding and drought risks through the 'Assembly Method' which consisted of organizing the key relationships into sequential order in order to create two knowledge models.

The knowledge models presented below (figures 4.1 and 4.2) represent simplified versions of the more detailed models found in Appendix 2 and 3. These knowledge models use arrows connected to nodes to illustrate the sequential relationship for climate change-induced EEEs to lead to individual-level effects. The arrows symbolize influence from one node to another in the direction of the arrowhead, with the heavier arrows denoting a greater influence (key relationships). Two types of nodes are used to represent different kinds of information in the models. Oval nodes represent uncertain circumstances, with heavy ovals representing major factors, and light ovals representing sub-factors. Rectangles (only found in Appendix 2 and 3) represent mitigation measures that can impact variables and reduce risk to floods and drought. These mitigation measures can represent both individual and institutional level decision making.

4.2.1 The Drought Model

The expert drought model follows a series of key relationships that show the contributing factors that lead to risk associated with climate change-induced agricultural drought. The model is separated into three parts, each representing a different domain of conditions, including *atmospheric conditions* in Part 1, *physical environment* in Part 2, and *human/social impacts* in Part 3 (Appendix 2). Figure 4.1 is a generalized version of the expert drought knowledge model which shows the major factors and influences (heavy nodes and arrows) that lead from climate change to agricultural drought and eventually to individual-level effects. The sequential relationship represents the key findings from this model, which includes:

1) an increase in GHG concentration leads to a rise in mean temperature;

2) a rise in temperature leads to a soil moisture deficit;

3) a soil moisture deficit leads to agricultural drought;

4) a reduction in agricultural production leads to economic loss; and eventually

5) economic loss leads to psychological stress.

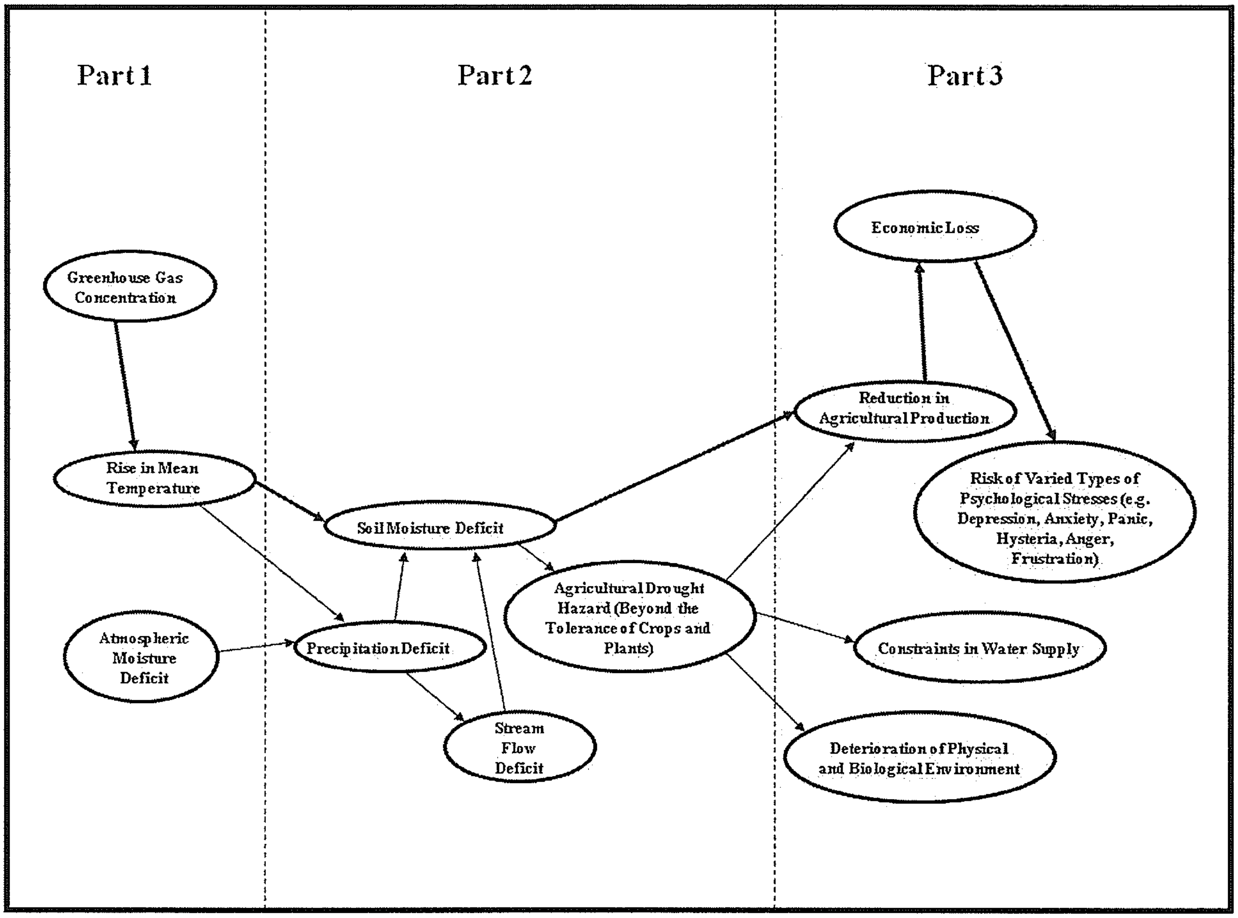

Figure 4.1: Generalized Version of the Expert Drought Knowledge Model

Part 1- Atmospheric Conditions

In order for agricultural drought conditions to emerge, the sequences in Part 1 of the diagram must first occur. Part 1 of the model represents atmospheric conditions which involve several key variables which are primarily scientific and technical in nature, such as: GHG concentration, mean temperature, and atmospheric moisture content. The heavy oval nodes denote key factors which influence GHG concentration, temperatures and moisture. The factors in the light ovals create the conditions for the heavy ovals to occur, acting as variables.

According to the model, GHG concentration is directly influenced by population growth and consumer life style. Population growth is further positively influenced by several sub-factors, including: a lack of health services and birth control devices, low income and poverty, personal belief system, and low literacy. Provisions of birth control devices and family planning, as well as changes in social value through public policy were proposed as possible mitigation measures to population growth by the experts. In addition, consumer life style is influenced by several factors, including: the types and modes of transportation, high consumption of goods and services, fossil fuel energy intensive production system, and a throw away mentality. It is also proposed by the model that these variables can be influenced or mitigated by environmentally friendly technology (including 3 R's, public transportation, and efficient energy use), alternative fuels, and pre-consumer product standard by legislation.

Several GHG abatement strategies that could be used to decrease the amount of GHG concentration in the atmosphere were identified. If these strategies are ignored or unsuccessful and the conditions are met for both 'consumer life style' and 'population growth', then this will lead to an increase in GHG concentration. This increase in greenhouse concentration, in addition to several other factors (including: the elimination of natural vegetation cover through changes in land-use patterns, UV radiation, surface albedo, inversion, intensity of isolation, and ocean surface temperature) leads to a rise in mean temperature. In addition, an atmospheric moisture deficit is caused by changes in the circulation of the atmosphere which caused many sub-factors such as: wind speed, changes in the pressure system, shifting wind patterns, ocean circulation, and teleconnection frequencies.

Part 2 - Physical Environment

If the conditions for a rise in mean temperature and atmospheric moisture deficit are met in part 1 then in part 2 these conditions will lead to a precipitation deficit. This sequentially leads to a stream flow deficit and subsequently to a soil moisture deficit which is also intrinsically affected by a lack of surface water availability. When the conditions for a soil moisture deficit are met, it directly leads to an agricultural drought hazard beyond the tolerance of crops and plants.

Part 3 - Human/Social Impacts

Once agricultural drought conditions have been met in part 2 of the model, three consequences can potentially occur in part 3, including constraints in water supply, deterioration of the physical and biological environment, and reduced agricultural production. A reduction in agricultural production directly influences individual economic loss, in addition to other effects such as damage to community and social relations, and the foreclosure of farms.

The mitigation strategies identified for this section of the model include reliance and strengthening of community relations, a rural stress line, crop insurance and social services planning. If the previous conditions are met and the mitigation strategies are unsuccessful or unimplemented, there is an associated risk of various types of psychological stresses which are also affected by other sub-factors in the domain of psychological impacts, including: increased dependence on social and institutional services, detachment from land based livelihood causing out-migration, as well as fear and uncertainty. According to the model the occurrence of psychological stresses will sequentially lead to health and social behaviours, such as: truancy, drug/alcohol abuse, increased family violence, increased divorce rate, increased crime rates, increased suicide, and chronic psychological disorders.

4.2.2 The Flood Model

The expert flood knowledge model follows a series of factors that show the sequential relationship that leads to risk associated with climate change-induced flooding. Figure 4.2 is a generalized version of the expert flood knowledge model, revealing the major factors and influences (heavy nodes and arrows) that lead from climate change to flooding and eventually psychological stress. The model is separated into four parts, each representing a different domain of conditions, including: *GHG concentration* in Part 1, *atmospheric conditions* in Part 2, *physical environment* in Part 3, and *human/social impacts* in Part 4 (Appendix 3). The drought model used four parts because it contains more information and therefore required a larger diagram to encapsulate it. The key finding identified in the model is the sequential relationship, which includes:

1) an increase in GHG concentration leads to a rise in atmospheric temperature;
2) a rise in temperature leads to changes in the hydrological condition;
3) changes in the hydrological condition when combined with human activity in the floodplain area lead to increased risk to flooding;
4) extreme flood exposure leads to an individual loss of property; and
5) an individual loss of capital leads to psychological stress.

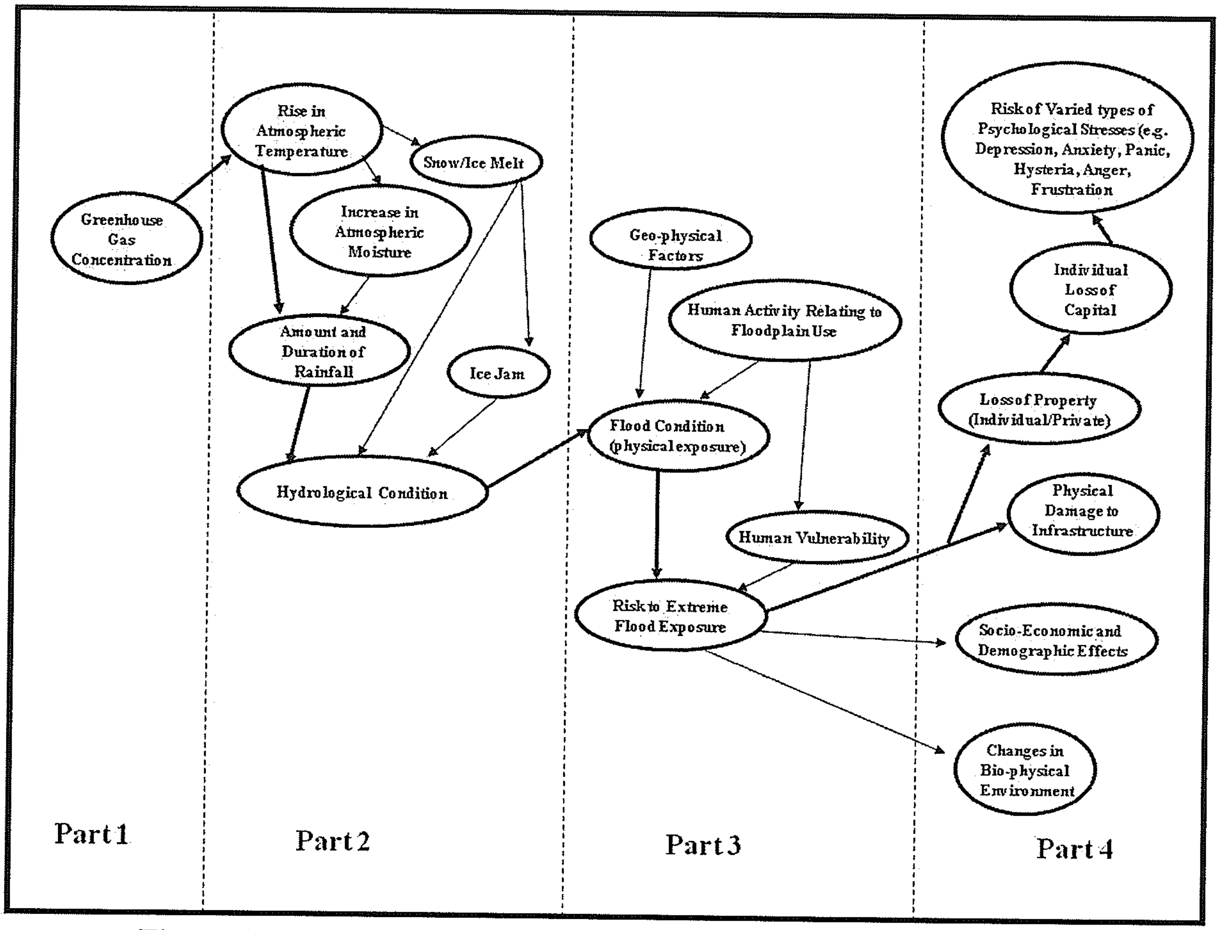

Figure 4.2: Generalized Version of the Expert Flood Knowledge Model

Part 1 - GHG Concentration

According to the expert flood knowledge model an increase in GHG concentration is primarily caused by 'consumer lifestyle' and 'population growth' which are influenced by many sub-factors and mitigation strategies that were also previously identified in the drought model.

Part 2 – Atmospheric Conditions

If these conditions are met in part 1 then in part 2, in addition to many sub-factors, such as: elimination of natural vegetation cover, stratospheric ozone depletion, UV radiation, inversion, ice cover, surface albedo, intensity of isolation, and ocean surface temperature; there will be corresponding rise in atmospheric temperature. A rise in atmospheric temperature directly effects snow and ice melt, while in addition to an increase in atmospheric moisture, also affects the amount and duration of rainfall. The model then indicates that with an increase in the amount and duration of rainfall combined with increased snow and ice melt, which can be exacerbated with ice jams, leads to an increase in the intensity of the hydrological condition.

Part 3 - Physical Environment

The model indicates that an increase in the hydrological condition directly influences the conditions for a flood to occur. Flood conditions are then also further influenced by geo-physical elements which are controlled by various other factors, including: drainage network factors, stability of the basin (i.e. altitude, shape, slope, area, and its aspect), unstable basin factors (i.e. geology, vegetation cover, soil type, infiltration, storage capacity, soil moisture, and transmissibility), and channel factors. In addition to geo-physical factors, it was identified that human activity related to floodplain use, which is primarily affected by technological interventions (i.e. dams, dykes, and floodway diversions) and unwise land use practices, also has a significant influence on the flood condition. If the flood condition is intensified by these additional factors then there is direct risk to exposure of extreme flooding, if humans are present. The model also identifies several mitigation strategies throughout Part 3, such as: risk assessment, a flood forecasting and warning system, and floodplain use and zoning amongst others, which could either directly or indirectly increase the coping capacity to extreme flooding.

Part 4 – Human/Social Impacts

In part 4, risk to extreme floods is shown to influence the bio-physical environment, socio-economic and demographic effects, as well as physical damage to infrastructure and loss of property. With the loss of property at the individual level there is a direct link with individual loss of capital in addition to various other affects which include: the need for compensation, an increased tax burden to share the loss, social disruption, and discontinued businesses. Several mitigation strategies were identified that would potentially buffer some of these affects, such as: property assessment, flood insurance, and public policy on compensation. If the conditions surrounding an individual loss of capital are met then it can both directly and indirectly led to psychological stresses. In addition, if an evacuation occurs, it influences the feeling of isolation as well as a decline in the regional economy which both influence the occurrence of psychological stress. The occurrence of psychological stresses also influences many effects related to health and social behaviours, which includes: truancy, increased crime rates, increased family violence, drug and alcohol abuse, increased divorce rate, and chronic physical disorders.

4.3 Public Knowledge

This section presents the findings from the face-to-face qualitative interviews (Appendix 4) and confirmatory questionnaire surveys (Appendix 5). Both the interviews and questionnaires where designed to examine the extent of public knowledge regarding these specific relationships in order to identify a gap between expert and public knowledge in the following section. As part of the face-to-face qualitative interviews, participants in both communities were asked broad, open-ended questions in order to determine their thoughts, ideas, and beliefs concerning the key relationships that were identified in the expert models. Random questionnaires were then distributed in both communities in order to test the consistency of the results from the face-to-face interviews and attempt to quantify these findings. Through this process it was determined that public knowledge does differ from expert knowledge and that there is a strong correlation in both communities concerning the location of the gaps.

4.3.1 Cornwallis Perspectives on Drought

GHG and an Increase in Temperature

The first key relationship in the expert model indicates that an increase in GHG concentration leads to a rise in mean temperature. Therefore, in the face-to-face interviews public participants were asked to divulge their knowledge concerning GHG's. The findings from the interviews suggested that the public was, to a large degree, confused about GHG's and in particular its association to climate change (Figure 4.3). In addition, many respondents associated GHG's with atmospheric ozone depletion as the primary cause of climate change and not as affecting the intensity of the greenhouse effect.

The results from the questionnaires (Table 4.1) supported the findings from the face-to-face interviews, indicating a large degree of confusion associated with GHG's amongst respondents. Accordingly, only 60.9% ($N_3 = 46$) of the respondents believed that GHG's were associated with a rise in temperature, while 10.9% ($N_3 = 46$) believed this relationship to be "maybe false" and 28.3% ($N_3 = 46$) indicated that they "didn't know". It is significant to note, however, that not one individual chose to indicate that they thought the statement was "false". Therefore, the results from both the qualitative and quantitative data suggest that the public holds many misconceptions concerning the role of GHG's and its relationship to climate change.

Table 4.1: GHG's and increased temperature

	Frequency	Percent (%)
True	17	37.0
Maybe True	11	23.9
Don't Know	13	28.3
Maybe False	5	10.9
False	0	0
Total	46	100.0

What can you tell me about GHG's?

Honestly, I don't know a lot about that. (Cornwallis#4 – middle aged female)

It's connected to climate change but I'm not sure how it works. (Cornwallis#9 – middle aged male)

I'm going to say that's what is depleting the ozone layer. (Cornwallis#2 – middle aged male)

I don't have a big understanding, no. (Cornwallis#3 – middle aged female)

Figure 4.3: GHG's and Public Knowledge

Increased Temperature and a Soil Moisture Deficit

The second key relationship identified in the expert model is a rise in mean temperature leading to a decrease in precipitation. The findings from the face-to-face interviews revealed that when asked to comment on the causes of agricultural drought, most participants associated it with a lack of precipitation over a prolonged period of time, but very few mentioned an increase in temperature as a variable influencing precipitation or soil moisture (Figure 4.4). Therefore, although many participants understood that agricultural droughts are slow creeping hazards, temperature was rarely mentioned as factor contributing to this condition.

The questionnaires supported this finding, as only 50% ($N_3 = 46$) of the Cornwallis respondents believed that a rise in the earth's temperature is linked to a deficit in precipitation and to drought (Table 4.2). Interestingly, this was the smallest proportion of agreement amongst public respondents concerning a key relationship of the study. These findings, both qualitative and quantitative, suggest that the majority of the public do not associate a rise in temperature with a decrease in precipitation and a soil moisture deficit, contrary to expert knowledge.

Table 4.2: Increased temperature and drought

	Frequency	Percent (%)
True	8	17.4
Maybe True	15	32.6
Don't Know	15	32.6
Maybe False	2	4.3
False	6	13
Total	46	100.0

Can you tell me what causes agricultural droughts?

I don't know; a lack of rain. (Cornwallis#2 – middle aged male)

A lack of rain for three weeks or more. (Cornwallis#3 – middle aged female)

Well, obviously if they don't have enough snowfall during the winter or rainfall going into the ground, so it's totally dry. (Cornwallis#5 – middle aged female)

It happens when people don't have enough pasture to graze their animals and enough water to water them, and certainly they can't grow enough feed. (Cornwallis#6 – senior male)

I would say a drought in this area tend to be the tail end of one growing season, dry winter, go into the spring dry and you don't get a lot of compensation. (Cornwallis#9 – middle aged male)

Figure 4.4: Public Knowledge concerning the cause of Agricultural Drought

Soil Moisture Deficit and Agricultural Drought

According to the expert model, once there is a soil moisture deficit it quickly leads to an agricultural drought hazard. The face-to-face interviews revealed that when asked to define an agricultural drought, many participants generally described it as a lack of moisture affecting crops (Figure 4.5). The confirmatory questionnaires revealed that 63% ($N_3 = 46$) of the respondents believed that soil moisture deficit is linked to drought, while 17.4% ($N_3 = 46$) "didn't know", and 19.6% ($N_3 = 46$) believed that this relationship was "false" (Table 4.3). The findings from the face-to-face interviews suggest that, in general, the public associates the occurrence of agricultural drought with a soil moisture deficit, similar to expert knowledge. However, the findings from the questionnaires suggest that although many respondents do understand the relationship similar to experts, there is still some confusion amongst the entire population regarding the link between a soil moisture deficit and agricultural drought. Overall, there appears to be a moderate correlation between expert and public knowledge concerning this relationship.

Table 4.3: Droughts and soil moisture deficit

	Frequency	Percent (%)
True	16	34.8
Maybe True	13	28.3
Don't Know	8	17.4
Maybe False	5	10.9
False	4	8.7
Total	46	100.0

How would you define an agricultural drought?

Anytime that it gets dry enough to affect the yields by about 10% of 20%. (Cornwal*lis*#1 – senior male)

Well, no moisture and not enough rain. (Cornwallis#7 – middle aged female)

It's when we run out of enough moisture to produce a good crop. I can remember a number of years stick out. Farmers are always saying 'if we could have had just another half an inch'. If we go into the spring with good spring moisture and the crops germinate, then we don't need tons and tons of rain as long as we get some good timely showers. The farmer mentality is always looking for that extra little bit of rain at the right time, but not too much, not too little. I can remember a couple of times when we just didn't have any spring moisture, which I would consider a drought. (Cornwallis#9 - middle aged male)

Not enough water to germinate the seeds or keep the plants alive for maturity, and the plant dies somewhere along the line before the drought comes. (Cornwallis#8 – middle aged female)

Figure 4.5: Public Knowledge of Agricultural Drought

A Reduction in Agricultural Production Leading to Economic Loss

The expert model indicates that the main effect of drought is its reduction in agricultural production which leads to economic loss. The face-to-face interviews suggest that much of the public understands the relationship between agricultural drought and its connection to the local economy (Figure 4.6). The findings from the interviews reveal that many of the participants have dealt with this relationship first-hand, and even for those who haven't, there exists a strong level of understanding concerning the link between agriculture, the economy, and the community.

This finding was supported by the questionnaires which revealed that 89.2% ($N_3 = 46$) of Cornwallis respondents agreed with the relationship and only 4.3% ($N_3 = 46$) disagreeing, while 6.5% ($N_3 = 46$) "didn't know" (Table 4.4). The questionnaires therefore revealed a very strong proportion of public agreement with this relationship. Overall, there appears to be high correlation between expert and public knowledge concerning a reduction in agricultural production leading to economic loss.

Table 4.4: Agriculture and economic loss

	Frequency	Percent (%)
True	21	45.7
Maybe True	20	43.5
Don't Know	3	6.5
Maybe False	0	0
False	2	4.3
Total	46	100.0

How does agricultural drought affect you and your community?

I would think that under extreme circumstances farmers couldn't sell any crops at all, couldn't support their livestock, couldn't pay their bills, couldn't pay their taxes, perhaps you would have some of the land sold for taxes. (Cornwallis#6 – senior male)

Were always expecting drought here, because of where we are- we are expecting it. If there is not enough rain, that affects everyone, not just agriculture. (Cornwallis#8 – middle aged female)

It affects the whole economy, all the businesses in town suffer, its' a snowball effect. (Cornwallis#9 – middle aged male)

My farm would have a very poor year and we would lose money. You have to pay for all the overhead and if you don't get a crop out of it that you can sell, you are out of luck. (Cornwallis#10 – middle aged female)

The spin-off is that there is just less dollars around, not the immediate year but usually one year later. Often times you are feeling the previous year's grain throughout the year. (Cornwallis#2 – middle aged male)

Figure 4.6: Public Knowledge of Drought in the Community

Economic Loss and Psychological Stress

In the final section of the expert model there is direct link with individual level economic loss leading to various types of psychological stress. Most of the participants in the face-to-face interviews recognized that psychological stress is often associated with drought-induced economic loss (Figure 4.7). There was also a high degree of recognition from public participants with the many effects caused from psychological stress identified in the expert model, including alcohol abuse and suicide. The results from the questionnaires support the qualitative findings, revealing that 84% ($N_3 = 46$) of the respondents agreed with this relationship while only 4.4% ($N_3 = 46$) believed that it was false (Table 4.5). Overall, the public displayed a high correspondence in both qualitative and quantitative data with expert knowledge concerning the relationship between drought and the occurrence of psychological stress.

Table 4.5: Droughts and psychological stress

	Frequency	Percent (%)
True	25	54.3
Maybe True	14	30.4
Don't Know	5	10.9
Maybe False	1	2.2
False	1	2.2
Total	46	100.0

What would happen if the stress caused by drought persisted?

Well suicide is the worst case scenario, marital troubles is second worst case, and family abuse. I guess it kind of strikes the community, if they go out less and try and conserve nickels. The human elemental side of their life is going to go downhill. (Cornwallis#1 – senior male)

I think there would be certain people in the community that would look for ways of coping that would add to the problem, alcohol, that sort of thing. (Cornwallis#3 – middle aged female)

It could certainly lead to a determent of their psychological well-being. I know one case in particular where a farmer was severely distraught by draught and he couldn't do any farming at all and he welded the well door shut so he couldn't use it and no one else could use it. (Cornwallis#6 – senior male)

Communities are already facing people leaving all the time; less and less people living in small communities. I have actually experienced in one event cases of suicide because of psychological stresses, it has such an effect on the community that people are leaving the farms because they aren't going put up with it any more. You see the effects especially in small communities it has such a ripple effect. (Cornwallis#7 – middle aged female)

Figure 4.7: Public Knowledge of Drought Related Stress

4.3.2 Stuartburn Perspectives on Floods

GHG and an Increase in Temperature

Consistent with the drought model, the flood model commences with an increase in GHG concentration leading to a rise in atmospheric temperature. The face-to-face interviews in Stuartburn, revealed a large amount of confusion amongst participants regarding this relationship, including associating GHG's with atmospheric ozone depletion, similar to Cornwallis participants (Figure 4.8). The questionnaires confirmed this finding with only 59.5% ($N_3 = 41$) of the Stuartburn respondents believing there is a link between GHG concentration and an increase in temperature (Table 4.6). Overall, both methods suggest that there is significant amount of confusion amongst the public concerning this relationship.

Table 4.6: GHG's and increased temperature

	Frequency	Percent (%)
True	14	34.1
Maybe True	10	24.4
Don't Know	8	19.5
Maybe False	4	9.8
False	5	12.2
Total	41	100.0

What can you tell me about GHG's?

Really, I don't think it's affected anything (in reference to GHG's). In fact the GHG's, your trees would use up most of it. (Stuartburn#6 – senior male)

These are things that we do that destroy the ozone layer in the atmosphere which causes all these changes to take place. (Stuartburn#7 – senior male)

There is a big hole in the ozone layer, letting in more harmful rays. I don't know why patterns are shifting from one part of the country to the other. (Stuartburn#9 – middle aged female)

Figure 4.8: GHG's and Public Knowledge

Temperature and the Hydrological Condition

Once there is a rise in atmospheric temperature, the expert flood model then indicates that this will lead to changes in the hydrological condition which lead to flood conditions. In the face-to-face interviews the statements made by the public revealed that public knowledge concerning this relationship was similar to expert knowledge as the majority of the participants associated the cause of flooding with various aspects of the hydrological condition, such as extreme rainfall, saturated soil, and ice jams (Figure 4.9). The confirmatory questionnaires confirmed this high level of correlation with expert knowledge, with 90.2% ($N_3 = 41$) of the respondents believing that flooding was directly linked to the hydrological condition, while only 9.8% ($N_3 = 41$) believing that it was either "false" or "maybe false" and no one indicating that they "didn't know" (Table 4.7). Therefore there appears to be a strong correlation between expert and public knowledge concerning the relationship between the hydrological condition and flood conditions.

Table 4.7: Temperature and changes to the hydrological condition

	Frequency	Percent (%)
True	27	65.9
Maybe True	10	24.4
Don't Know	0	0
Maybe False	2	4.9
False	2	4.9
Total	41	100.0

Can you tell me what causes a flood?

Saturated ground water, levels in the fall, heavy snow fall in the winter and then a quick melt, and there is no place for the water to go. Loss of vegetation cover would be another cause; heavy and sudden amounts of water. (Stuartburn#1 – middle aged male)

Lots of rainfall, poor drainage, and rapid thaws in spring. (Stuartburn#7 – senior male)

Ice jam, unprecedented rainfall, we've had that over the past few years. Access drainage and a quick meltdown in the spring will cause that. (Stuartburn#6 – senior male)

Usually it's caused by a mixture of extreme precipitation followed by poor drainage with pre-saturated soils. (Stuartburn#5 – young male)

Figure 4.9: Public Knowledge of the causes of Floods

Human Vulnerability and Flooding

The expert model indicates that when there is a combination of a flood condition and human vulnerability there is an extreme risk to flood exposure. In the face-to-face interviews there was a fairly high awareness amongst the public that living in the floodplain means an associated risk to flooding (Figure 4.10). Some respondents could list several ways that humans put there selves at risk, while others were more convinced that large floods are unavoidable.

In the questionnaires, 73.2% ($N_3 = 41$) of the Stuartburn respondents believed that human activity in the floodplain leads to an increased risk to flooding, while 14.6% ($N_3 = 41$) said they "didn't know" if it did and 12.2% ($N_3 = 41$) believed that it was either "maybe false" or "false" (Table 4.8). These findings suggest that much of the public agrees with the experts and believes that human vulnerability is a major component of risk to flooding, while there is still an underlying believe by some that risk to flooding is beyond the realm of human control.

Table 4.8: Human vulnerability to flooding

	Frequency	Percent (%)
True	22	53.7
Maybe True	8	19.5
Don't Know	6	14.6
Maybe False	2	4.9
False	3	7.3
Total	41	100.0

What human decisions do you think affect your risk to flooding?

You chose to live in the floodplain (in reference to: 'what puts you at risk?'). (Stuartburn#1 – middle aged male)

Where you put your building, putting it in a low lying area. That's the biggest issues followed by poor drainage. (Stuartburn#5 – young male)

Well the Red River Valley has decided what they are going to do, and that's either build dykes or builds paths. But if someone builds on a lake bottom they are going to have to take a risk of being flooded. However, we lie on the escarpment and we've been flooded. It's a difficult thing to try and find an answer to that question. Events that happen once in a lifetime or once in two lifetimes, you don't prepare for that. (Stuartburn#6 – senior male)

Drainage, we lease crown land and everyday you get people putting in drainage messing up the flow of water, everybody wants to save their property.
After the big flood, everyone is on their toes waiting to see if it will happen again. If it hits you once you realize it can happen again. If it continues people would move to drier grounds. Anyone who has been affected they've had to go through so much. It's a battle you can't win. I can't see people holding on to their farms. It depreciates the value of buildings so you can't afford it. We had 6 inches of water in our basement. We put in a claim to EMO and couldn't get anything. (Stuartburn#10 – middle aged female)

Figure 4.10: Human Decisions and Flooding

Flood Affecting the Community

Once an extreme flood occurs, the expert flood model shows that it leads to many impacts. However it is the loss of individual property that is identified as the primary consequence. The face-to-face interviews yielded a variety of responses in regards to how they believed that flooding affects their community, including the individual loss of property (Figure 4.11). In the questionnaires, 73.2% ($N_3 = 41$) of the respondents believed that the loss of property was the top concern during extreme floods, while 7.3% ($N_3 = 41$) "didn't know", and 19.5% ($N_3 = 41$) didn't think that it was a top concern (Table 4.9). These findings indicate that while there is a strong correlation between the public and experts in regards to this relationship, it is perhaps not as linear and direct as other relationships because flooding causes many affects, and the individual loss of property is just one amongst several.

Table 4.9: Loss of property from flooding

	Frequency	Percent (%)
True	19	46.3
Maybe True	11	26.8
Don't Know	3	7.3
Maybe False	7	17.1
False	1	2.4
Total	41	100.0

How does a flood affect you and your community?

People have been forced out of their homes, they have to sand bag a lot. They've had instances where children have had to go to different schools. People with livestock have had to find different places for their livestock, as well as their grain too. (Stuartburn#7 – senior male)

With wells in the area, it definitely affects some of them. Different neighborhoods have had damage to their basements and yards and forced people out of their homes. (Stuartburn#2 – middle aged male)

Figure 4.11: The Effects of Flooding in the Community

Drought-Induced Psychological Stress

The final relationship in the expert model shows that with an individual loss of property is an associated loss of capital which can then lead to various kinds of psychological stress. The face-to-face interviews revealed that most participants recognized that the individual loss of capital caused by flooding can lead to various forms of psychological stresses (Figure 4.12). The questionnaires revealed that 75.6% ($N_3 = 41$) of the respondents made the connection that flooding can lead to psychological stress in their communities, while the remaining 24.4% ($N_3 = 41$) either "didn't know", or disagreed with the relationship (Table 4.10). These findings suggest that overall, the public is generally aware and agrees that there is a connection between flooding and psychological stress.

Table 4.10: Flood related stress in the community

	Frequency	Percent (%)
True	17	41.5
Maybe True	14	34.1
Don't Know	5	12.2
Maybe False	1	2.4
False	4	9.8
Total	41	100.0

What would happen if the stress caused by flooding persisted?

There is an extreme psychological edge there and people might be pushed to the brink (Stuartburn#1 – middle aged male)

I think it would cause people a lot of sleepless nights. Raises the stress level, causes health problems, and causes heart attacks. (Stuartburn#2 – middle aged male)

Yes, I think people worry about it every spring time. If it happened continuously, I think people would move, although some people are very stubborn. I think a lot of people would move. A lot of mental stress with it. (Stuartburn#7 – senior male)

Figure 4.12: Flooding and Psychological Stress

4.4 The Gap in Expert/Public Knowledge

This section identifies and examines the gaps in knowledge that were found between experts and the public in the previous section. In comparing the findings from the expert models, the face-to-face interviews and confirmatory questionnaires, it was determined that the knowledge gap was substantially larger in the earlier (scientific/technical based) sequences and smaller in the later (human/social based) sequences of both models. This finding suggests that public knowledge is more divergent from expert knowledge concerning scientific/technical information but is more closely aligned with expert knowledge concerning human/social information.

4.4.1 Gap Analysis

Gap analysis was used as a conceptual framework in this research in order to identify and contrast the gap between expert and public knowledge. Gap analysis has traditionally been used as a means of attempting to identify the divergence between experts and the public in various fields such as medicine, business, and government. In the context of this research, gap analysis was specifically adopted as part of the *knowledge model approach* in order to identify the gap in knowledge that exists between the expert and public domains so that a risk communication tool could target this gap.

The gap between expert and public knowledge has long been a subject of discussion in the field of risk perception (Siegrist *et al.*, 2007; Garvin, 2001; Rowe and Wright, 2001; Lazo *et al.*, 2000; Kraus *et al.*, 1991). Accordingly, expert knowledge has traditionally been characterized as rigidly objective and able to produce accurate estimates of risk consistent with statistical data (Rowe and Wright, 2001). In contrast, public knowledge has typically been portrayed as more subjective, less specific and more generalized than experts (Lazo *et* *al.*, 2000). These concepts have lead to a general understanding amongst experts that the public has a tendency to react emotionally or subjectively to complexity and are therefore frequently incapable of making effective decisions regarding complex problems; even though they often produce estimates of risk consistent with statistical data (Margolis, 1996; Irwin and Wynne, 1996). In addition, the public tends to criticize experts for using inaccessible, technical language and for failing to act in their own best interests (Garvin, 2001). These misconceptions have led to confusion amongst both groups and have been reflected through the one-way, top-down approach of traditional risk communication (Hinds, 1999; Schmidt and Boshuizen, 1992).

It is contended that this gap has less to do with what the public doesn't know, but more to do with what the public believes about risk that the experts fail to recognize (Margolis, 1996). The *knowledge model approach* is specifically designed to understand the differences between expert and public knowledge so that risk messages can accurately target specific misconceptions or issues that underlie knowledge (Morgan *et al.*, 2002; Fischhoff, 1985).

4.4.2 Identifying the Gaps

To specifically identify the location of the knowledge gaps, the results from the confirmatory questionnaires were compared to the expert models in order to observe where there is either a 'high' or 'low' level of agreement between the two groups.

The findings from the Cornwallis respondents (Table 4.11) revealed that in the early parts of the model, which deal with more scientific/technical information, there was a large gap between expert and public knowledge. Contrarily, in the later part of the model, which deals with more human/social information, the gap is generally much smaller. In the first key relationship, only 60.9% ($N_3 = 46$) of the respondents believed that an increase build-up of GHG's in the atmosphere is the primary cause of climate change and, in the second key relationship only 50% ($N_3 = 46$) associated a rise in temperature with an increase in soil moisture deficit. In the third key relationship only 63% ($N_3 = 46$) of the respondents believed that droughts are usually caused by a soil moisture deficit. Cornwallis respondents exhibited a much higher agreement with the expert model in part three, as 89.1% ($N_3 = 46$) of the respondents made a connection between a decline in agricultural production and economic loss. In addition, 84% ($N_3 = 46$) of the respondents recognized that there is a direct link between individual-level economic loss and various associated types of psychological stress.

Table 4.11: Percentage of Cornwallis agreement with expert identified key relationships

Relationship	**% agreed with expert knowledge**
an increase in GHG concentration leads to a rise in mean atmospheric temperature	60.9
increased temperature leads to a soil moisture deficit	50
soil moisture deficit leads to a reduction in agricultural production	63
decrease in agriculture leads to individual level economic loss	89.2
economic loss leads to psychological stress	84

The same correlation of a smaller gap in the later part of the model (parts three and four) was also evident, yet not as pronounced in Stuartburn. Similar to Cornwallis, a large gap appeared in part one, where only 59.5% ($N_3 = 41$) of the respondents (Table 4.12) believed there was a relationship between GHG concentration and a rise in temperature. However in part two of the model, an overwhelming 90.2% ($N_3 = 41$) of the respondents agreed that changes in the hydrological condition lead to flooding. The last three key relationships were more consistent with Cornwallis' findings, where 73.2% ($N_3 = 41$) of respondents believed that human activity in the floodplain leads to increased vulnerability to flooding, 73.2% ($N_3 = 41$) believed that the individual loss of property caused by floods (other than loss of life) was the most significant impact, and 75.6% ($N_3 = 41$) believed that a loss of individual capital often leads to psychological stress in their communities.

Table 4.12: Percentage of Stuartburn agreement with expert identified key relationships

Relationship	**% agreed with expert knowledge**
an increase in GHG concentration leads to a rise in mean atmospheric temperature	59.5
changes in the hydrological condition, including extreme rainfall, lead to flooding conditions	90.2
human activity in the floodplain leads to increased risk from flooding	73.2
extreme flood exposure can lead to an individual loss of property	73.2

individual loss of capital can lead to psychological stress	75.6

In comparing the expert knowledge derived from the models and the public knowledge derived from the face-to-face interviews and confirmatory questionnaires, the findings suggest that the gap is largest concerning the technical/scientific information (earlier parts of the models) and smallest regarding more human/social aspects (later parts of the models) concerning climate change-induced EEEs. The findings suggest that expert and public knowledge is most divergent concerning the relationship between GHG's and a rise in the earth's temperature. In addition, Cornwallis respondents did not associate a rise in temperature with a reduction in soil moisture deficit, while in comparison Stuartburn respondents overwhelmingly believed that floods are caused by changes in the hydrological condition. This finding is likely associated with the high frequency of over-land flooding caused by poor drainage that occurs each year in Stuartburn, and thereby with experiential knowledge. Many of the face-to-face interviews (shown below) indicated that over-land flooding was a common occurrence and therefore suggested that this phenomenon led to a closing of the knowledge gap concerning the relationship between the hydrological condition and flooding.

Can you tell me what causes a flood?

We would never have had bad floods if it wasn't for the States. The amount of snow and melting in the U.S. adds to it and causes overland flooding. It's caused by drainage; we lease crown land and everyday you get people putting in drainage messing up flow of water, everybody wants to save their property. (Stuartburn#10 - middle aged female)

The right weather conditions, rain, the ground is saturated. When the swamps are full, and you get a few broken beaver dams around here, everything falls into place and it takes out the culvert. There is nothing to protect against that. (Stuartburn#4 – senior male)

A couple of years ago it rained so hard and long we had to cancel exams so everybody could sand bag. There was danger south of town, the water was right up to the top of the dyke and it was built in the 1930's so it wasn't very stable. If the dyke had broke we would all be underwater 3 feet. And then we've had floods on the Roseau River which is just a few miles west of here, and certainly on the Red river, so more in the last couple of years we've been seeing examples in Stuartburn or Diminion City, or even here in Vita. So there's definitely a concern about flooding in certain areas within the last decade. (Stuartburn#1- middle aged male)

Figure 4.13: Causes of Flooding

5.0 Chapter 5 – Exploring the Gaps with Worldview

5.1 Introduction

Having identified, analyzed and compared the gaps between expert and public knowledge in the previous chapter, this chapter attempts to explore the nature of these gaps. The findings from the previous chapter suggest that the expert/public knowledge gaps regarding climate change-induced EEEs are larger concerning the scientific/technical areas of knowledge, and smaller concerning the more human/social issues. The objective of this chapter was therefore to determine which variables associated with worldview were associated with these gaps. By identifying which factors associated with worldview are correlated with the occurrence of a gap in knowledge, it is the intention to help identify the required elements of a risk communication tool. Accordingly, the key findings from this chapter revealed that the following variables were correlated with a gap in knowledge.

- Male
- Postsecondary education
- Middle age
- Radio and Internet as sources of knowledge

5.2 Exploring the Gaps in Knowledge

Based on the results of both the face-to-face interviews and the confirmatory questionnaires in the previous chapter, two key relationships were identified that showed significant gaps between expert and public knowledge regarding climate change- induced EEEs. The first key relationship examined was an 'increase in GHG concentration leading to a rise in temperature' (*Inc GHG and Rise Temp*). This relationship was chosen to be examined because both communities showed a consistent gap regarding the role of GHG's and an increase in temperature. The second relationship examined was an 'increase in temperature leading to a soil moisture deficit and drought' (*Inc Temp and Drought*) in Cornwallis. This relationship was chosen because it exhibited the largest gap between expert and public knowledge of the entire study.

5.2.1 The First Key Relationship – Inc *GHG and Inc Temp*

The relationship between an *Inc GHG and Rise Temp* was the first key relationship examined to see if worldview could be correlated with a gap in knowledge. Accordingly, 59.8% of the public respondents (N^3=87) believed an *Inc GHG and Rise Temp* was either 'true' or 'maybe true', while 24.1% claimed that they 'did not know' and 16% believed that the relationship was either 'maybe false' or 'false' (Figure 5.1). Relative to the other gaps identified in the study, this gap was consistent in both communities and because it is the first key relationship in both models it holds particular relevance towards understanding the sequential relationship for climate change to lead to EEEs and individual-level effects.

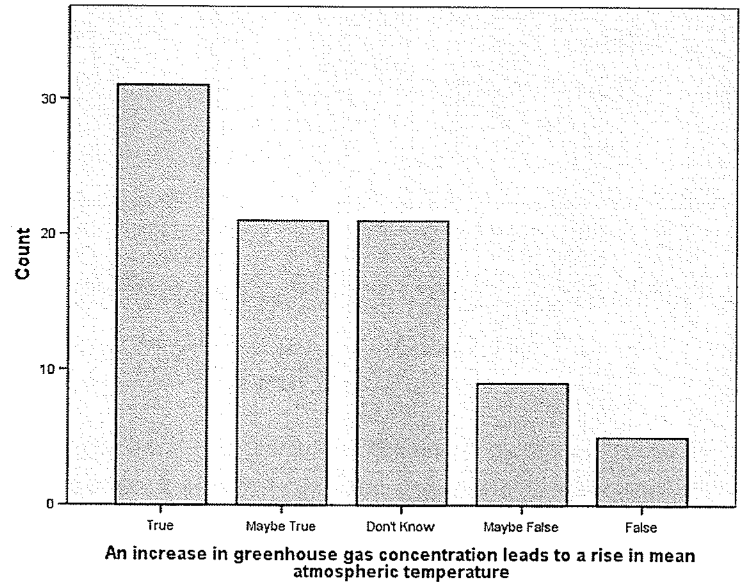

Figure 5.1: Overall Distribution of Recognition to the Role of '*Inc GHG and Rise Temp*'

5.2.2 The Second Key Relationship - *Inc Temp and Drought*

The second key relationship examined in this study was an 'increase in temperature leading to a deficit in precipitation and to drought' (*Inc Temp and Drought*) in Cornwallis. Interestingly, this relationship displayed the largest gap between expert and public knowledge of the study. Only 50% of the Cornwallis respondents ($N_3 = 46$) indicated that they believed an *Inc Temp and Drought* was either 'true' or 'maybe true'. In comparison, 32.6% claimed that they did not know if an *Inc Temp and Drought* was true or not, and the remaining 17.3% thought the relationship was either 'false' or 'maybe false' (Figure 5.2). In particular, the large proportion of respondents who indicated that they 'didn't know' if the relationship between an *Inc Temp and Drought* was true or not, illustrates the confusion on the behalf of the public concerning the various affects associated with this relationship.

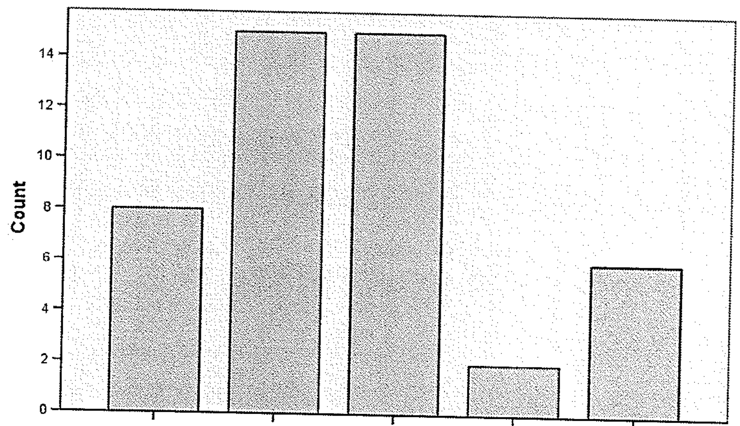

Figure 5.2: Cornwallis distribution of recognition to the role of '*Inc Temp and Drought*'

5.3 Correlating Worldview with the Gaps

As was previously discussed in section 2.3.5, the risk perception literature generally describes worldview as the 'cultural lens' or 'cognitive filter' through which we view the world and influences the way individuals perceive risk (Etkin and Ho, 2007; Slovic, 1999; Peters and Slovic, 1996; Jenkins-Smith, 1993). Accordingly, risk perception research has grown to support the importance of worldviews as one of the fundamental factors involved in understanding different perceptions of risk (Lima and Castro, 2005; Lorenzoni *et al.*, 2005; Peters and Slovic, 1996). Therefore, understanding worldview has emerged as an essential component towards achieving effective risk communication (Haque and Burton, 2005).

The literature has typical categorized worldview into four basic groups: hierarchical, fatalistic, individualistic, and egalitarian. In the context of this research, it was neither practical nor important to determine which of these particular groups the public respondents belonged to. Rather, worldview was applied as a way to identify 'who thinks what'. The questionnaire surveys therefore asked respondents to identify different variables related to worldview, such as gender, age, income, education, religion, ethnic background, family dynamics, and sources of knowledge. This was done in order to determine if any of these variables associated with worldview could be correlated with a gap in knowledge. By correlating worldview with the gap, it was the objective of this process to identify which variables associated with worldview showed a gap with expert knowledge, so that risk messages could target 'those who need to know'.

Traditional approaches in risk communication have not typically taken this into consideration, producing risk messages that, although perhaps accurate, often do not convey meaningful information to the public that is comprehensible and pragmatic. Also, risk communication messages are typically designed with only one target audience in mind and not enough consideration has been given to who is vulnerable and what they need to know (Morgan *et al.*, 2002).

In order to achieve this, particular emphasis was placed on identifying which factors associated with worldview were correlated with the belief that the relationships examined were either 'false' or 'maybe false'. The variables examined in this chapter include gender, education, age, and sources of knowledge. Other variables examined in the confirmatory questionnaire surveys included income, marital status, occupation, religion, ethnicity, and length of residency in the community. However, these variables did not yield any significant results and were therefore not explored in this chapter.

5.3.1 Gender and the Knowledge Gaps

In order to determine whether a gap in knowledge could be correlated with gender, both of the key relationships (*Inc GHG and Rise Temp* and *Inc Temp and Drought*) were separated by male and female. The results revealed that in both relationships (Figure 5.3 and 5.4) males were much more likely to believe they were false, even though the number of female respondents was proportionally larger (Appendix 6). In comparison, females showed a strong positive recognition of both relationships and were far less likely to believe either relationship was false. Males therefore represented a large proportion of the gap that exists between expert and the public knowledge in both key relationships (*Inc GHG and Rise Temp* and *Inc Temp and Drought*).

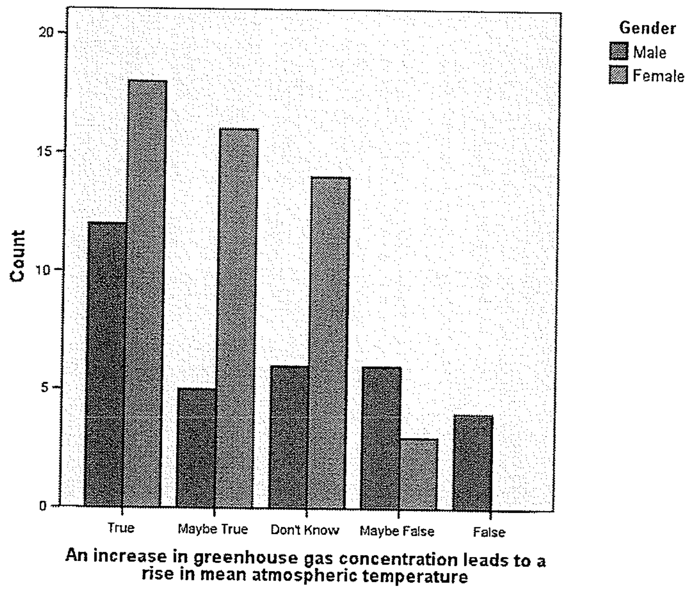

Figure 5.3: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by gender

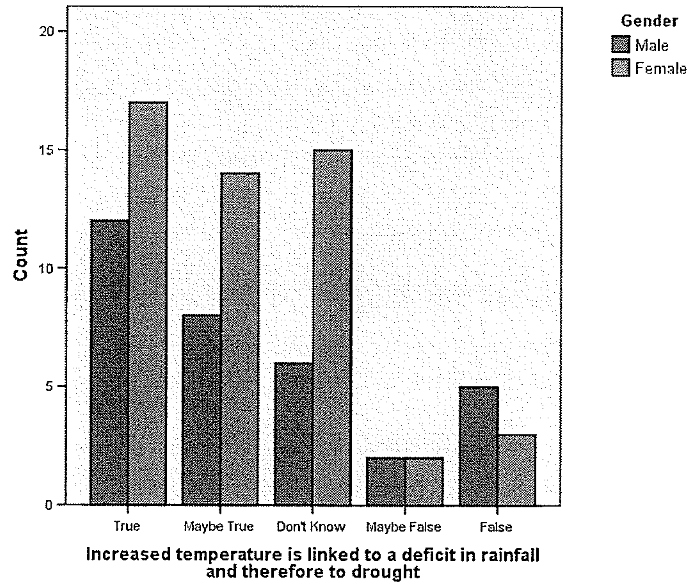

Figure 5.4: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by gender

5.3.2 Education and the Knowledge Gaps

In order to determine if different levels of education were correlated with a gap in knowledge, both of the key relationships were separated by the level of education each respondent had attained. The results indicated that in both relationships (Figure 5.5 and 5.6) respondents with high level of education were primarily associated the gap. Respondents with a high school education or less were more likely to believe the relationship was true and therefore displayed a much smaller gap. In comparison, almost all of the respondents who believed that the relationship was false either had some postsecondary education or were a graduate. Therefore, these findings indicate that the most educated respondents showed the largest gap in knowledge between experts concerning both relationships.

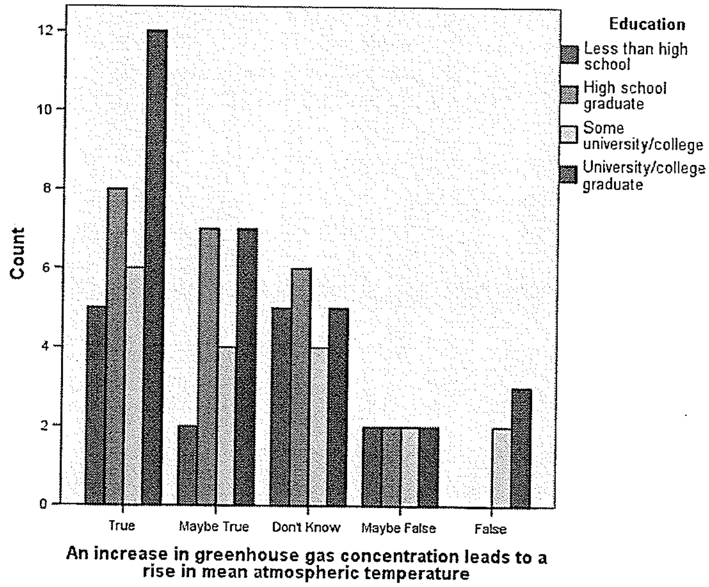

Figure 5.5: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by education

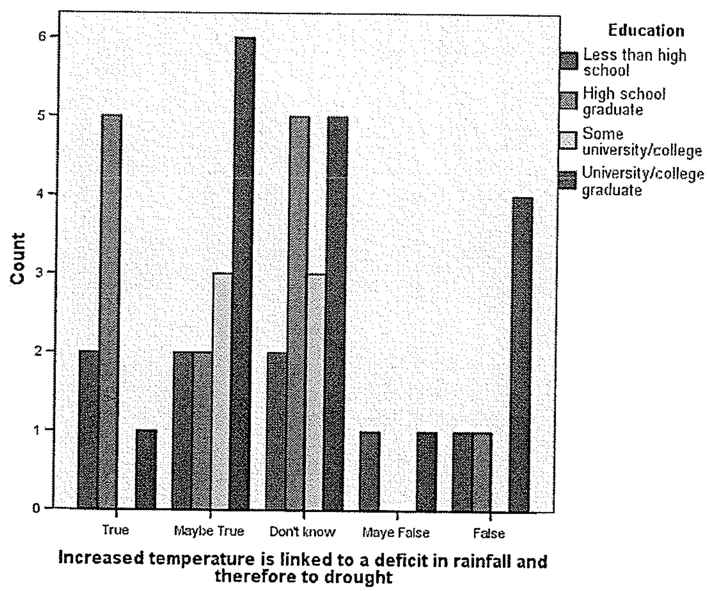

Figure 5.6: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by education

5.3.3 Age and the Knowledge Gaps

Age was also used in order to determine if it was associated with a gap in knowledge in both key relationships (Figure 5.7 and 5.8). Accordingly, both relationships showed a strong correlation with middle-aged (30-69) respondents and a gap in knowledge. Interestingly, no one from the oldest age group (70 to 99) believed that either relationship was false, showing virtually no gap in knowledge between experts. In addition, the youngest age group (0 to 29) represented only a very small proportion of the gap in both relationships. These findings suggest that the middle aged respondents are primarily responsible for the gaps in knowledge, while the older and younger respondents show a much smaller gap with expert knowledge.

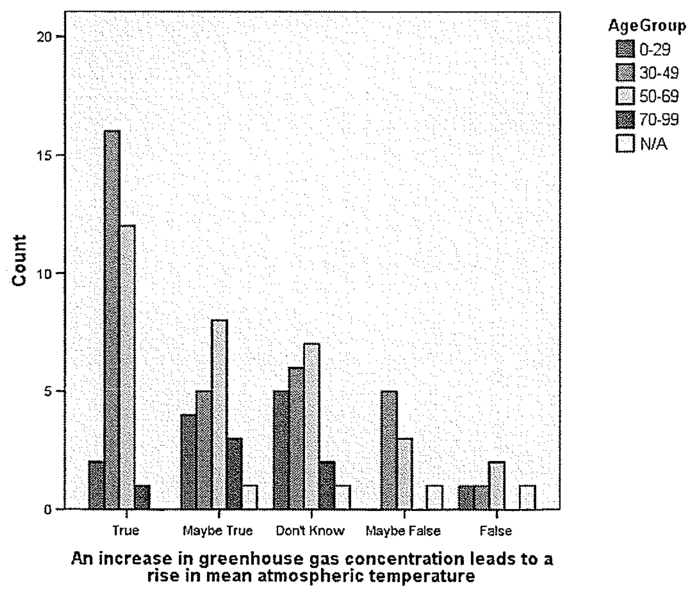

Figure 5.7: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by age

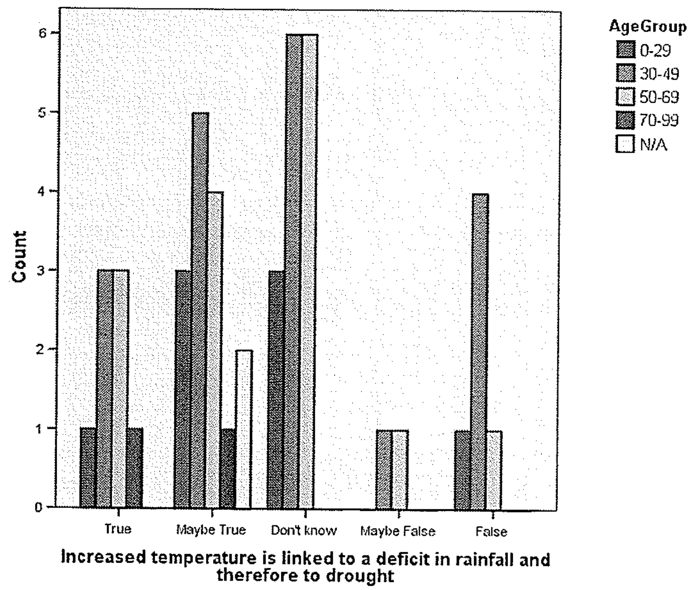

Figure 5.8: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by age

5.3.4 Sources of Knowledge and the Gaps

In order to determine if a gap in both key relationships could be correlated with a respondents sources of knowledge regarding climate change, various sources of knowledge were identified as primary, secondary, tertiary, or 'not a source of knowledge' by respondents in the confirmatory questionnaire survey. The results revealed that the gap in knowledge is primarily correlated with the radio and internet as sources of knowledge in both key relationships.

In the first key relationship (*Inc GHG and Inc Temp*), the results reveal that there was a high correlation between television as a primary or secondary source of knowledge and belief that the role of an (Figure 5.9) was true. Newspaper also (Table 5.10) showed a strong correlation with a large proportion of the respondents citing it as their secondary source of knowledge and a positive belief in the first key relationship.

The radio showed a tendency to believe for those who listed it as a primary, secondary, or tertiary source of knowledge and a negative belief in the first key relationship (Figure 5.10). In addition, although not ranked high as an overall source of knowledge, it is interesting to note that all of those who did rate the internet as a primary source of knowledge tended to believe the relationship was false (Figure 5.10).

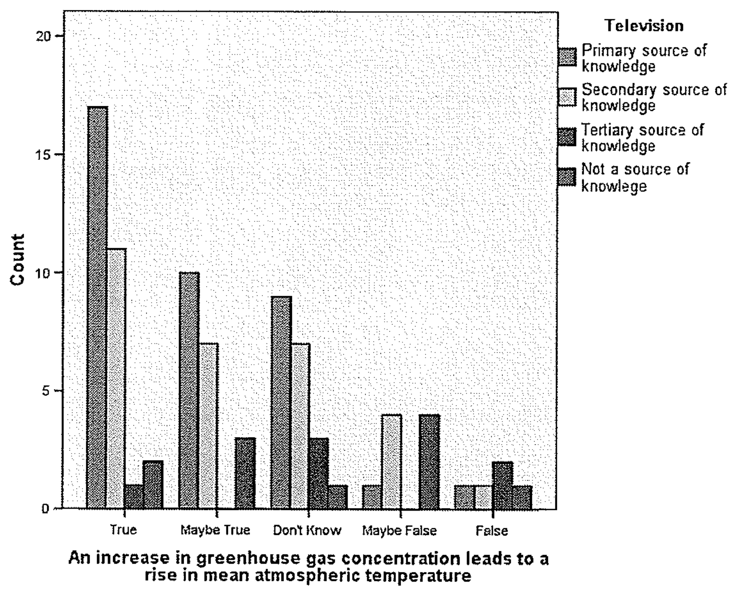

Figure 5.9: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by television as a source of knowledge

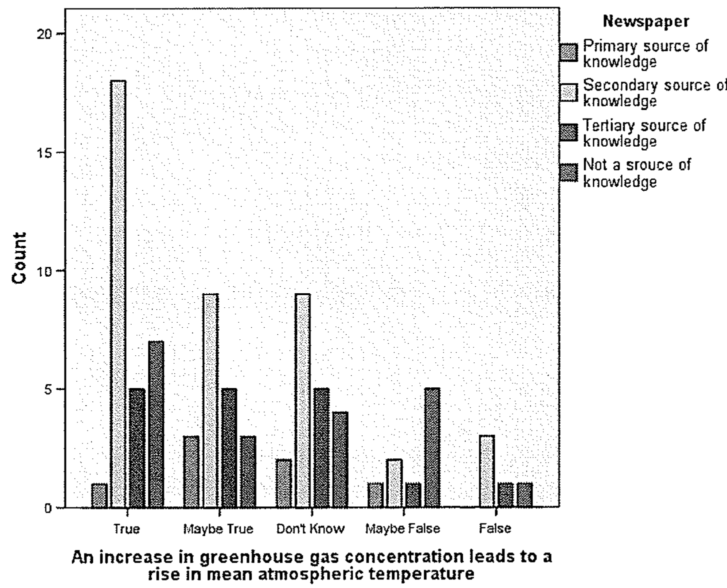

Figure 5.10: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by newspaper as a source of knowledge

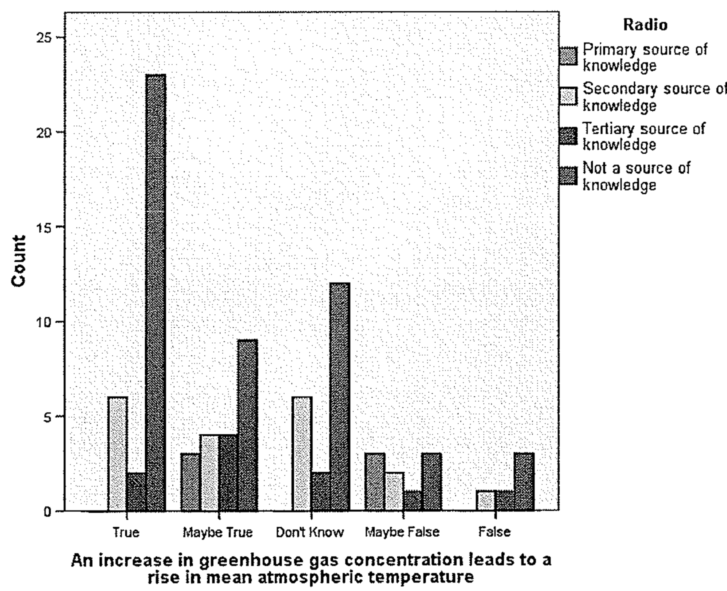

Figure 5.11: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by radio as a source of knowledge

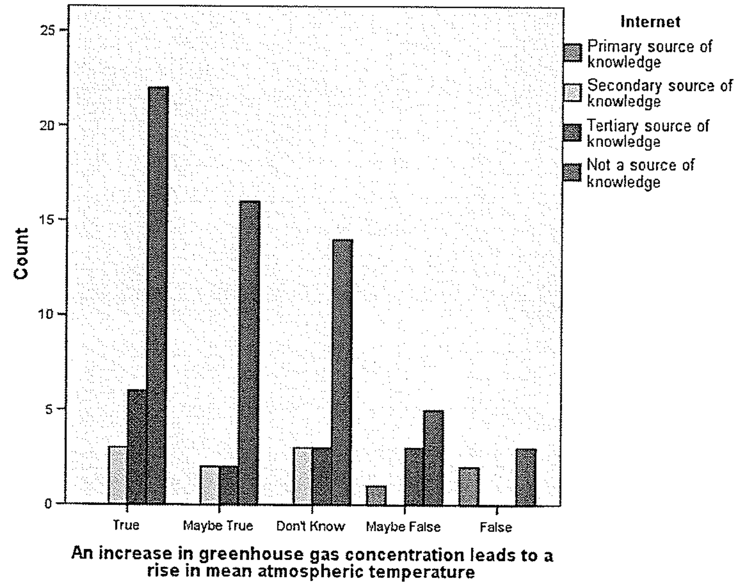

Figure 5.12: Overall distribution of recognition to the role of an '*Inc GHG and Inc Temp*' by internet as a source of knowledge

In the second key relationship (*Inc Temp and Drought*), the results indicated that although television and newspaper showed a stronger association with the gap than in the first key relationship, respondents who identified television and newspaper as significant sources of knowledge, tended to show a positive belief in the relationship (Figure 5.13 and 5.14). Contrarily, those who listed radio as a source of knowledge accounted for the majority of the respondents who believed the relationship was false (Figure 5.15). In addition, respondents who listed the internet as a tertiary source of knowledge also represented a large proportion of those who believed the relationship was false (Figure 5.16).

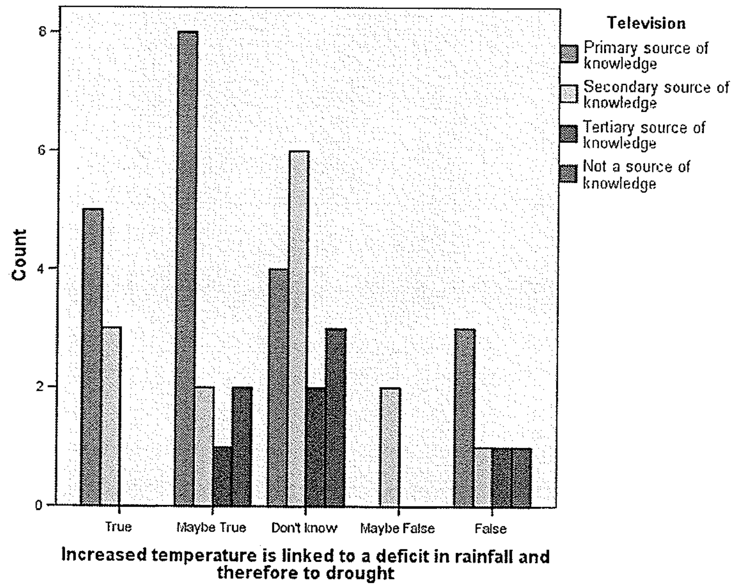

Figure 5.13: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by television as a source of knowledge

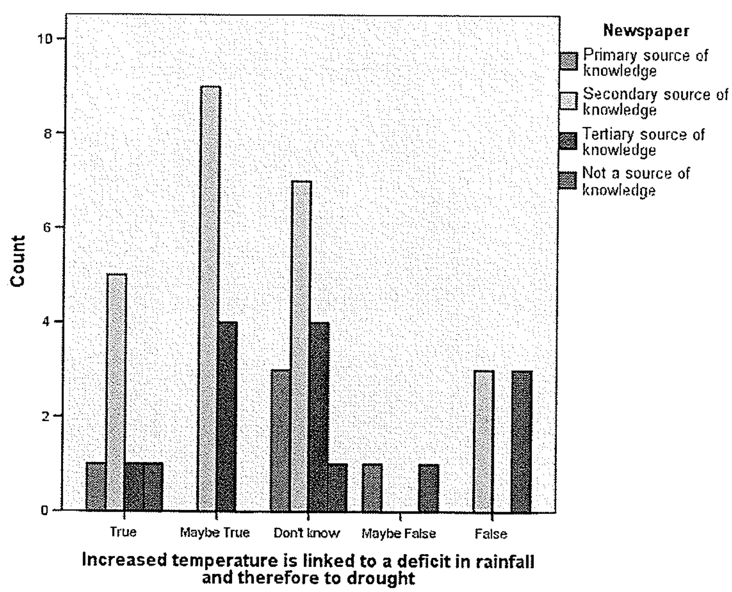

Figure 5.14: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by gender newspaper as a source of knowledge

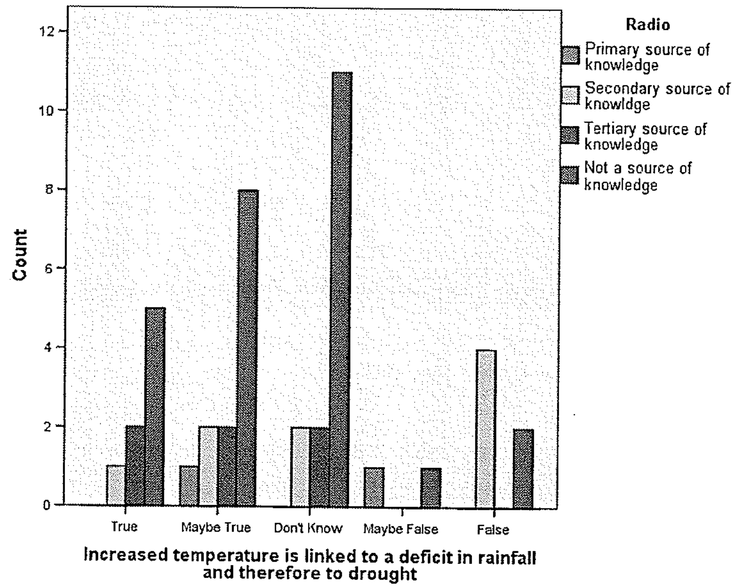

Figure 5.15: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by radio as a source of knowledge

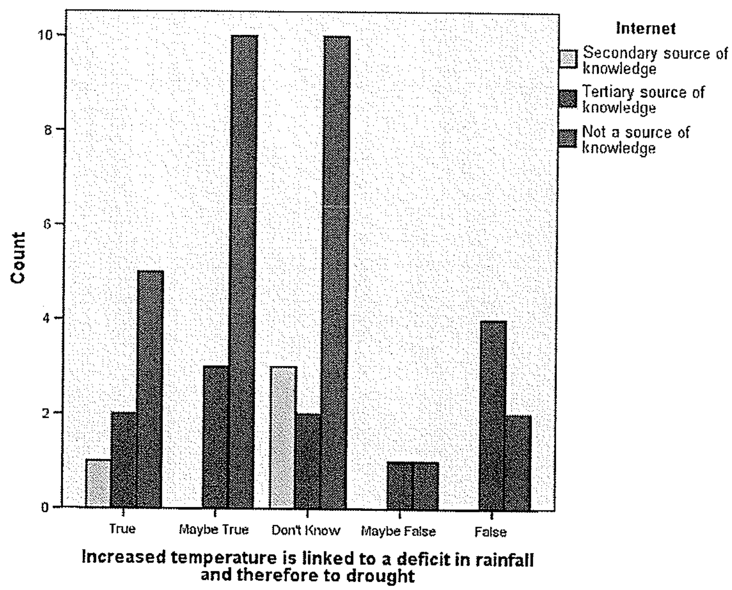

Figure 5.16: Cornwallis distribution of recognition to the role of an '*Inc Temp and Drought*' by internet as a source of knowledge

These findings suggest that both television and the newspaper appear to play a factor in minimizing the knowledge gap between experts and the public in both key relationships. In contrast, those who list radio and the internet as sources of knowledge were strongly correlated with a gap in both relationships. Therefore the gap in knowledge concerning both key relationships was primarily correlated with the radio and internet as sources of knowledge.

5.4 Discussion

5.4.1 Correlating the Gaps with Worldview

Both of the key relationships that were examined show very similar and consistent results in terms of how they correlate with the worldview variables (Table 5.1). Accordingly they both show strong correlations with 'male' respondents, a 'postsecondary education', 'middle age', and the occurrence of a gap. In addition, 'television and the newspaper' were both identified as the 'primary and secondary sources of knowledge' and were predominantly associated with a positive belief in both relationships, while 'the radio and internet' were correlated with a gap. Both of these relationships occur early in the models, are scientific/technical knowledge based, show large gaps in knowledge and show similar results regarding the correlation between variables associated with worldview and the gaps.

Table 5.1: Variables correlated with a gap in knowledge

#	Relationship	Gender	Education	Age	Sources of knowledge
1	*Inc GHG and Inc Temp*	Male	Postsecondary Education	Middle Age	Radio and Internet
2	*Inc Temp and Drought*	Male	Postsecondary Education	Middle Age	Radio and Internet

When both key relationships were separated by gender, males exhibited a significantly larger knowledge gap than females. This finding is consistent with the risk perception literature which suggests that women tend to judge risk as higher compared to males (Zinn and Pierce, 2008; Momsen, 2000; Gustafson, 1998; Davidson and Fruedenburg, 1996; Flynn *et al.* 1994). In the disaster management literature gender is seen as a distributive system through which women and men are differently empowered before, during, and after disasters (Enarson and Scanlon, 1999). This distribution of power has traditionally favored men and put women at risk through inequalities of power and resource distribution (Blaikie *et al.*, 1994).

The literature suggests that because men often feel more empowered, they are more reluctant to engage in preventative approaches, more willing to take risks, and more likely to ignore risk messages (Bateman and Edwards, 2002). In addition, socially constructed gender differences in care-giving roles, access to evacuation incentives and exposures to risk are attributed to a heightened perception of risk in females (Bateman and Edwards, 2002). Research has also found that women tend to worry about risks that threaten their entire family, whereas men tend to be more concerned about work and their economic situation (Gustafson, 1998; Morrow and Enarson, 1996). Women are seen as more likely to take preventative approaches to various risks because they live at greater risk and therefore have a heightened perception of risk compared to men.

When the relationship between *GHG and Inc Temp* was separated by education, the results reveal that the highest level of education (post secondary) was primarily associated with a gap in knowledge. This finding is also consistent with the literature which suggests that as an individual's level of education increases, they are less likely to perceive risks as high (Bostrom *et al.*, 1994; Krewski *et al.*, 1994; Pilisuk and Acredolo, 1988). This is substantiated by the 'control and power theory' whereby individuals with higher levels of education are not only exposed to less risks but also feel empowered and therefore judge risk as low (Dosman *et al.*, 2001). Similar to the issues associated with gender, because individuals with less education generally feel less empowered, they are believed to exhibit heightened perceptions of risk (Dosman *et al.*, 2001; Flynn *et al.*, 1994).

In regards to age, the risk perception literature has traditionally asserted that younger age groups tend to judge risk as lower compared to older age groups (Dosman *et al.*, 2001; Glendon *et al.*, 1996). It is believed that younger individuals generally perceive risk as less because, unlike older age groups, they have not yet experienced the possible negative effects that are associated with risks (Dosman *et al.*, 2001). Accordingly, older age groups did exhibit the smallest gap in knowledge and this is consistent with the risk perception literature (Kalkstein and Sheridan, 2007; Dosman *et al.*, 2001; Glendon *et al.*, 1996). However, the findings from this research do not necessarily correspond with the literature's concept of a linear relationship with age and risk perception. The findings from this research suggest that the occurrence of a knowledge gap is not associated with the youngest age group, but with middle-aged respondents. This could be explained in that, similar to the previous two findings, because middle-age respondents are typically more empowered than younger and older respondents they have a decreased perception of risk.

5.4.2 The Middle-Aged Well-Educated White Male

The previous section established that the gap in knowledge (section 5.4.1) was primarily associated with middle-aged, well-educated males. Overall, these findings suggest that if a worldview group was associated with the gaps in knowledge, it would be middle-aged, well-educated males. Interestingly, this worldview appears to correspond with the 'white male effect' which was first described by Flynn *et al.* (1994). According to this theory, much research has suggested that there is evidence that white males perceive various risks to be lower compared to females and other ethnic groups (Palmer, 2003; Flynn *et al.*, 1994; Dejoy, 1992; Brody, 1984). Although there was no specific question that addressed the ethnicity of the respondents in the confirmatory questionnaires, based on census statistics from 2006 only 2% of residents in Cornwallis were listed as visible minority, while no one from Stuarburn was listed as a visible minority (Statistics Canada, 2006). Therefore the overall majority, if not all of the male public respondents were likely 'white males'. The results suggest that like the 'white male effect', white males who are middle-aged and well-educated tend to judge risks as lower compared to other groups. This tendency to judge risk as low is likely correlated, like the other variables listed above, to this group's feeling of empowerment.

Therefore, based on this research and its findings, a risk communication tool should target middle-aged, well-educated, white males. This finding however generally contradicts the status-quo of traditional risk management, which has typically viewed this group as more empowered and therefore less in need of attention to receive risk messages. This dichotomy in power has traditionally favored white male dominated groups and subjugated groups with low income, low education, and other social disadvantages (Field *et al.*, 2000; Flynn *et al.*, 1994). The bulk of attention in risk communication has thus focused on communicating risks to more 'disadvantaged' groups because they are believed to be the most vulnerable. This is certainly true in scenarios such as heat-waves and hazardous waste exposure, where the effects are more dependent on access to resources (air conditioning) and physical exposure (Applegate *et al.*, 1981).

However, although middle-aged, well-educated, white males show the largest gap with expert knowledge they are more likely to posse's higher levels social power.

Accordingly, Mann (1986) describes social power as the ability to pursue and attain goals through the mastery of one's environment and as having four main sources of influence: ideological, economic, military, and political. In addition, Raven (1990) defines social power as the ability to produce a change in the belief, attitude, or behaviour of another person. Therefore, those who posses high levels of social power are able to take control of situations and influence the world around them. An example of this, in the context of risk management, is that middle-aged, well-educated, white males are much less likely to live in areas where there are hazardous and noxious waste facilities compared to other groups and are therefore less likely to be at risk to these hazards.

This group is therefore unlikely to assume the risk that is created through a gap in knowledge and are more likely to augment the risk to other groups. More specifically, in regards to climate change-induced extreme environmental events, this group is likely to make the majority of the decisions regarding the risk but is unlikely to experience the effects first-hand. Rather, they are likely to transfer the risk to other groups who lack social power and the means to cope with the risks. This raises some important questions regarding the role of social power in mitigating risk and the way in which risk is transferred from one group to another.

6.0 Chapter 6 – Risk Communication in Practice

The expert feedback workshop took place on July 17th 2008, and provided an opportunity to present the research findings to a group of professionals at the Office of Disaster Management at Manitoba Health and receive feedback regarding its potential relevance to disaster management policy in Manitoba. Information was obtained over a half day workshop in which the research findings were presented and a discussion period that targeted specific questions followed.

This chapter is separated into five sections, including: perspectives on climate change-induced EEEs, Manitoba risk communication policy, applying the *knowledge model approach* in Manitoba, challenges to implementation, and the identification of the required elements a risk communication tool. Each section attempts to address some of the important issues that have relevance to this research and in particular to policy with the use of feedback from the expert workshop to facilitate a discussion.

6.1 Perspectives on Climate Change-Induced EEEs

This section addresses the issue of climate change-induced EEEs with specific insight from the expert workshop as well as additional findings that were obtained from both the face-to-face interviews and confirmatory questionnaires that support some of the following discussions.

When confronted with the issue of climate change-induced EEEs and presented with the findings from the research, the expert group expressed the overt need to be more proactive in disaster management through. This is articulated throughout the literature and is specifically important because climate change is likely to continue regardless of any substantial reductions of emissions (IPCC, 2007A). The experts also articulated a distinct need for "*more robust public preparedness*". It was acknowledged that in order for this to occur, there is a need for more research concerning the ability of the public to cope with challenges that climate change-induced EEEs will pose. This sentiment is aligned with the impetus for this research and in particular with the need to increase public knowledge of risk as well as increased coping capacity.

Additional feedback from the expert workshop also expressed the desire for "*the implementation of policy that creates a social/environmental change*". This would undoubtedly require a re-thinking of, not only the way-in-which risk is communicated, but a "*paradigm shift in approaches that will require that we keep trying new things until we find something that works*". This is undoubtedly a very ambitious desire, however when it is examined from a more holistic perspective, it is perhaps an unavoidable requirement. More specifically, in order to make the changes that are required for humans to live sustainably in Canada, and while coping with the negative forces of climate change, there is going to be a specific need for a paradigm shift that insights cultural change which embraces societies 'interconnection with' and 'dependence on' the environment.

This will likely require a period of adjustment in which it is determined which techniques and tools are essential towards obtaining these goals. Therefore these comments, while they may appear to be extremely ambitious and perhaps even unrealistic, are really just the expressed need for the changes that are required in order to maximize the resiliency of our society. Overall, the experts maintained the need for research which aspires to promote policy that creates a paradigm shift of social/environmental awareness and ultimately leads to sustainability.

The feedback from the workshop also indicated that there were no overt disagreements amongst the expert participants that climate change-induced EEEs will undoubtedly have serious and long-lasting repercussions to the global climate and overall sustainability of life on earth (ICCP, 2007; Van Aalst, 2006). However, based on the results from both the face-to-face interviews and the confirmatory questionnaires there appears to be a great deal of confusion amongst the public concerning the causes and effects of climate change-induced EEEs. This divergence between public and expert knowledge is the fundamental basis of this research. The large gap in knowledge that the public demonstrated concerning the relationship between GHG's and climate change has already been well documented (see sections 4.3.1 and 5.3). However, based on the findings from the confirmatory questionnaires and face-to-face interviews there are a few additional insights that illustrate the nature of the public knowledge gap regarding climate change.

It is contended that the underlying cause for public misconception regarding climate change is due to the failure to understand the connection with GHG's (Etkin and Ho, 2007; Seacrest *et al.,* 2000). It is also argued that the public often confuses climate change with other climate or atmospheric related processes, such as: stratospheric ozone depletion, tropospheric air pollution, and seasonal and geographic temperature variation (Kempton, 1991). Interestingly both of these trends were found in the confirmatory questionnaires. The gap concerning the relationship between GHG's and climate change has already been well documented (see section 5.3), but the confirmatory questionnaire also revealed that 50.6% of the public respondents ($N^3=87$) showed a strong tendency to believe that climate change is primarily caused by a hole in the ozone layer (Table 5.23). In accordance with the literature, this high proportion of public respondents who believe climate change is caused by a hole in the ozone layer seems to correspond with an equally high proportion of respondents (54.0%) who either don't believe or don't know if climate change is affecting their lives presently (Table 5.24). Interestingly, when the same public respondents were asked if they think that climate change will affect their lives in the next 25 years, 74.7% believed that it would (Table 5.25). This suggests that most public respondents perceive climate change as a distant risk that is not part of their lives, even though most believe that it will be in the next 25 years. This misconception, as indicated in the literature and observed in the confirmatory questionnaires, seems to be linked with the gap in knowledge concerning the causes of climate change.

Table 6.1: Global climate change is primarily caused by a hole in the ozone layer

	Frequency	Percent (%)
True	13	14.9
Maybe True	31	35.6
Don't Know	22	25.3
Maybe False	15	17.2
False	6	6.9
Total	87	100.0

Table 6.2: Global climate change is affecting my life presently

	Frequency	Percent (%)
True	15	17.2
Maybe True	25	28.7
Don't Know	16	18.4
Maybe False	13	14.9
False	18	20.7
Total	87	100.0

Table 6.3: Global climate change will likely affect my life in the next 25 years

	Frequency	Percent (%)
True	34	39.1
Maybe True	31	35.6
Don't Know	15	17.2
Maybe False	2	2.3
False	5	5.7
Total	87	100.0

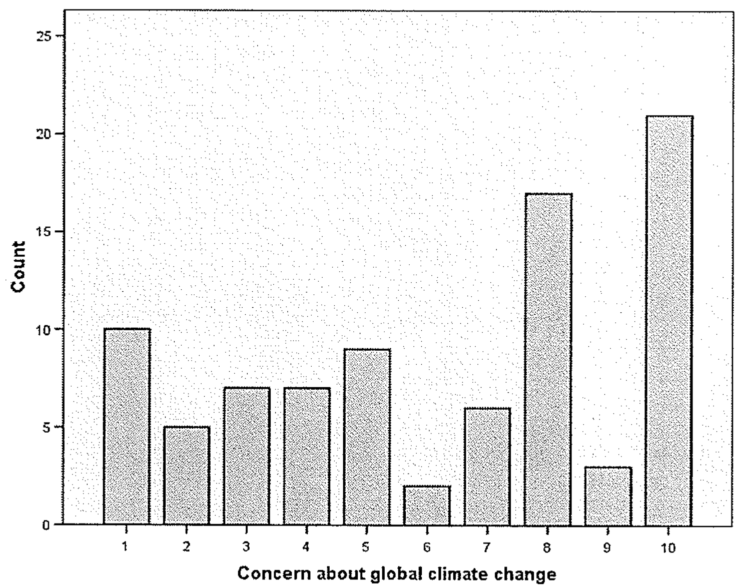

Figure 6.1: Overall concern from 1 to 10 (1-least, 10-most) concerning global climate change

In addition, the confirmatory questionnaires also revealed that although many individuals contend that they are very concerned about climate change, there are still a large amount of those who show 'little to no' concern. Figure 5.28 reveals that although a large number of respondents indicated that there concern for climate change is high (10 or 8), a large proportion still believes it is a low concern. The findings from the face-to-face interviews support this finding and further suggest that individuals tend take fringe positions, either expressing overt cynicism or genuine concern.

Most residents can give examples of change in the natural environment, however there is still a high degree of uncertainty regarding what causes climate change and whether or not it is natural or anthropogenic in nature. Public attitude and belief can be separated into three distinct groups that were identified by Lorenzoni *et al.* (2005) and are consistent with the findings. These groups consist of

- those who are skeptical about climate change and either don't believe it is happening at all or believe that it is natural and not anthropologically induced (Figure 6.2);
- those who are concerned about climate change, although they may or may not understand the science behind it (Figure 6.3); and
- those who confuse climate change with stratospheric ozone depletion (Figure 6.4).

What do you know about climate change?

If global warming is happening, I'm all for it. It's 30 below today, and you know its tongue and cheek, but it wouldn't bother me if it warmed up in this country, as far as the season is longer and the winter being warmer. (Cornwallis#2 – middle aged male)

I guess my take on it is that I'm not convinced. (Cornwallis#9 – middle aged female)

*I think there are lots of theories and hypothesis out there but I don't think that anyone can say for sure that this is what's causing it. I mean there is so much controversy over whether it's really happening or if it's just normal fluctuation that happens over billions of years. I think the jury is still out. (*Cornwallis#10 – middle aged female)

I understand that its carbon rise and the hole or whatever, I'm not the scientists that studies this. I don't see any effects. I don't believe you can see climate change over 1, 2, 3 generations. (Suartburn#4 – senior male)

Personally I'm kind of a skeptic about it really. Seems like from all the data they really don't have enough, it only traces back to 100 years ago really. In a way I think it might be job creation. In my opinion the weather is different now but it is obviously a long-term cycle. Look 10 years ago it's not much. My point of view is that it is more an idea brought upon by society. It just seems like more of a myth than anything else. I believe humans do have an effect but it's more of cycle that the planets going through. (Stuartburn#5 – young male)

Basically people are talking about what they don't really know about. Climate change has been an on-going thing for millions of years. It comes and then goes, are we affecting it? I don't know that. (Stuartburn#6 – senior male)

Figure 6.2: Skeptical Public Attitudes concerning Climate Change

What do you know about climate change?

I think that for anybody who thought this was just a random phenomena this Global Warming thing, after you see that movie (the Inconvenient Truth) you realize it's something that is people caused and it's got to be dealt with sooner than later. (Conrwallis#1- senior male)

To me, I think in the grand scheme of things the earth does go through changes where you have slow warming and slow cooling again, but I think the earth itself is warming at a higher rate than ever before. (Cornwallis#6 - senior male)

I think a lot of the pollution and garbage and all the emissions that they are putting into the air, is causing the climate to change. It's definitely changed from even 20 years ago, it's completely different. (Stuartburn#2 – middle age male)

You talk to people who are naive and talk about it like it's a phase, I don't think it's a phase, these are irreversible changes. (Stuartburn#3 – middle aged female)

But in the arctic, the glaciers are melting up there, they can see it. The temperatures aren't as severe as it used to be either. And even here the weather is not as severe as it used to be. The winters are quite a bit warmer. When the snow melts, we don't have quite as much snow as we used to. (Stuartburn#8 – senior female)

It's scary when you read up north about the melting, we've gotten their weather. Their cold is our cold. The States are getting snow they didn't get before. All the gas from GHG's, it all has its effects. (Stuartburn#10 – middle aged female)

Figure 6.3: Concerned Public Attitudes concerning Climate Change

Can you tell me the causes of climate change?

Supposedly the ozone layer (Cornwallis#2 – middle aged male)

The hole in the ozone layer causes the UV to be more dangerous. (Cornwallis#4 – middle aged female)

Well years ago it was PCP's, aerosol cans, but they have changed all that. (Cornwallis#5 – middle aged female)

The Freon from the fridge cause it affects the atmosphere. We have our own protection for the world and we are burning that thing away and that can affect the climate (Cornwallis#8 – middle aged female)

I know quite a bit about it. I follow it very carefully. These are things that we do that destroy the ozone layer in the atmosphere which causes all these changes to take place. (Stuartburn#7 – senior male)

There's a big hole in the ozone layer, letting in more harmful rays. (Stuartburn#9 – middle aged female)

Figure 6.4: Confused Public Attitudes concerning Climate Change

6.2 Implications for Manitoba Risk Communication Policy

In the Canadian prairies, like other regions in the world, there is an increased likelihood for new hazards to occur outside traditional coping thresholds (Sauchyn and Kulshreshtha, 2008; IPCC, 2007A; Van Aalst, 2006). This makes risk communication a particularly important policy issue. This section attempts to draw upon expert feedback in order to identify how the findings from this research apply towards improving risk communication policy in Manitoba.

According to the feedback obtained from the expert workshop there is currently no overt risk communication policy concerning climate change-induced EEEs in Manitoba. Risk communication for disaster management in Manitoba does occur, however it is "*event-driven* *and approached issue by issue*". Furthermore "*communications of risk to the public are seldom and the current risk communication approach remains largely conceptual and reactionary in nature with no clear direction or accepted methodology*". In addition, these methods are usually "*manifested through separate, compartmentalized approaches and that emphasize personal preparedness as the primary objective*".

This inherently reductionistic and compartmentalized approach, outlined by the experts, makes it difficult to apply an effective risk communication strategy towards large and complex problems like climate change. Based on these suggestions put forward by the experts, there appears to be a distinct need for a more coordinated approach towards risk communication concerning climate change-induced EEEs that is integrated within the disaster management mandate and that takes a preventative approach. The expert group also recommended that there is a need for "*both formal and informal communication strategies that perpetuate a common informed message*". This is an important concept, as this study as well as the bulk of literature, have indicated that the public shows a great deal of confusion associated with climate change and would therefore benefit from a more coordinated approach towards risk communication (Etkin and Ho, 2007; Lorenzon *et al.*, 2005; Seacrest *et al.,* 2000; Bostrom *et al.*, 1994).

These recommendations, however, would most likely face considerable challenges towards implementation. Demand for policy change is ultimately influenced by the public's level of risk perception and risk perception is generally believed to be directly influenced by an individual's experience with a hazard (Visschers *et al.*, 2007; Leiserowitz, 2006). The expert workshop also expressed the suggestion that there is a disconnection with public policy and people's lives. In order to overcome this obstacle, it will requires *a "re thinking'* *of the goal's and scope of materials and communications to link concepts to consequences"*. In the case of climate change, where the effects are largely projected and often difficult to link, public risk perception could potentially remain low until the public is convinced that they are feeling the effects. Therefore it is essential that the risks that are communicated to the public are tangible and pragmatic, otherwise people will simply overlook them and demand policy changes for issue they deem more substantial to their daily lives. These problems highlight the inherent complexities involved with attempting to communicate the risks associated with climate change and in particular to a public audience that holds divergent views concerning the issue.

With this in mind, the experts suggested that one of the most effective approaches towards a more proactive risk communication approach has traditionally targeted children in the early-years of education as the primary audience. This group is commonly upheld as instilled with the ability to absorb knowledge and apply new tools, beyond the capacity of adults. This approach has proven to be successful throughout numerous risk communication campaigns, including most notably: smoking leading to cancer, seatbelts saving lives in automobiles, and the value of reducing, re-using, and recycling.

There are several current examples of climate change and natural disaster related education programs and forums directed toward youth in Canada. For example, the Red Cross currently offers a program in the lower mainland of B.C. targeting children called 'Youth TAP'. This program provides online interactive workshops, including 'Natural Disasters: Exploring the Un-natural Causes of Vulnerability' which aim to provide educators with the resources needed to educate youth concerning this and various other issues. In addition, the 'Taking It Global' (TIG) social network and the Global Youth Action Network, both provide opportunities for learning, capacity-building, cross-cultural awareness, and self-development through interactive and collaborative online database platforms. There have also been several conferences directed towards youth and climate change related disasters, including the Natural Disaster Youth Summit 2008 in Trinidad and Tobago on climate change and disaster reduction, which provided an opportunity for youth to learn and interact in a conference setting.

Although the identification of children as the target audience for risk communication is a proven approach which has many examples of changing risk perception at a societal scale (Keeney and von Winterfeldt, 1986), current risk communication strategies are largely fragmented and uncoordinated with each other. Therefore, there is a distinct need to build upon these pre-existing platforms and develop a national educational initiative concerning climate change-induced EEEs intended for youth.

6.3 Applying the Knowledge Model Approach in Manitoba

The purpose of this section attempts to examine the potential application of the *knowledge model approach* in Manitoba and specifically whether the experts believe this method would be useful within this context.

One expert expressed his belief in the *knowledge model approach*, citing that "*risk messages are often confined to a message box and rarely attempt to communicate the conceptual path like the model does*". The experts recognized that *the knowledge model approach* would have a valuable application in the context of disaster management in Manitoba, but time and finance issues would present obstacles. In the words of one expert, "*risk communication needs attention but it really depends on how much a department can* *focus their work*". This is a common dilemma for any level of bureaucracy or institution and is no exception with disaster management.

The suggestion then surfaced that in order to overcome the challenge of time and money, there should be an increased emphasis towards linking academic, NGO and government institutions. One expert participant articulated, "*I think it could work with the right collaboration of organizations, government, universities, and NGO's, which need to contribute to the process and facilitate a means for creating awareness of the sequential relationships. This would entail a consensus that pulls evenly from left and right (of the models) with an emphasis on the human affects. I feel that this would appeal to a province that groups their interconnectedness to resources that are and will be affected by EEEs.*" This approach focused on interconnectedness would allow universities to carry-out tangible, meaningful research that can be directly applied within the context of government or NGO institutions; and at the same time allow government and NGO's to advance their ability to conduct research, without compromising valuable time and resources.

There was also skepticism expressed during the workshop as to whether or not the *knowledge model approach* could "*distinguish the variation associated with human health issues as distinctive from other phenomenon*". Specifically, many experts felt that the public may not be able to discern risk messages that are too complex or deal with abstract concepts. If a risk message that is designed to target human health issues includes information that goes beyond this subject it may confuse the intended audience and render the message ineffective. Therefore it should be emphasized that "*a macro event will require a different approach than a micro event*". In the case of climate change-induced EEEs, which deal with complex and interdisciplinary issues, "*it may prove valuable to focus on specific risks through salient* *messages that focus on how and not why*". As another expert noted, *"in terms of the expert model and your findings, risk communication appears to need to find its home between the right and the left of the model, because it is in this middle ground where you are able to impact change within.*" This suggests that there is a need to communicate risk at the intersection of scientific/technical and human/social knowledge, or within the realm where humans interact with the environment.

More specifically, there is a fundamental need to focus on specific risks through direct approaches that do not confuse the public with the inherent complexities involved with climate change. Therefore, in addition to focusing on specific risks, we need to create risk messages that are presented in ways that appeal to the human/social conditions yet also contain salient scientific/technical information.

6.4 Challenges to Implementation

This section attempts to identify some of the specific challenges associated with the *knowledge model approach* that were identified throughout the expert workshop.

The experts asserted that "*major political issues are always associated with the implementation of any new policy, particularly in the case of climate change in which the residing federal government may not acknowledge the issue as a priority.*" This problem is highlighted by the current political situation in which the current provincial government displays a commitment towards climate change initiatives as a priority, but the current federal government does not. According to one expert, the adoption of a new risk communication policy that focuses on climate change-induced EEEs "*would require a tolerance to increased risk of policy changes, which may not reflect the policies throughout the various levels of government*". Therefore, in order to convince the public and the government to commit resources to this approach "*there is a need to establish evidence of a successful implementation.*"

One expert believed that the *knowledge model approach* was "*certainly effective in determining gaps in knowledge but was limited in expressing the crafting of a risk communication message itself.*" To this point it should be considered that the *knowledge model approach* is not necessarily designed to identify a specific message. However, the *mental model approach* developed by Morgan *et al.* (2002), from which the *knowledge model approach* was adapted, does place more emphasis towards directly crafting and testing the effectiveness of a specific risk communication message. The emphasis towards crafting a specific message has been excluded in the *knowledge model approach* in favour of identifying the required elements of a risk communication tool for disaster management. By identifying the required elements of a risk communication tool, it is the objective to create a more holistic framework from which the disaster manager can engage the public and apply to various scenarios. Therefore, this is an issue that should not necessarily be attributed to a deficient methodological design, but rather a specific challenge that is more aligned with the strengths of the *mental model approach.*

6.5 Identifying a Risk Communication Tool

As noted in the previous section, the *knowledge model approach* should be considered as a framework from which to engage the public, locate the gaps in knowledge, and identify the required elements of a risk communication tool. Having located the gaps in knowledge in the previous two chapters, the purpose of this section is to identify the required elements of a risk communication tool based on the research findings and the feedback from the expert workshop, summarized in Table 6.4.

Table 6.4 represents a series of ideas put forward by the expert participants in response to the research findings, reflecting their beliefs concerning how a risk communication tool should be applied within disaster management in Manitoba. It is important to note that this section does not attempt to create but to 'identify the required elements' of a risk communication tool based on the results of this research.; and which has the potential to increase community coping capacity in rural Canadian prairies to climate change-induced EEEs.

According to the experts, the prerequisite condition essential for communicating risk to the public includes having an integrated policy mandate within disaster management that takes a preventative approach. This contrasts the current risk communication strategy which is described by several experts as "*event-driven - largely conceptual and reactionary in nature - with no clear direction or accepted methodology - manifested through separate, compartmentalized approaches*". A preventative approach ensures that a risk message is effective at increasing the resiliency and coping capacity of the public, and not as a temporary, short-term solution. In addition by taking an integrated approach a risk communication message can propagate a single idea throughout multiple forums and reach a larger audience. One expert expressed his vision of this as "*concentric circles of media that that link different audiences*". In this instance, the sources of knowledge that are found to be linked with a gap would help identify which forms of media would be most effective.

The overall purpose of taking a preventative and integrated approach is to create the foundations (i.e. social capital, education, social programs) to increase the resiliency and coping capacity of the public at a societal level. This would undoubtedly also require policy changes, which would entail both public and government commitment to increasing community coping capacity to climate change-induced EEEs.

Secondly, education in the early years was again identified by the experts as the proven and most effective target audience to insight a shift of risk perception at the societal-level and therefore would need to be a focus of any risk communication strategy. However, in terms of specifically addressing the gap that was identified in this research, there is also a need to direct risk messages specifically towards middle aged, educated, white males. By targeting both 'early years education' and the 'white male worldview', risk communication can address the knowledge gap in individual's who already hold misconception as well as prevent the misconceptions from developing in early years.

Finally, the experts expressed a fundamental need to focus risk messages on specific risks through direct approaches that do not confuse the public with the inherent complexities involved with climate change. One expert expressed the need to "*communicate risk at the intersection of scientific/technical and human/social knowledge*", or within the domain where humans interact with the environment. This requires presenting messages in ways that appeal to the human/social condition yet also contain salient scientific/technical information. More specifically, "*risk messages need to build upon individuals and their experiences*" in order to create messages that are tangible and understandable. Therefore it is essential that the risks that are communicated to the public are tangible and pragmatic, otherwise people will simply overlook them and demand policy changes and focus their attentions towards issues they deem more important to their daily lives.

The intended outcome of this process is to engage the public and facilitate a two-way exchange of ideas between experts and the public. Even the experts in the workshop acknowledged that traditionally, "*public knowledge has been the secondary emphasis behind expert knowledge*", and that this is an issue in disaster management. By presenting messages that 'make sense' to the public and that have 'real meaning', it will enable the public to engage in a two-way discussion with risk managers which will in turn generate new ideas, exchange knowledge, and set the conditions to close the knowledge gap. By closing the knowledge gap, it is the intention to insight behavioural change through raising social consciousness, improving knowledge of key issues, and increasing social power which ultimately allows individuals to make informed choices concerning risk.

Table 6.4: Expert identified required elements of a risk communication tool

	Method	Outcome
Strategy	• Integrated and preventative approach • Propagate a common message • Use the knowledge model approach to identify the most effective form of communication	• Create a culture/paradigm shift
Audience	• White, middle-aged males with a post-secondary education • Early years education	• Target the knowledge gap
Message	• Create a straight-forward message • Link complex information with practical examples • Tangible and pragmatic	• Facilitate a two-way discussion

7.0 Chapter 7 – Conclusion

7.1 Overview

The purpose of this research was to enhance practices in disaster management by identifying the required elements of a risk communication tool in an attempt to increase community coping capacity to climate change-induced EEEs in the rural Canadian Prairies. In order to achieve this, the research employed the *knowledge model approach* which included four objectives designed to locate the gaps in expert/public knowledge concerning climate change-induced EEEs and identify the required elements of a risk communication tool. Ultimately, this thesis provides a framework for the disaster manager to engage the public through a participatory method and create a risk communication tool.

The first objective of this research was to determine the status of knowledge concerning climate change-induced EEEs in the expert community. This objective was achieved with the creation of the expert flood and drought knowledge models presented in chapter 4. These models identified five key relationships, pertaining to both drought and floods, that illustrate the sequential relationship in order for an increase in GHG's to lead to climate change induced-EEEs and eventually individual-level effects.

The second objective of this research was to determine the status of knowledge concerning climate change-induced EEEs in the rural public community. This objective was fulfilled through administering 20 face-to-face interviews, followed by a round of 400 confirmatory questionnaires in the rural municipalities of both Cornwallis and Stuartburn.

The third objective was to identify the gap in knowledge between experts and the public. This was accomplished by directly comparing the key relationships in the expert knowledge models with the results from the face-to-face interviews and the confirmatory questionnaires. These findings revealed that the gap between expert and public knowledge was largest concerning the technical/scientific information (earlier parts of the models) and smallest regarding the human/social aspects (later parts of the models). In particular the findings suggested that expert and public knowledge is most divergent concerning the relationship between GHG's and a rise in the earth's temperature in both communities, as well as with the relationship between a rise in temperature and a reduction in soil moisture deficit in Cornwallis.

The fourth and final objective of this research was to identify the required elements of a risk communication tool in an attempt to increase community coping capacity to climate-change-induced EEEs. In order to achieve this, the gaps that were identified in chapter 4 were correlated with variables associated with worldview including gender, education, age, and sources of knowledge in chapter 5. These variables were used to determine which factors associated with worldview were correlated with a gap in knowledge. Accordingly, both of the key relationships examined showed a strong correlation with a gap in knowledge and 'male' respondents, a 'postsecondary education', and 'middle age'. In addition, 'television and the newspaper' were both identified as the primary and secondary sources of knowledge and were predominantly associated with a positive belief in both relationships, while 'the radio and internet' were correlated with a gap. Therefore the worldview associated with gaps in this research could be described as 'middle-aged, male, with a postsecondary education'. These findings were then presented to a group of experts who provided feedback which ultimately culminated in the identification of the required elements of a risk communication tool (Table 6.4) for climate change-induced EEEs in chapter 6.

7.2 Implications for Disaster Management Policy

The disaster management literature has typically insisted that the most vulnerable groups are the poor, women, racial and ethnic minorities, as well as those who are members of other disenfranchised groups (Mileti & Gailus, 2004; Hewitt, 1997). In terms of climate change-induced EEEs in the Canadian Prairies, aboriginal and rural populations are also believed to be at increased risk through a range of personal, social, economic, and environmental factors working against them (Field *et al.*, 2007; PHAC, 2005; Haque, 2000).

The results from this research, suggest that middle-aged, white males with a post-secondary education demonstrate the largest gap in knowledge with experts when compared to other groups. This finding is consistent with the risk perception literature which suggests that white males with a high level of education often exhibit a decreased sense of risk (Palmer, 2003; Slovic, 1999; Flynn *et al.*, 1994; Krewski *et al.*, 1994; *Dejoy* 1992; Pilisuk and Acredolo, 1988; Brody, 1984). This group is typically depicted as more socially empowered and therefore as being less vulnerable to various hazards when compared to other groups. This tendency to judge risk as low is therefore likely a reflection of this group's feeling of empowerment. This raises the question that if middle-aged, white males with a post-secondary education are traditionally more empowered and less vulnerable, what does it mean if they understand and perceive risk differently than experts? It is likely, and particularly in the case of climate change-induced EEEs, that this group will augment risk to other more vulnerable groups.

Work by Slovic (1979; 1982; 1999; 2000) has continually argued that the existence of a gap in knowledge is one of the fundamental obstacles towards achieving a more effective risk and disaster management system. Many other researchers have also argued that reducing risk and vulnerability at the local level is less likely to be successful if (expert) decision makers perceive risk differently than the public (Haque 2000; Rasid 2000; Buckland and Rahman 1999). An example of this, and how it specifically applies to gender was documented during the1997 Red River flood in rural Manitoba, where Enarson and Scanlon (1999) found that women's desires to take mitigation measures were often dismissed by men as a gendered personality trait. In many of these cases, women were more likely to listen to the recommendations of experts, while men often ignored the advice of experts and the mandatory evacuation order while attempting to save their homes (Haque, 2000). This example illustrates the need to revisit the concept of vulnerability in risk management in order to incorporate 'a gap in knowledge' as an integral component of creating 'risk'.

It is however widely acknowledged that engaging the public and producing behavioural change is not necessarily a simple function of only increasing the public's knowledge (Bergmans, 2008). Recent lessons from various countries have shown that formulation of mitigation and adaptation strategies cannot be exclusively top-down; as they require social, political, and cultural acceptance as well as a sense of ownership from the public (Haque and Burton, 2005). Therefore, in order to directly address the issue of knowledge gaps and subsequent vulnerability, disaster management must increase the emphasis towards the use of participatory approaches in risk communication.

7.3 Recommendations for Future Research

This research attempted to use the *knowledge model approach* as a means to identify a gap in expert/public knowledge. These results were then presented to an expert feedback workshop where the required elements of a risk communication tool were identified. This research however only reflects the findings from two rural Manitoban communities and it is therefore important to put the findings from this research into perspective. Consequently, there should not only be a larger study to represent the entire rural Canadian Prairie region but also additional studies that examine various other populations in different regions. This thesis should therefore only be used as a framework on how to locate gaps in knowledge and engage the public towards developing a risk communication tool. Additional research should specifically examine the effectiveness of other risk communication tools and attempt to identify more effective methods of engaging the public with participatory approaches and communicating risk.

In addition, by identifying the required elements of a risk communication tool, this research cannot assume that these measures are suffice alone to increase the coping capacity of rural prairie communities to climate change-induced EEEs. Rather, in order to effectively achieve this goal it will require many other adaptation techniques that address issues of social inequalities (i.e. social power and location) that lead to increased vulnerability; as well as increased mitigation efforts.

As was previously mentioned, there needs to be an increased emphasis towards how to incorporate participatory approaches into disaster management and specifically towards risk communication. Fortunately, participatory approaches have become increasingly accepted as an emerging component of the disaster management process (Pearce, 2003). An example of this in Canada is the Home Emergency Response Organization System (*HEROS*) in Coquitlam, B.C. This program recruits leaders and volunteers from each neighborhood to inventory local equipment, develop a list of special-needs situations, and arrange for community stockpiles, in return for which the community provides basic emergency and first aid training as well as financial assistance for equipment costs (Pearce, 2003). However, there is a distinct need to incorporate participatory approaches beyond the context of only emergency response, but also into the creation and implementation of risk communication messages. The *knowledge model approach* represents one way of doing this, by giving the disaster manager a framework from which to engage the public and construct a risk communication tool. Future research must therefore test the effectiveness of the *knowledge model approach* as a framework to engage the public, as well as attempt to identify other methods that provide effective implementations of participatory approaches in risk communication.

In direct reference to the findings from this research, increased attention must also be focused towards understanding how risk is transferred from one group to another. If middle-aged, well-educated, white males are creating risk by virtue of a gap with expert knowledge, there is a distinct need to understand how this risk is transferred to other more vulnerable groups. Therefore, future research must also address how social power affects the ability of individuals and groups to 'act' based on their knowledge.

7.4 Concluding Remarks

The fourth and most recent IPCC report (2007) suggests that although North America has considerable adaptive capacity, its actual practices are insufficient at protecting people and property from the adverse impacts associated with climate change-induced EEEs. The findings from this research ultimately aspire to promote policy that will lead to an increased emphasis of risk communication as a preventative approach towards climate change-induced EEEs by increasing community coping capacity. Unfortunately, despite the overwhelming scientific evidence, climate change has been consistently neglected as a priority issue, in both the political and social realms.

In the context of reducing risk to climate change-induced EEEs, other than mitigation, the most effective option is to reduce vulnerability (Haque and Burton, 2005). This approach has however not yet infiltrated the realm of government policy, where EEEs are still portrayed as "deviations from order of the established structures" (Hewitt, 1983, p.29). Disaster management policies have thus traditionally propagated a decentralized approach in which adaptation strategies tend to be reactive, unevenly distributed, and focused on coping rather than prevention (Field *et al.*, 2007). Although the vulnerability/resilience paradigm has largely replaced the hazards paradigm within the social science literature and much of the professional emergency and disaster management theory, it has yet to transcend into policy and more importantly public discourse (Haque and Etkin, 2007). In a western democracy such as Canada, public awareness should ultimately coerce government policy into action. Unfortunately, to date in North America public attitude and subsequently political leadership surrounding climate change has negated any opportunity to advance policy to cope with the additive effects of climate change-induced EEEs, including an emergence of the vulnerability/resilience framework into policy.

There is therefore a distinct need for a collective movement towards sustainable development which embraces the role of disaster management as interrelated to other initiatives, including poverty reduction and GHG emission reduction, as a pillar of resiliency in our society. This thesis hopefully reinforces the need to continue to examine and explore new and emerging approaches towards reducing human, social, economic and environmental losses caused by the cumulative impacts of climate change-induced EEEs.

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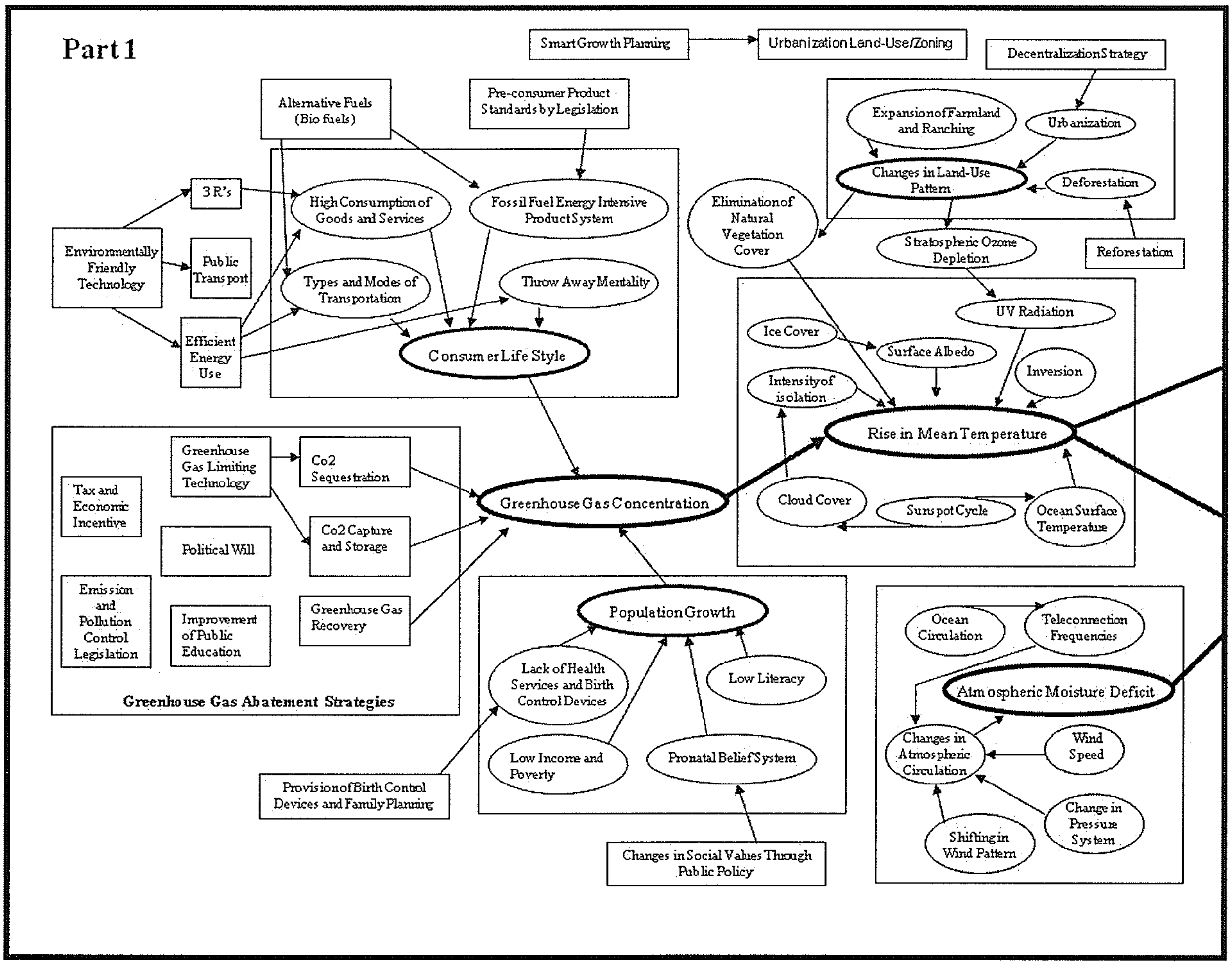
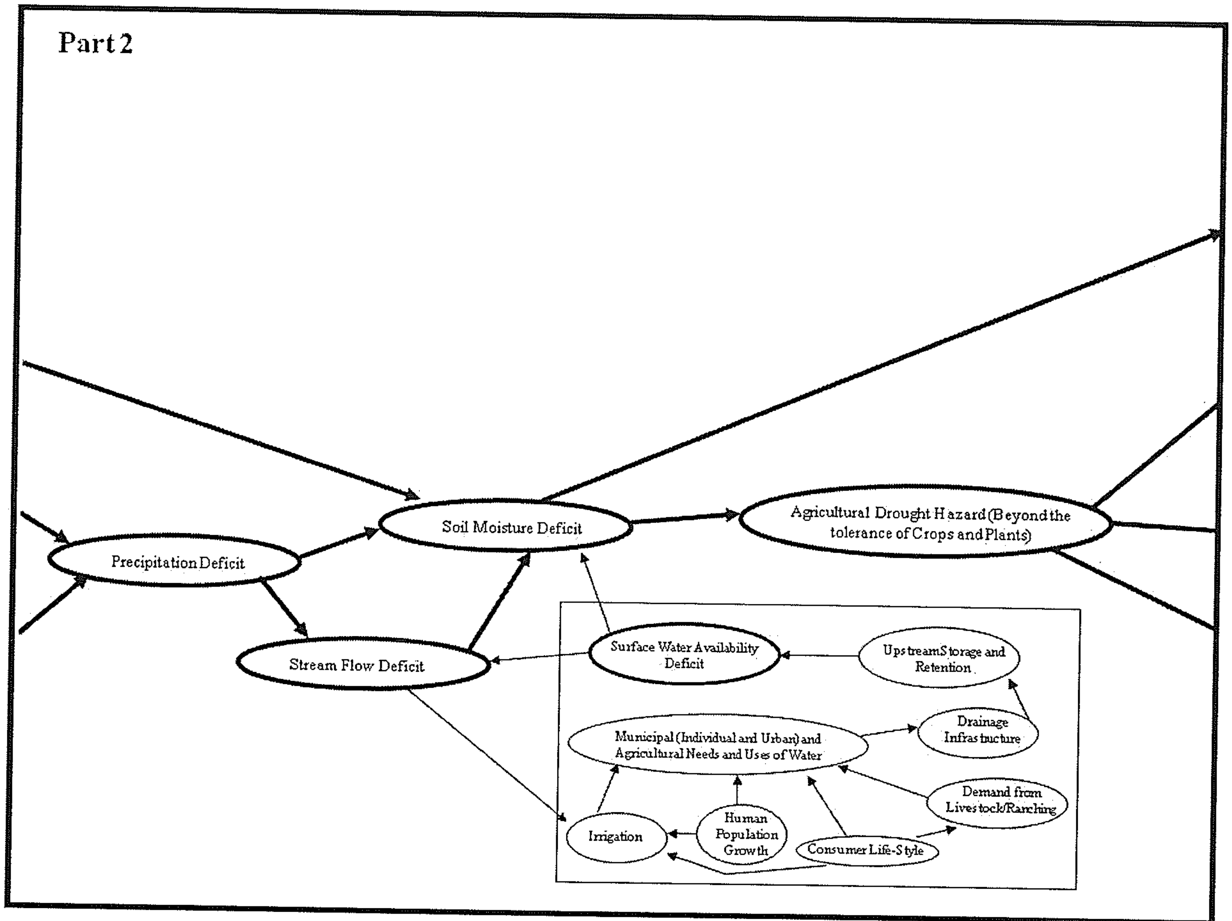
Appendix 1: Expert Workshop

Name	Affiliation	Specialization
Dr. Peter Berry	Health Canada, Ottawa	Public Health
Kristina Hunter	University of Manitoba	Geography and Health
Elish Cleary	Manitoba Health	Medicine and Health
Jody Kelloway	Canadian Red Cross	Community Services
Barbara Crumb	Manitoba Health	Public Health
Dr. Danny Blair	University of Winnipeg	Meteorology
Irene Hanuta	Agriculture Canada	Disasters
Ron Fortier	Family Services and Housing	Social Work
Dr. Elaine Enarson	Brandon University	Disasters
Pat Lachance	Public Health Agency of Canada	Public Health
Dr. C. Emdad Haque	University of Manitoba	Risk Management

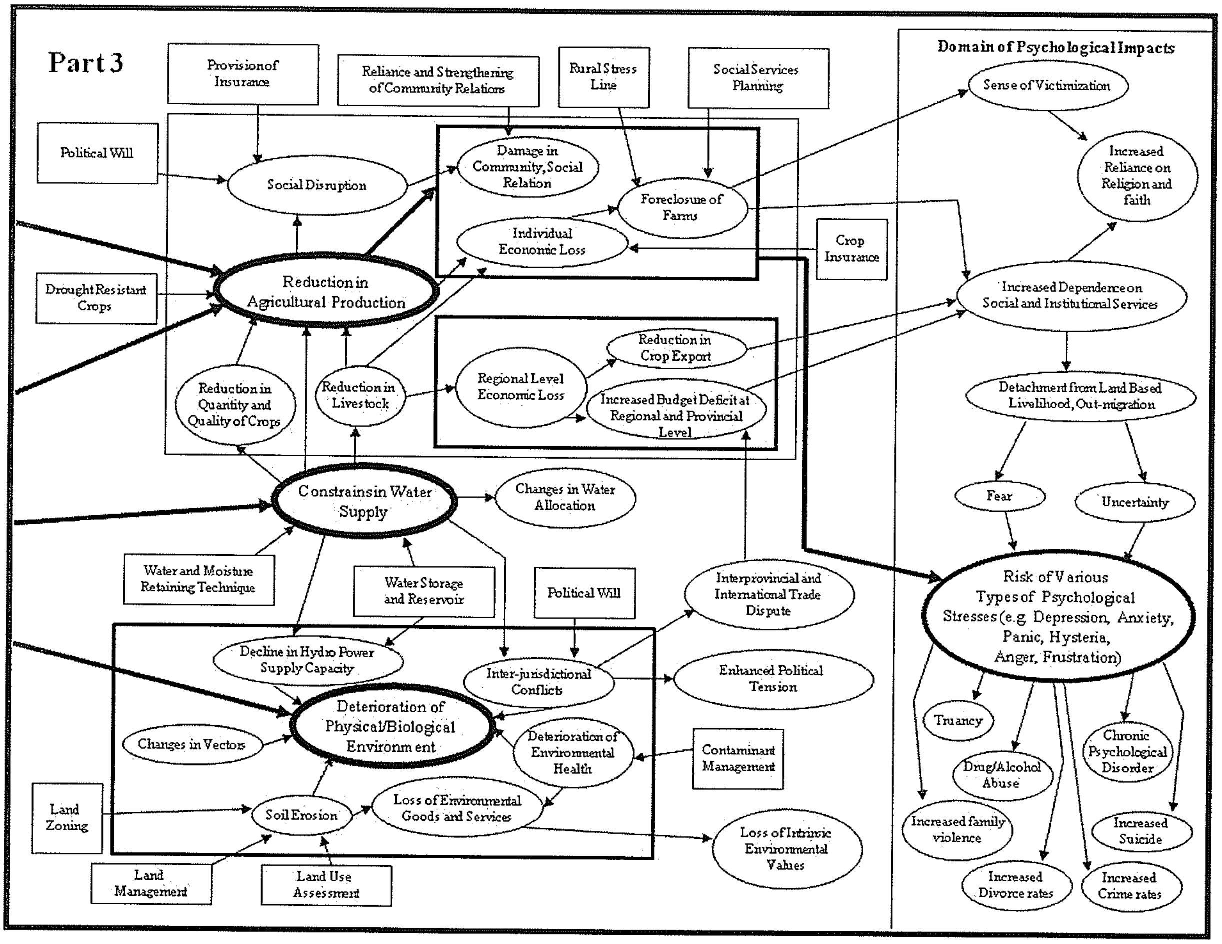
Appendix 2: Detailed Drought Model



Part 1 of the Expert Climate Change-Induced Drought Knowledge Model

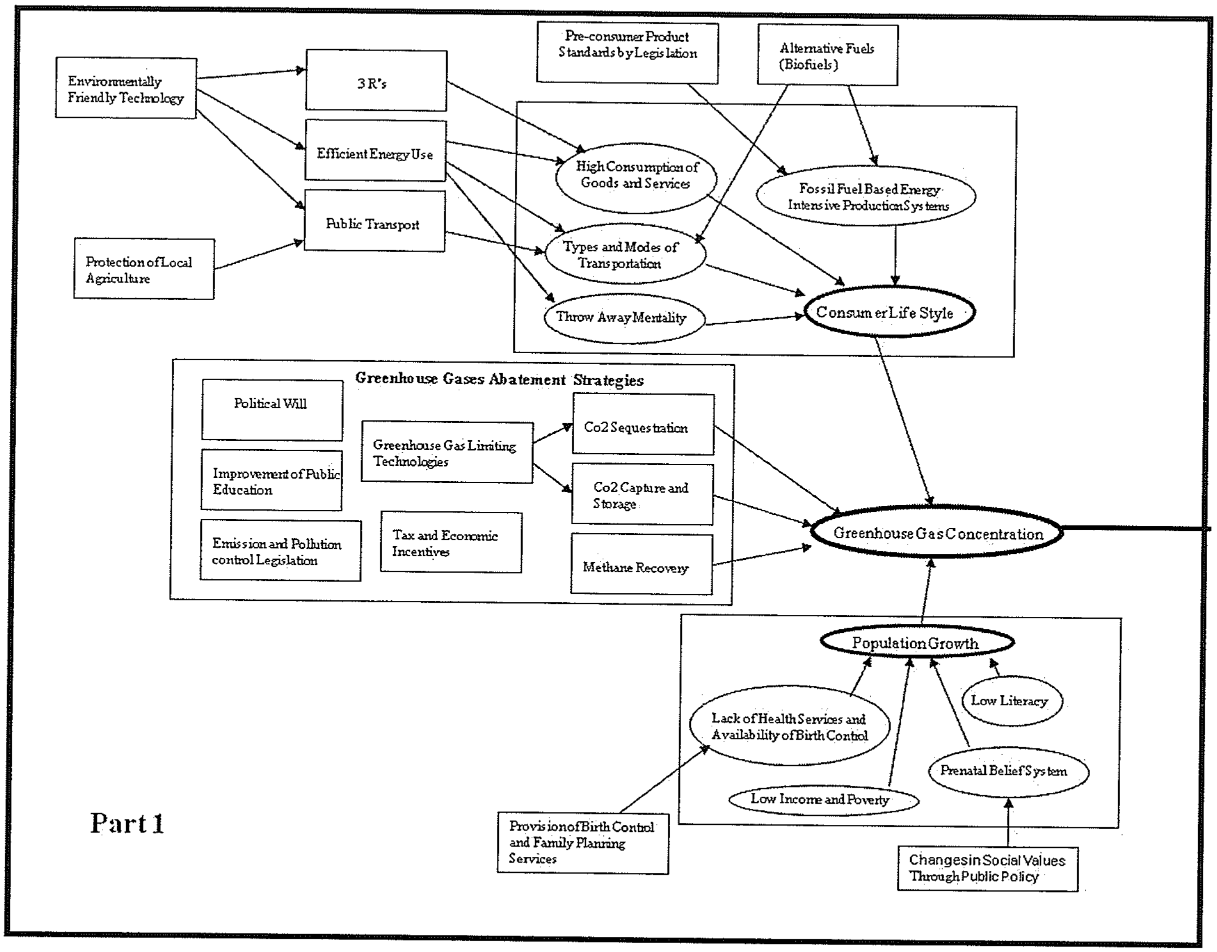


Part 2 of the Expert Climate Change-Induced Drought Knowledge Model

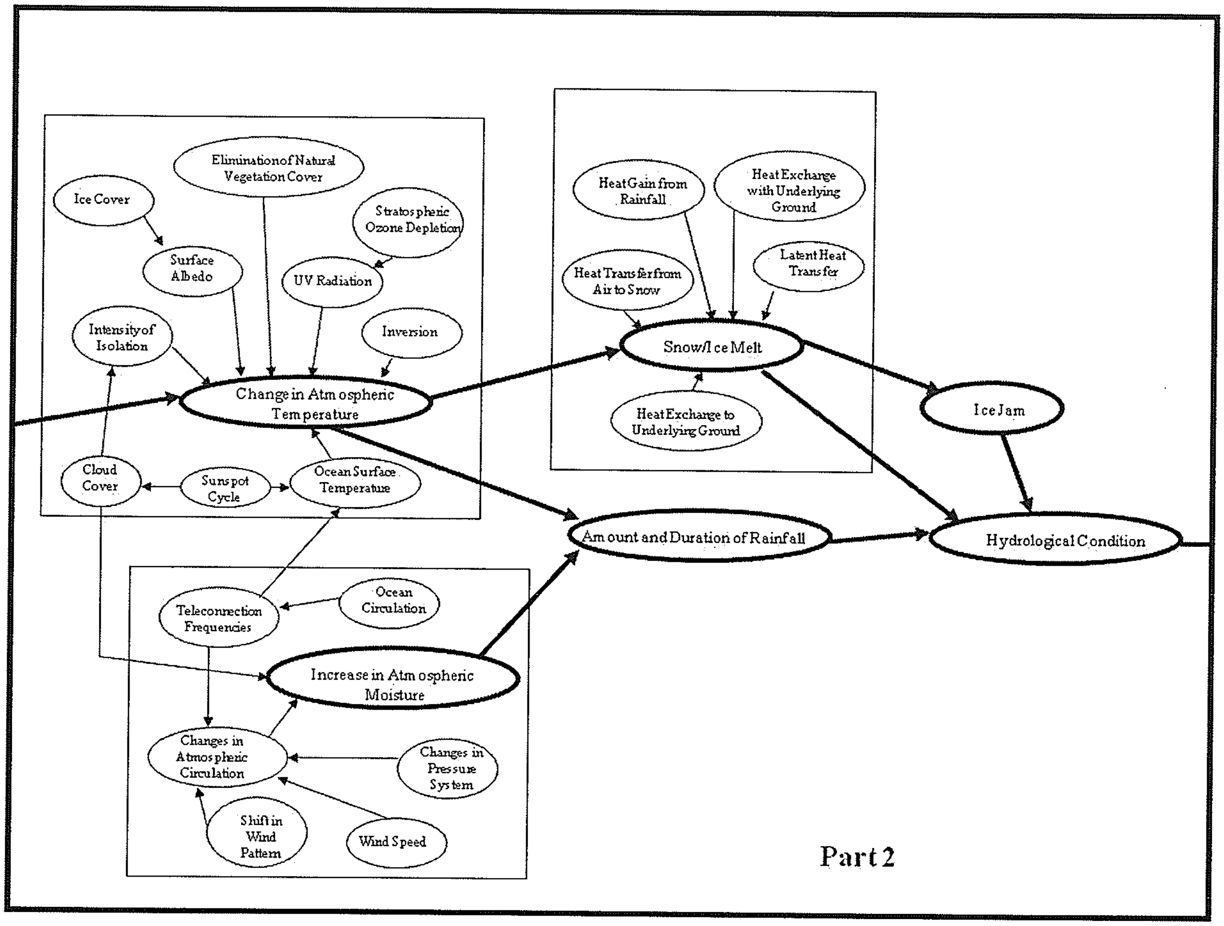


Part 3 of the Expert Climate Change-Induced Drought Knowledge Model

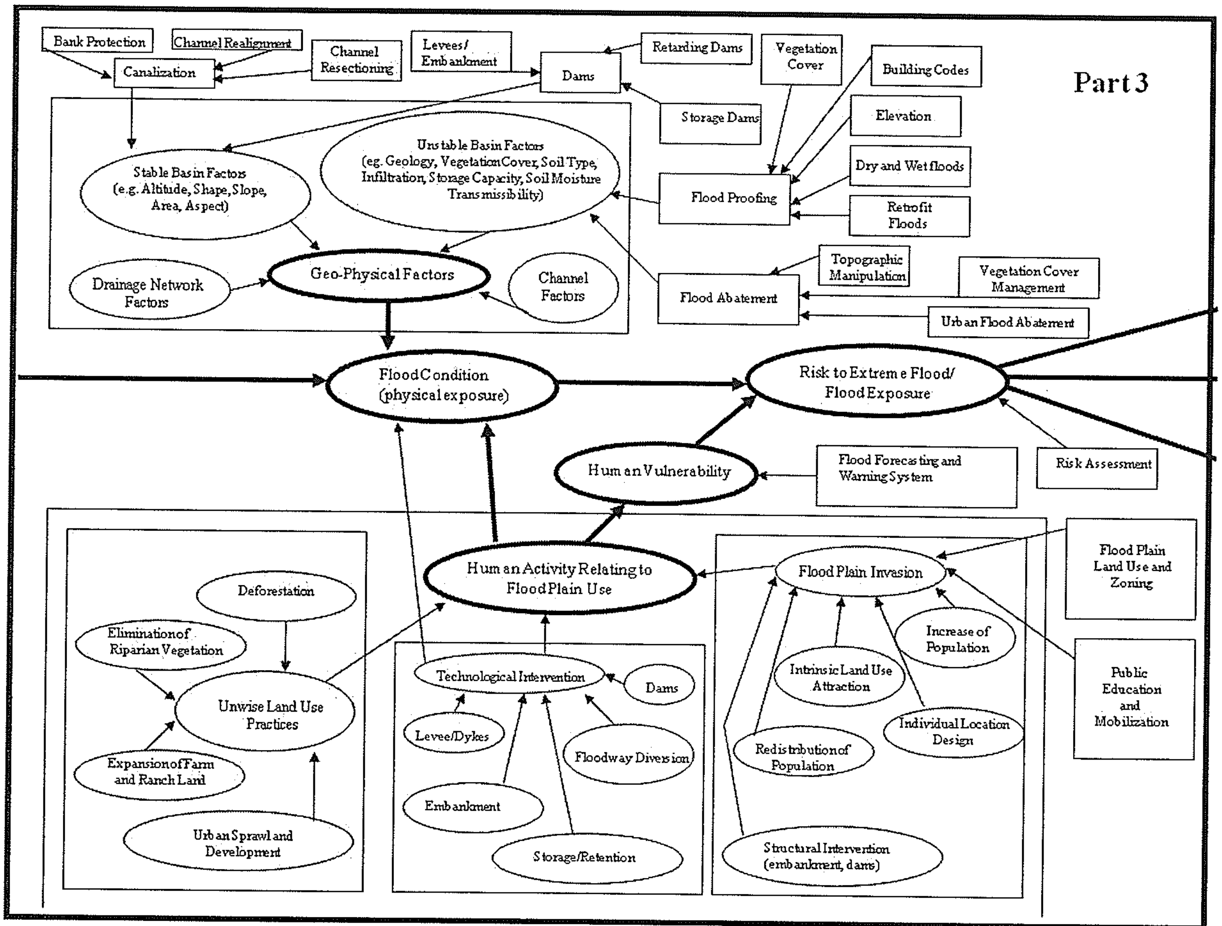
Appendix 3: Detailed Flood Model



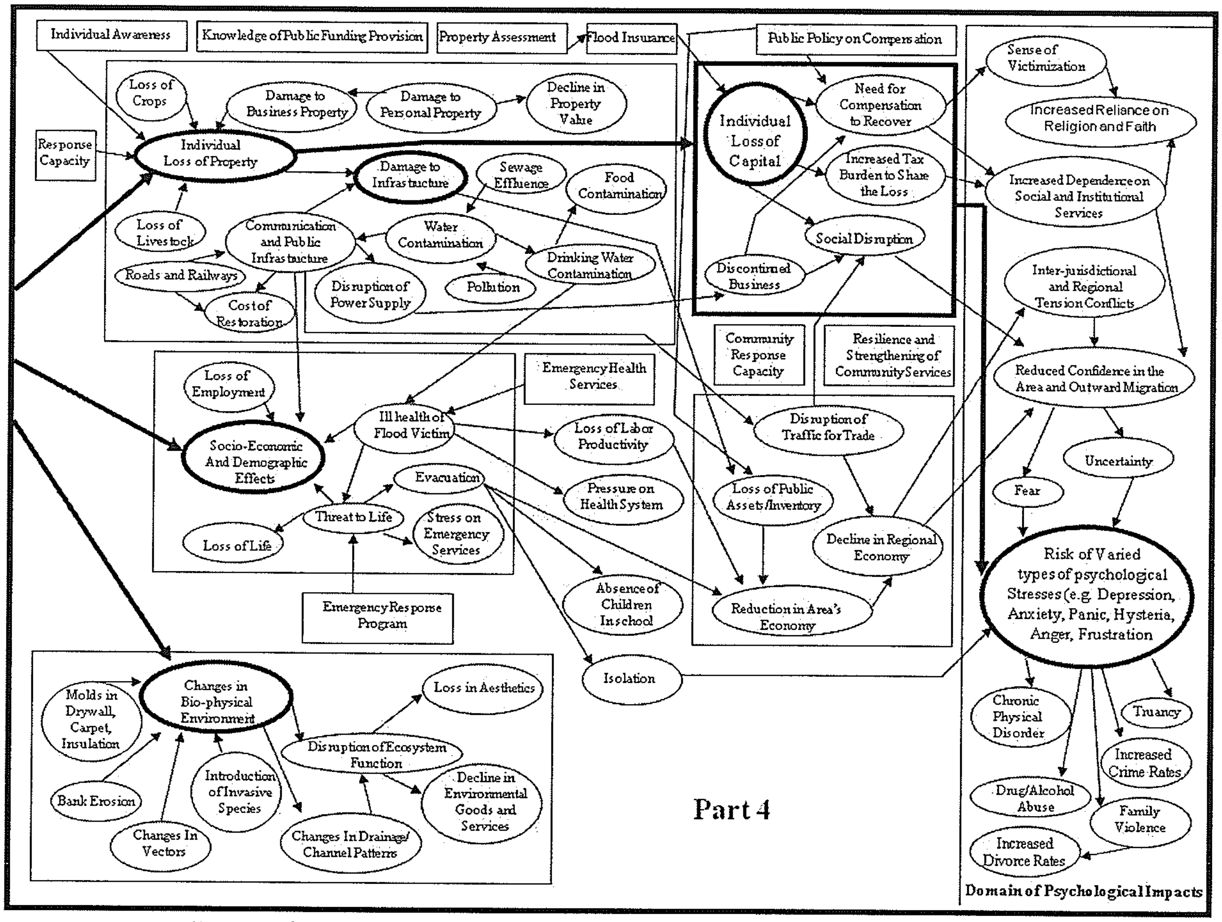
Part 1 of the Expert Climate Change-Induced Flood Knowledge Model



Part 2 of the Expert Climate Change-Induced Flood Knowledge Model



Part 3 of the Expert Climate Change-Induced Flood Knowledge Model



Part 4 of the Expert Climate Change-Induced Flood Knowledge Model

Appendix 4:Face-to-Face Interviews

Drought Interview (Cornwallis)

1. What can you tell me about extreme environmental events?
2. How would you define an agricultural drought?
3. Can you tell me what causes agricultural droughts?
4. How does an agricultural drought affect you and your community?
5. What human decisions do you think affect your risk to drought?
6. Do you think that the threat of drought in your community leads to psychological stresses?
7. What would happen if these stress conditions persist?
8. What can be done to limit the risk of agricultural droughts at the community level?
9. How do you perceive your personal risk to agricultural drought?
10. What do you know about global climate change?
11. Can you tell me about the causes? Effects?
12. What can you tell me about greenhouse gases?
13. Do you think that the earth's average temperature is increasing?
14. Do you think that the natural environment is changing? Any personal experience?

Flood Interview (Stuartburn)

1. What can you tell me about extreme environmental events?
2. How would you define a flood?
3. Can you tell me what causes a flood?
4. How does a flood affect you and your community?
5. What human decisions do you think affect your risk to flood?
6. Do you think that the threat of flood in your community leads to psychological stresses?
7. What would happen if these stress conditions persist?
8. What can be done to limit the risk of floods at the community level?
9. How do you perceive your personal risk to flood?
10. What do you know about global climate change?
11. Can you tell me about the causes? Effects?
12. What can you tell me about greenhouse gases?
13. Do you think that the earth's average temperature is increasing?
14. Do you think that the natural environment is changing? Any personal experience?

Appendix 5: Confirmatory Questionnaire Surveys

Stuartburn Questionnaire Survey

UNIVERSITY OF MANITOBA

The following questions are about extreme environmental events and climate change. We are interested in knowing your perceptions, knowledge and beliefs concerning them. Please circle the answer that best represents your opinion.

True: To the best of my knowledge this is true.

Maybe True: I think this might be true.

Don't know: I don't know if this is true or false.

Maybe False: I think this might be false.

False: To the best of my knowledge, this is false.

1. Extreme environmental events (i.e. floods, drought, and storms) have been increasing in frequency and intensity in recent years.

True **Maybe True** **Don't Know** **Maybe False** **False**

2. The agricultural community is the most affected by extreme environmental events (i.e. floods, droughts, storms) and is therefore the most vulnerable.

True **Maybe True** **Don't Know** **Maybe False** **False**

3. Please rank the following extreme environmental events from most threatening to least threatening to you (***1 – most threatening, 7 – least threatening***).

- Flood ____
- Drought ____
- Snow Storm ____
- Heat Wave ____
- Tornado ____
- Forest Fire ____
- Severe Thunderstorm ____

4. On a scale of 1 to 10 how concerned are you (***1–not concerned, 10–very concerned***) about drought in your community?

1 2 3 4 5 6 7 8 9 10

5. The threat of droughts leads to psychological stress in your community.

True Maybe True Don't Know Maybe False False

6. Please rank the drought impacts (***1-most concerned, 5-less concerned***), as they are concerns to you.
   - reduction in agricultural production ____
   - social impacts ____
   - loss of income ____
   - changes in the environment ____
   - regional economic impacts ____

7. Droughts are usually caused by a soil moisture deficit.

True Maybe True Don't Know Maybe False False

8. A rise in the earth's average temperature is linked to a deficit in rainfall and therefore to droughts.

True Maybe True Don't Know Maybe False False

9. Human intervention, such as zero-till and minimum-till farming, minimizes human risk to drought.

True Maybe True Don't Know Maybe False False

10. An increase in the frequency and intensity of extreme environmental events can be directly linked to climate change.

True Maybe True Don't Know Maybe False False

11. The earth's temperature is increasing.

True Maybe True Don't Know Maybe False False

12. On a scale of 1 to 10 how concerned (***1–not concerned, 10–very concerned***) are you about global climate change?

1 2 3 4 5 6 7 8 9 10

13. Population growth is a major contributing factor to global climate change.

True Maybe True Don't Know Maybe False False

14. Land-use, for example deforestation and urbanization, is a contributing factor to global climate change.

True **Maybe True** **Don't Know** **Maybe False** **False**

15. Global climate change is primarily caused by a hole in the ozone layer.

True **Maybe True** **Don't Know** **Maybe False** **False**

16. The release of greenhouse gases has burned a hole in the ozone layer.

True **Maybe True** **Don't Know** **Maybe False** **False**

17. Global climate change is affecting my life presently.

True **Maybe True** **Don't Know** **Maybe False** **False**

18. Global climate change will likely affect my life in the next 25 years.

True **Maybe True** **Don't Know** **Maybe False** **False**

19. The agricultural community is particularly vulnerable to climate change.

True **Maybe True** **Don't Know** **Maybe False** **False**

20. An increase in greenhouse gas concentration leads to a rise in mean atmospheric temperature.

True **Maybe True** **Don't Know** **Maybe False** **False**

As part of this research, we would like to know a little about the people and families who are taking part. For each question, please circle the number which best describes your answer.

21. Please indicate your gender.
    1 ..... Male   2 ..... Female

22. How old are you? Please specify number of years. ____ ____

23. How would you describe your living situation?
    1 ..... Single, never married   4 ..... Divorced or separated
    2 ..... Married   5 ..... Widowed
    3 ..... Living with a partner

24. Do you have school age children (elementary or high school) living with you?
    1 .... Yes   2 .... No

25. Including yourself, how many people live in your household?
    1 ..... One person (you live alone)   4 ..... Four people

2 ..... Two people
3 ..... Three people
5 ..... Five people
6 ..... Six or more people

26. What is the highest level of schooling you have completed?

1 ..... Less than high school
2 ..... High school graduate
3 ..... Some university/college
4 ..... University/college graduate

27. Please indicate and rank your top three sources of knowledge concerning global climate change (1 to 3).

- Books ____
- Newspaper ____
- Television ____
- Internet ____
- Church ____
- Magazine ____
- Journals ____
- Movies ____
- Radio ____
- Other (please indicate) ___________

28. Would you please indicate your religious belief? (i.e. Christian, Muslim, Atheist)

____

29. Would you please indicate your ethnic background? (i.e. English, French, First Nations)

____

30. Would you please indicate your profession or occupation? ___________________

31. Which answer below best describes your annual net household income (income to you and your family after taxes)?

1 ..... $10,000 - $20,000
2 ..... $20,000 - $35,000
3 ..... $35,000 - $50,000
4 ..... $50,000 - $65,000
5 ..... $65,000 -$80,000
6 ..... $80,000 or more

32. How long have you lived in this area? **If not your entire life**, please indicate how many months or years.

_____ months _____ years _____ Entire Life (please check)

You have now finished the Questionnaire. Thank you very much for your time and consideration.

Stuartburn Questionnaire Survey

UNIVERSITY OF MANITOBA

The following questions are about extreme environmental events and climate change. We are interested in knowing your perceptions, knowledge and beliefs concerning them. Please circle the answer that best represents your opinion.

True: To the best of my knowledge this is true.

Maybe True: I think this might be true.

Don't know: I don't know if this is true or false.

Maybe False: I think this might be false.

False: To the best of my knowledge, this is false.

1. Extreme environmental events (i.e. floods, drought, and storms) have been increasing in frequency and intensity in recent years.

   True **Maybe True** **Don't Know** **Maybe False** **False**

2. The agricultural community is the most affected by extreme environmental events (i.e. floods, drought, storms) and is therefore the most vulnerable.

   True **Maybe True** **Don't Know** **Maybe False** **False**

3. Please rank the following extreme environmental events from most threatening to least threatening to you (***1 – most threatening, 7 – least threatening***).

   - Flood ____
   - Drought ____
   - Snow Storm ____
   - Heat Wave ____
   - Tornado ____
   - Forest Fire ____

- Severe Thunderstorm ____

4. On a scale of 1 to 10 how concerned are you (***1–not concerned, 10–very concerned***) about flooding in your community?

   1 2 3 4 5 6 7 8 9 10

5. The threat of flooding leads to psychological stress in your community.

   True Maybe True Don't Know Maybe False False

6. Please rank the flooding impacts (***1-most concerned, 5-less concerned***), as they are concerns to you.
   - loss of property ____
   - loss of income ____
   - changes in the environment ____
   - regional economic impacts ____
   - social impacts ____

7. Floods are usually caused by extreme rainfall and other weather conditions.

   True Maybe True Don't Know Maybe False False

8. Human activity, such as deforestation and farming practices, leads to increased human vulnerability during floods.

   True Maybe True Don't Know Maybe False False

9. Technological interventions, such as dams and dykes, make humans less vulnerable to floods.

   True Maybe True Don't Know Maybe False False

10. An increase in the frequency and intensity of extreme environmental events can be directly linked to climate change.

    True Maybe True Don't Know Maybe False False

11. The earth's temperature is increasing.

    True Maybe True Don't Know Maybe False False

12. On a scale of 1 to 10 how concerned (***1–not concerned, 10–very concerned***) are you about global climate change?

    1 2 3 4 5 6 7 8 9 10

13. Population growth is a contributing factor to global climate change.

True **Maybe True** **Don't Know** **Maybe False** **False**

14. Land-use, for example deforestation and urbanization, is a contributing factor to global climate change.

True **Maybe True** **Don't Know** **Maybe False** **False**

15. Global climate change is primarily caused by a hole in the ozone layer.

True **Maybe True** **Don't Know** **Maybe False** **False**

16. The release of greenhouse gases has burned a hole in the ozone layer.

True **Maybe True** **Don't Know** **Maybe False** **False**

17. Global climate change is affecting my life presently.

True **Maybe True** **Don't Know** **Maybe False** **False**

18. Global climate change will likely affect my life in the next 25 years.

True **Maybe True** **Don't Know** **Maybe False** **False**

19. The agricultural community is particularly vulnerable to climate change.

True **Maybe True** **Don't Know** **Maybe False** **False**

20. An increase in greenhouse gas concentration leads to a rise in mean atmospheric temperature.

True **Maybe True** **Don't Know** **Maybe False** **False**

As part of this research, we would like to know a little about the people and families who are taking part. For each question, please circle the number which best describes your answer.

21. Please indicate your gender.
    1 ..... Male 2 ..... Female

22. How old are you? Please specify number of years. ____ ____

23. How would you describe your living situation?
    1 ..... Single, never married 4 ..... Divorced or separated
    2 ..... Married 5 ..... Widowed
    2 ..... Living with a partner

24. Do you have school age children (elementary or high school) living with you?

1 .... Yes 2 .... No

25. Including yourself, how many people live in your household?

a. ..... One person (you live alone)
b. ..... Two people
c. ..... Three people
4 ..... Four people
5 ..... Five people
6 ..... Six or more people

26. What is the highest level of schooling you have completed?

1 ..... Less than high school
2 ..... High school graduate
3 ..... Some university/college
4 ..... University/college graduate

27. Please indicate and rank your top three sources of knowledge concerning global climate change (1 to 3).

- Books ____
- Newspaper ____
- Television ____
- Internet ____
- Church ____
- Magazine ____
- Journals ____
- Movies ____
- Radio ____
- Other (please indicate) __________

28. Would you please indicate your religious belief? (i.e. Christian, Muslim, Atheist)
____

29. Would you please indicate your ethnic background? (i.e. English, French, First Nations)
____

30. Would you please indicate your profession or occupation? ________________

31. Which answer below best describes your annual net household income (income to you and your family <u>after</u> taxes)?

a. ..... $10,000 - $20,000
b. ..... $20,000 - $35,000
c. ..... $35,000 - $50,000
4 ..... $50,000 - $65,000
5 ..... $65,000 -$80,000
6 ..... $80,000 or more

32. How long have you lived in this area? **If not your entire life**, please indicate how many months or years.

_____ months _____ years _____ Entire Life (please check)

You have now finished the Questionnaire. Thank you very much for your time and consideration.

Appendix 6: Distribution of Respondents by Variable

Table 5.1: Overall respondent distribution by gender

Gender	Frequency	Percentage%
Male	33	37.9
Female	51	58.6
Missing	3	3.4
Total	87	100.0

Table 5.2: Cornwallis respondent distribution by gender

Gender	Frequency	Percentage%
Male	19	41.3
Female	26	56.4
Missing	1	2.2
Total	46	100.0

Table 5.3: Overall respondent distribution by education

Education	Frequency	Percentage%
Less than high school	14	16.7
High school graduate	23	27.4
Some university/college	18	21.4
University/college graduate	29	34.5
Missing	3	3.4
Total	87	100.0

Table 5.4: Cornwallis respondent distribution by education

Education	Frequency	Percentage%
Less than high school	8	17.4
High school graduate	13	28.3
Some university/college	6	13.0
University/college graduate	17	37.0
Missing	2	4.3
Total	46	100.0

Table 5.5: Overall respondent distribution by age

Age Group	Frequency	Percentage%
0-29 yrs	12	13.8
30-49 yrs	33	37.9
50-69 yrs	32	36.8
70-99 yrs	6	6.9
N/A	4	4.6
Total	87	100.0

Table 5.6: Cornwallis respondent distribution by age

Age Group	Frequency	Percentage%
0-29 yrs	8	17.4
30-49 yrs	19	41.3
50-69 yrs	15	32.6
70-99 yrs	2	4.3
N/A	2	4.3

Total	46	100.0

Table 5.7: Overall respondent distribution by Television as a source of knowledge

Television	**Frequency**	**Percentage%**
Primary source of knowledge	38	43.7
Secondary source of knowledge	30	34.5
Tertiary source of knowledge	6	6.9
Not a source of knowledge	11	12.6
N/A	2	2.3
Total	87	100.0

Table 5.8: Overall respondent distribution by Newspaper as a source of knowledge

Newspaper	**Frequency**	**Percentage%**
Primary source of knowledge	7	8.0
Secondary source of knowledge	41	47.1
Tertiary source of knowledge	17	19.5
Not a source of knowledge	20	23.0
N/A	2	2.3
Total	87	100.0

Table 5.9: Overall respondent distribution by Radio as a source of knowledge

Radio	**Frequency**	**Percentage%**
Primary source of knowledge	6	6.9
Secondary source of knowledge	19	21.8
Tertiary source of knowledge	10	11.5

Not a source of knowledge	50	57.5
N/A	2	2.3
Total	87	100.0

Table 5.10: Overall respondent distribution by Internet as a source of knowledge

Internet	**Frequency**	**Percentage%**
Primary source of knowledge	3	3.4
Secondary source of knowledge	8	9.2
Tertiary source of knowledge	14	16.1
Not a source of knowledge	60	69.0
N/A	2	2.3
Total	87	100.0

Table 5.11: Cornwallis respondent distribution by Television as a source of knowledge

Television	**Frequency**	**Percentage%**
Primary source of knowledge	20	43.5
Secondary source of knowledge	14	30.4
Tertiary source of knowledge	4	8.7
Not a source of knowledge	6	13.0
N/A	2	4.3
Total	46	100.0

Table 5.12: Cornwallis respondent distribution by Newspaper as a source of knowledge

Newspaper	**Frequency**	**Percentage%**
Primary source of knowledge	5	10.9

Secondary source of knowledge	24	52.2
Tertiary source of knowledge	9	19.6
Not a source of knowledge	6	13.0
N/A	2	4.3
Total	46	100.0

Table 5.14: Cornwallis respondent distribution by Radio as a source of knowledge

Radio	**Frequency**	**Percentage%**
Primary source of knowledge	2	4.3
Secondary source of knowledge	9	19.6
Tertiary source of knowledge	6	13.0
Not a source of knowledge	27	58.7
N/A	2	4.3
Total	46	100.0

Table 5.15: Cornwallis respondent distribution by Internet as a source of knowledge

Internet	**Frequency**	**Percentage%**
Primary source of knowledge	0	0
Secondary source of knowledge	4	8.7
Tertiary source of knowledge	12	26.1
Not a source of knowledge	28	60.9
N/A	2	4.3
Total	46	100.0

Appendix 7: Ethics Approval

UNIVERSITY OF MANITOBA | OFFICE OF RESEARCH SERVICES
Office of the Vice-President (Research)

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www.umanitoba.ca/research

APPROVAL CERTIFICATE

30 August 2006

TO: Dr. C. Haque (CCIAP, Natural Resources Canada)
Principal Investigator

FROM: Wayne Taylor, Chair
Joint-Faculty Research Ethics Board (JFREB)

Re: Protocol #J2006:093
"Impact of climate change and extreme events on psychosocial well being of individuals and community and consequent vulnerability."

Please be advised that your above-referenced protocol has received human ethics approval by the Joint-Faculty Research Ethics Board, which is organized and operates according to the Tri-Council Policy Statement. This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- If you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to Kathryn Bartmanovich, Research Grants & Contract Services (fax 261-0325), including the Sponsor name, before your account can be opened.

- If you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.