A remuneration of $ 30 per person will be provided for participating in this study. Please note that the project has received the required ethics approval from the University of Manitoba authority.

We will greatly appreciate your cooperation and assistance in conducting the interviews relating to the above project by providing a permission to do so and other necessary assistance.

Sincerely,

Dr. C. Emdad Haque
Director, Natural Resources Institute
University of Manitoba
303 Sinnott Building, 70 Dysart Road
Winnipeg, Manitoba, R3T 2N2

Contact information for interview-

Parnali Dhar Chowdhury
University of Manitoba
303 Sinnott Building, 70 Dysart Road
Winnipeg, Manitoba, R3T 2N2
E mail- umdarch@cc.umanitoba.ca
Phe No- 204 -290 - 4723

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

CTC Building
208 - 194 Dafoe Road
Winnipeg, MB R3T 2N2
Fax (204) 269-7173
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.**

ISSUES OF RISK COMMUNICATION: GAPS IN KNOWLEDGE AND PERCEPTION OF HUMAN HEALTH RISK DUE TO CLIMATE CHANGE INDUCED HEAT WAVE IN WINNIPEG

BY

PARNALI DHAR CHOWDHURY

A Thesis submitted to

The Faculty of Graduate Studies

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENVIRONMENT

Department of Environment and Geography

University of Manitoba

Winnipeg, Manitoba

R3T 2N2

© Parnali Dhar Chowdhury, July 2008

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

*****

COPYRIGHT PERMISSION

ISSUES OF RISK COMMUNICATION: GAPS IN KNOWLEDGE AND PERCEPTION OF HUMAN HEALTH RISK DUE TO CLIMATE CHANGE INDUCED HEAT WAVE IN WINNIPEG

BY

Parnali Dhar Chowdhury

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirement of the degree

Of

MASTER OF ENVIROMENT

Parnali Dhar Chowdhury © 2008

Permission has been granted to the University of Manitoba Libraries to lend a copy of this thesis/practicum, to Library and Archives Canada (LAC) to lend a copy of this thesis/practicum, and to LAC's agent (UMI/ProQuest) to microfilm, sell copies and to publish an abstract of this thesis/practicum.

This reproduction or copy of this thesis has been made available by authority of the copyright owner solely for the purpose of private study and research, and may only be reproduced and copied as permitted by copyright laws or with express written authorization from the copyright owner.

ABSTRACT

There is a general consensus in the experts' community now that the global mean temperature has increased remarkably in recent decades, and anthropogenic activities have contributed significantly to such changes. It has been projected that such change in temperature will cause frequent and more intense floods, droughts, tornadoes and heat waves globally as well as in Canada in the forthcoming decades. What is the 1) nature and level of knowledge about these emerging hazards and associated risks and 2) how these phenomena are being perceived both by the expert community and local residents were the key areas of inquiry of the present research. As heat waves carry a significant amount of risk through posing both the threat of heat-related illnesses and the aggravation of pre-existing health problems, the climate change-induced incremental change in the trends of heat wave frequency and intensity in the Prairie urban communities has become a major research and policy concern.

In consideration of the above, the specific study objectives were to: i) examine the state of knowledge and perception of climate change-induced heat wave hazards among the expert community; ii) analyze the state of knowledge, perception and awareness of climate change in general and its associated heat wave hazards among the community members at the local level; iii) identify the gap that exists between 'scientific/technical' and 'local community' knowledge regarding heat waves; and iv) explore the effective risk communication strategies that could help increase the community's coping capacity.

For the purpose of the present study as well as in consideration of the specific objectives of the present research, a model (i.e. "Knowledge Model") of the concerned phenomena was formulated. This method combines both qualitative and quantitative approaches through the implementation of three distinct steps: i) the development of an Expert ''Knowledge Model'', ii) carrying out the face-to-face interviews, and iii) conducting a confirmatory questionnaire survey at the local community level in the City of Winnipeg.

Analysis of the study have explored into the i) causes of heat waves, ii) risks associated with heat waves, iii) various effects of heat waves, and iv) potential preventive and mitigation options. A comparison between experts' and lay knowledge model has revealed that there are significant gaps which include the understanding of the complex earth and atmospheric systems, the relationships between variables relevant to climate change systems, misconception about the rise of global atmospheric mean temperature, conceptualizing cumulative effects of heat waves, heat wave "risk estimation" by the residents for the City of Winnipeg and its communities while recent hydro-meteorological data confirmed that Winnipeg is one of the most susceptible cities to heat wave hazards in Canada, and the role of precautionary measures in reducing mortality. Among the selected demographic and socio-economic explanatory variables, age, income status, level of education and gender were found to be modest predictors. Knowledge and perception of heat wave risks are thus also influenced by social and personal values, belief systems and previous experience. The findings have further revealed that not only risk messages need to address knowledge-gap areas, with clear and explicit statements with all of the intended points, serious efforts should be made to engage community level organizations and motivate people. In addition, effective risk messages need to be designed in ways: i) that communicate clearly and interestingly to the residents as well as to experts; and ii) that link to the issues and problems of daily life.

ACKNOWLEDGEMENTS

Completion of this study would not have been possible without the generous assistance provided by many individuals. I would first like to thank my Thesis Advisor Dr. C. Emdad Haque. Through your academic guidance and direction I was able to finish an interesting research topic that was very intellectually rewarding. Thank you for always having your door open and for taking the time to answer my numerous questions. I learned a great deal from you.

I would also like to acknowledge the members of my committee for their guidance. Dr. Dave Hutton, thank you for your input, helpful direction and suggestions that kept me on track. Dr. Stephane Mclachlan, I would like to thank you for your support and insightful comments. I greatly value the time spent conducting research with you and learning from you.

Last but not least, I would like to thank four most important people in my life: my mom, dad, my sister and my friend Debjit Saha, who were always there from India to provide me with everything I need to maintain my direction and stay focused. Mom and Dad, this degree reflects your hard work just as much as it does mine, without you I never would have been able to achieve this goal- thank you. To my sister, thank you for your moral support all the way. To Debjit, thank you for your help along the way and always reminding me that there is more to life than work. I never would have been able to do it without you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

Within the scientific community, a strong consensus has emerged in recent years that the global climate is changing and that the anthropogenic release and accumulation of greenhouse gas emissions in the earth's atmosphere are largely to blame (IPCC, 2007, 2001; Van Aalst, 2006). The most recent assessment of the Intergovernmental Panel on Climate Change (IPCC) Working Group 1 (WG1) described an increasing body of observations that provides a collective picture of a warming world and other changes in the climate system (IPCC, 2007; 2001). The concentration of carbon dioxide (CO_2) in the atmosphere has increased by around one-third, from 280 parts per million (ppm) in 1750 to 368 in 2000, representing the highest level in at least 420,000 years and likely the past 20 million years (IPCC, 2007; 2001).

1.1 Recent Climate Change Issues and Adaptation to Extreme Events

Global mean surface temperatures have risen by approximately 0.6 degrees over the past century, greater than during any other century in the past thousand years. The 1990s were likely the warmest decade of the past millennium (IPCC, 2007; 2001), with nine out of the ten warmest years on record between 1995 and 2004 (World Meteorological Organization, 2004). Since human emissions to date have already initiated substantial global climate change, and because most greenhouse gases remain in the atmosphere for at least several decades, global climate change is likely to continue. Furthermore, anthropogenic emissions are increasing, and are unlikely to decrease in the near future; this suggests that the effects of global climate change will accelerate and intensify (Van Aalst, 2006). Even the most optimistic scenarios, in which emissions would be dramatically cut, suggest the effects of climate change will continue for several decades and even centuries. Depending on the extent of future emissions and taking into account the different outcomes predicted among a range of climate models, the expected range in global temperature rise --from the present until 2100 -- is between 1.4° – 5.8° Celsius (Van Aalst, 2006).

The specific effects of global climate change are expected to be complex and wide-ranging but the general trend is that of a warming atmosphere. It is projected that while changes in average conditions can have significant consequences by themselves, the major impacts of global climate change will be felt due to changes in climate variability and extreme environmental events. Extreme environmental events are, by definition, rare stochastic phenomena. They may be defined in reference to large-scale, stressful environmental events that adversely affect a significant number of people. The number of extraordinarily severe floods, storms, heat waves and other weather-related calamities that have occurred within the past 15 to 20 years would seem to suggest that such events are becoming more common, and much scholarly literature correlates them with the recent warming of our atmosphere. Even if the statistical distribution of such events remains the same, a shift in the mean will entail a nonlinear response in the frequency of extreme events.

1.2 Observed Changes in the Frequency and Intensity of Heat Waves World-wide

A changing climate is expected to increase average summer temperatures, and the frequency and intensity of hot days. In particular, the frequency and intensity of extreme temperatures is expected to change (World Meteorological Organization, 2004). The effects of extreme temperatures on mortality have been recorded in numerous recent studies. For example, the 2006 North American heat wave which spread through most of the United States and Canada beginning on July 15, 2006, killed at least 225 people[1]. In August 2003, a record heat wave scorched Europe, claiming an estimated 35,000 lives (Larsen, 2003). During the 10th of August, 2003, London experienced its first triple-digit Fahrenheit temperature, causing the death of an estimated 900 people from the heat (Larsen, 2003). Heat-related fatalities across the United Kingdom reached 2,045 (Larsen, 2003). In Belgium, temperatures higher than any previously recorded in the Royal Meteorological Society's register, dating back to 1833, brought 150 deaths (Larsen, 2003). In the following table (Table 1.1), the country-wise death toll from heat for the continent has been demonstrated.

Few analyses have been completed on the impacts of heat waves in developing countries and the evidence is largely anecdotal. A heat wave in India in June 1998 was estimated to have caused 2,600 deaths over 10 weeks of high temperatures (Kumar, 1998). In Ores, the temperature rose to 49.5 degree Celsius and was reported to have caused 1,300 deaths. The high temperature was exacerbated by recurrent power failures that affected cooling systems and hospital services in Delhi, India.

[1] Dobnik, Verena, "Front brings East Coast temperatures down," Associated Press, *Houston Chronicle* (August 4, 2006). A subsequent United Press International report on August 9 quotes the State of California Office of Emergency Services as indicating 106 confirmed deaths, with 35 deaths "believed to be caused by heat stress or exhaustion." [Editor's note: I have made some suggested changes. Please be careful to modify this paragraph, as it appears to be originally from Wikipedia: http://en.wikipedia.org/wiki/2006_North_American_heat_wave]

Table 1.1: Country-Wise Death Toll from Heat Waves

Country	Number of Fatalities	Other Details
France	14,802	Temperatures soared to 104 degrees Fahrenheit in parts of the country; temperatures in Paris were the highest since record-keeping began in 1873.
Germany	7,000	High temperatures of up to 105.4 degrees Fahrenheit, the hottest since records began in 1901, raised mortality some 10 percent above average.
Spain	4,230	High temperatures, coupled with elevated ground-level ozone concentrations exceeding the European Union's health-risk threshold.
Italy	4,175	Temperatures in parts of the country averaged 16 degrees Fahrenheit higher than the previous year.
United Kingdom	2,045	The first triple digit (Fahrenheit) temperatures were recorded in London.
Netherlands	1,400	Temperatures ranged some 14 degrees Fahrenheit warmer than normal.
Portugal	1,316	Temperatures were above 104 degrees Fahrenheit throughout much of the country.
Belgium	150	Temperatures exceeded any in the Royal Meteorological Society's records dating back to 1833.
Total-	**35,118**	

Data obtained from Larsen, J.; 2003. Earth Policy Institute

In the 1970s and 1980s, research on heat wave impacts in the developed nations was limited. However, numerous empirical investigations since 1990s have accumulated valuable data, particularly on heat wave induced mortality. For example, during a record-setting heat wave in Chicago, USA, July 1995, there were at least 514 heat-related deaths, and 3,300 excess emergency admissions (Whitman et al., 1997). A 1987 heat wave in Athens resulted in 926 deaths, although the attributable excess mortality was estimated to be more than 2,000 (Katsouyanni et al., 1988). In the United States, the disastrous heat wave of 1980 resulted in deaths of more than 1,250 people (NOAA, 2003). The morbidity and mortality associated with the 1980 heat wave in St Louis and Kansas City were assessed retrospectively. Heat-related illness and deaths were identified by reviewing death certificates and the hospital emergency-room and medical examiners' records in the two cities. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation (NOAA, 2003).

Projected changes in climate are expected to bring a range of challenges to Canada, especially in the areas of health, infrastructure, water and other natural resource sectors. A strong linkage between climate and human health is viewed in the impact of extreme climate events and weather disasters. Flooding, droughts, heat waves, severe storms and other climate-related environmental hazards can damage health and social well-being by leading to an enhanced risk of injury, illness, stress-related disorders and death. Trends in illness and deaths related to air pollution, extreme weather events, allergies, respiratory diseases, and vector-, food-, and water-borne diseases indicate that weather and climatic factors influence health and well-being (Lemmen and Warren, 2004: 154). There is serious concern that climate change of the magnitude projected for the twenty-first century by the IPCC may have profound consequences for health and the health care sectors in Canada. The results of climate modelling exercises, assessments of regional environmental and resource vulnerabilities and climate abnormalities experienced across the country in recent years all indicate that changes in climate could make it more difficult to maintain the health and well-being of Canadians in the future. In light of these scenarios, as well as to highlight the gravity of heat wave effects, the areas of major heat wave-induced health risk are reviewed in the following section.

1.3 Heat Wave-Induced Human Health Risk

1.3.1 Physiological aspects

There has been a significant increase in interest in recent years in time series studies of temperature and mortality (Larsen, 2003) (i.e. the short-term relationships between ambient temperatures and daily mortality). During heat stress, the proper functioning of both hypothalamus and thermoregulatory systems is essential for thermal regulation. If they are unduly stressed and cannot match the thermoregulatory demands, this leads to excessive strain on the body and eventually may cause heat illness. Most heat-related illnesses (except for skin eruptions and heat cramps) are in essence consequences of varying severity of failure in the thermoregulatory system. Skin eruptions, heat fatigue, heat cramps, heat syncope, heat exhaustion and heat stroke are classic heat-related illnesses. Heat cramps, heat exhaustion, and heat stroke are some of the conditions that may arise during high temperature.

Heat waves can also aggravate other conditions such as heart disease, high blood pressure, kidney failure, and psychiatric disorder. The main predisposing factors for heat-related illness are age, lack of acclimatization, dehydration because of reduced food and liquid intake, intestinal problems, use of diuretics and alcohol abuse, and use of other drugs affecting the temperature regulation system, such as phenotiazines, barbiturates and other medications. Low fitness, overweight, fatigue, sleep deprivation, long-term, high-level exercise, and protective clothing also increase the risk of heat-related severe illness and, in the extreme cases, mortality.

1.3.2 Psychological impacts

Modern life demands high energy intensive economic activities, efficiency and ever increasing productivity in relation to unit of time and resources. In our consumer society people's daily lives require high income and efforts to improve and maintain a high standard of living. As a consequence of increasing costs to maintain a high standard of living and the anticipated impact of climate change on extreme events, mounting evidence indicates that chronic stresses and depressive symptoms are related to morbidity and mortality from heat waves and heat wave-induced illness. Recent studies of extreme climatic events and human health have provided important inferences about their relationships revealing some significant qualitative insights into these relationships and the factors affecting population vulnerability (Patz, 2002; Boardman, 2003). The psychological aspects of natural hazards and disasters have viewed in terms of individual distress and trauma arising from extreme environmental events. The present research uses the term psychosocial to refer to both the potential emotional and behavioural impacts experienced by people as a result of climate change induced heat wave, as well as the underlying values, attitudes and beliefs that may affect the way in which people perceive and interpret both climate change itself as well as initiatives taken by authorities to reduce such effects (Hutton et al., 2007).

Climate change, particularly from extreme environmental hazards, may have a significant influence on mental health (Hutton et al., 2007). Such effects are clearly evident in the case of climate-related environmental hazards, where property losses and displacement from residence can cause significant psychological stress, with long-lasting effects on anxiety levels and depression. Social disruptions resulting from family and community dislocation due to extreme weather events pose a particular kind of stress for children and people of lower socio-economic status. Boardman (2003) has observed that high level of community or neighbourhood stability and the relevant social capital can offer an important buffer to the otherwise deleterious effects of enhanced stress. Neighbourhood residents may not only be related to differential access to material, social and psychological resources, all of which may affect coping to stressors including climate change. Similarly, the impacts of environmental change events may well be aggravated by the vulnerability of certain population groups, as defined by basic socio-demographic determinants such as age, gender, education, disability and income status (Hutton et al., 2007). Hutton et al's (2007) study has revealed that those experiencing high level of stress also often have less access to personal supports during times of needs. Exploration into whether such individuals are from vulnerable groups will provide useful insights regarding these issues.

1.4 Role of Risk Communication in Heat Wave Hazards

> "In 1988, the Surgeon General mailed a pamphlet about AIDS to every home in the United States and The Centres for Disease Control have conducted a massive campaign to inform Americans about the risks (and non risks) of HIV/AIDS...All these communications aim to supply people with the information that they need in order to make informed decisions about risk" (Morgan et al., 2002: 2).

Commonly, hazard risk analysis applies a probabilistic approach which is distinct from its application in engineering and business and aims at providing a thorough understanding of uncertainty and the extent to which it can be expressed mathematically by using probability. Risk analysis also encapsulates integration of value judgement with uncertainties so that optimal decisions can be made. Effective communication can help people to identify risks with adequate attention. In this study, "risk communication in heat wave hazards" is used to mean communication intended to supply community people with the information they need to make informed, independent judgements about risks to health during a heat wave. Because mortality due to heat wave is largely preventable, knowledge of heat wave events and their impacts is important for reducing mortality and promoting public health.

Given people's time constraints in modern daily life activities, heat wave risk communication should not focus on every impact and the entire knowledge of heat wave events but only on the issues that recipients most need to understand. A large body of research shows that people, particularly when asked about risks outside their area of expertise, apply a complex understanding of risk when they make personal judgements about risks (e.g. health, finance, environmental threats) and their acceptability (Wilde, 1994; Slovic, 2000). For this reason, it has been noticed that direct training and persuasion by professionals and health workers has proven to be a more effective approach towards generating behavioural change and enhancing risk perception (Ferrier and Haque, 2003). This means that for recipients of the risk messages through direct methods, there is less probability to accept the message at face value or reinterpret it in ways that attempt to undo perceived biases.

It has also been identified throughout the literature that there remains a significant gap between the general public's perception of risk and the risk communication strategies devised by expert groups through policy and planning. One key difference is that scientists usually define risk in terms of effects on populations, while the community member audience is concerned with effects on individuals (Morgan et al., 2002). The psychometric approach developed by Slovic and his co-workers has indicated that different factors, such as whether the risk is perceived as involuntary, whether it will affect a large number of people, or whether it is seen to be unnatural, are likely to be important determinants of responses by community residents, and partly explain the disparity between community resident's and expert beliefs about risks. Also, the information system and characteristics of public response that compose social amplification are necessary components in influencing the nature and magnitude of risk (Kasperson et. al., 1988). This has generally been referred to as a *psychometric paradigm*, which is an extremely important starting point for understanding risk communication as it helps to know how people make decisions regarding a particular risk. Heat wave risk communication will be more effective should it address the actual concerns of the public regarding the hazards and their interest in them (i.e., to save their lives and properties), not just those concerns which are believed to be important by the experts. For example, heat wave risks as seen from a scientific perspective may produce very different public responses compared with specific risks of heat waves on individuals or with risks assessment that incorporates public perception of these hazards. Conventional risk communication strategies do not take into account the concerns or beliefs of the public and this has led to a general distrust and lack of confidence in the activities and programs devised for public protection (Committee on Risk Perception and Communication, 1989).

There is a clear need to investigate the dynamic changes in both the extent and nature of the public's perceptions of heat wave-specific hazards in order to better understand the concerns and levels of awareness that are present. This knowledge can then be applied towards developing the best possible practices in risk communication by incorporating public views and societal values into risk analysis.

1.5 The Issue of Climate Change-Induced Extreme Events in the Canadian Prairies

In the United States, predictions have been made that, as global temperature continues to rise, the frequency and magnitude of floods in North Carolina will correspondingly increase in the future (Robinson, 2003). In Canada, the vast majority of historical disasters are hydro-meteorological in origin (OCIPEP, 2004), and the trend in the occurrence of such environmental disaster is rapidly changing under the claimed climate change regime. Results from 37 weather stations, along with 50 sets of natural streamflow data and 13 sets of evapotranspiration data have validated that the Prairies have become warmer and drier over the last four to five decades (Gan and Xu, 1999). Conforming to this view, Blair (1997) has observed that the average maximum and minimum temperatures in Winnipeg (Manitoba) have been rising (study period 1872-1993), supporting the assertion that a warmer global climate will result in less 1-15 day temperature variability. The rapid nature of the change also supports the hypothesis that climate changes tend to be non-linear.

As a consequence of escalating costs and the anticipated impact of climate change on climate variability and extremes, the research and policy communities are now paying closer attention to the health impacts of disasters. This is being done with a view towards increasing the understanding of individual and local vulnerabilities so that policies and programs can be developed to mitigate negative impacts on physical and psychosocial health. Traditionally, the psychosocial aspects of extreme events have been contextualized in terms of individual distress and trauma arising from disasters, but the social and psychological aspects are now receiving increased attention.

Sauchyn and Kulsheshtha (2008), by assessing the sensitivities and vulnerabilities of natural resources and human activities, concluded that the most significant threat posed by climate change in the Prairies is the projected increase in climate variability and frequency of extreme events. They insist that the Prairie ecosystems are most vulnerable entities to climate change and climatic extremes will limit the opportunities afforded by changing climate and present the greatest challenges for adaptation. Adaptation generally refers to reforming, restructuring, and reorganizing for the purpose of making a phenomenon suitable for a new situation, context and need, and from this perspective adaptation has an evolutionary connotation (Haque and Burton, 2005: 342). In this research, it implies deliberate or incidental human efforts to adapt to changing environmental conditions and risks.

1.6 Research Purpose and Objectives

This study was part of a larger research project titled "Psychosocial Impacts and Well Being of the Individuals and Community due to Climate Change-Induced Extreme Events." The project was funded by the Climate Change Impacts and Adaptation Program of Natural Resources Canada to examine how to enhance mitigation and the adaptive capacity of the health sector at the local community level, as it relates to reducing the social and psychological consequences of climate change on Canadians. By using a Community Participatory Framework (CPF) (Chambers and Blackburn, 1996; Mitchell, 1997) as a means of analysis, the goals of the project 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. Resilience is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to continue with essentially the same function, structure, identity and feedbacks (Walker et. al., 2004) Within this framework, attempts were made to determine the degree to which broader community functions (such as social participation in formal and informal networks of civil society) play a critical role in coping and adaptability to climate change and other major environmental changes. Specific tasks included the assessment of the degree of psychosocial stress associated with extreme climate events and climate change in three selected local communities (North Kildonan in Winnipeg, Stuartburn Rural Municipality, Cornwallis Rural Municipality) in Manitoba, identification of key indicators (based on population health determinants) which influence individual and community vulnerability to climate change, and examination of the means and methods of integrating psychosocial aspects of climate change into risk management and preparedness, and response policies and practices in the health and emergency preparedness sectors.

I was a graduate student member of a five-person research team that investigated the heat wave risk and its associated communication topic areas. Within the scope of community and individual risk management capacity, individual researchers were assigned disparate components. My responsibility was to examine the gaps between the mental maps of experts and community residents relating to the knowledge of heat wave hazards and risk perception concerning them. My focus was on urban communities, and I conducted background research and provided input for this component of the larger research project. Specific tasks included establishing the research design and selecting the study area, delineating and ascertaining the respondent sample for both open-ended interviews and the confirmatory survey, designing the research instruments, and collecting and analyzing the primary data about the selected urban community. While I contributed to the overall process as a team member, the research framework was designed in a way so that each individual researcher's objectives, data, and analytical findings did not overlap and could be easily delineated within the broader study.

The primary goal of my research was to examine the problems and issues of risk communication with especial reference to the gaps in knowledge and perception of human health risk due to climate change-induced heat waves in Winnipeg. Research of this nature is required because disaster preparedness and responses demand a complex process whereby experts' or specialists' mental models need to integrate community residents' ideas and concerns. Policy and program implementation based solely on experts' ideas often receive limited acceptance by the community members, potential and actual victims, and other local inhabitants. Also, such gaps lead to serious challenges in dealing with risk perception and behaviour change at the individual and local community levels. In light of this context, key intentions of my study were to involve urban community members who are susceptible to heat wave and extreme hot weather hazards and to gain an understanding of their beliefs, views, and perceptions.

In order to ensure that community strengths, resiliency and sustainability are upheld, decision makers and responsible institutions need to have an awareness of the potential implications that their decisions may have bearing on prior constraints to implementation. No single expert has a prerogative on knowing what kind of development, or response to hazard, is 'right'. Local people may have knowledge unavailable to the 'expert': they will certainly have different frames of reference(Morgan et. al., 2002). An informed decision maker, aware of diverse views and perceptions on an issue, will be apt to make better and effective judgments in hazard and disaster management decision-making (Olczyk, 2005: 13), particularly by making better efforts in improving risk communication.

The specific objectives of my research were to:

i) examine the state of knowledge and perception of climate change-induced heat wave hazards among the expert community;

ii) analyze the state of knowledge, perception and awareness of climate change in general and its associated heat wave hazards among the community members at the local level;

iii) identify the gap that exists between 'scientific/technical' and 'local community' knowledge regarding heat waves; and

iv) explore the effective risk communication strategies that could help increase the community's coping capacity. Coping implies the way people act within existing resources and range of expectations of a situation to attain various ends, involving defense mechanism, active ways of solving problems and methods for handling stress (Blaikie et. al., 1994: 64).

1.7 Organization of the Thesis

The thesis is organized into five main chapters. Following this introductory **Chapter 1**, I present a review of the literature **(Chapter 2)** that helps to create the context of my study and outlines the main lessons that are important for the purpose of this study. It focuses specifically on preparing the conceptual base of the research and for the analysis of its outcomes. **Chapter 3** outlines the methodological approach to the research and the various field methods and tools used in the study.

Chapter 4 first offers the experts' ''knowledge model'' of climate change-induced heat wave hazards, along with its various component parts. It then presents community residents' mental model concerning heat wave risks and the associated preventive and mitigation measures. The analytical framework captures the community at large, the elderly population, and low income residents of urban Winnipeg. Finally, a comparison is made between the experts' ''knowledge model'' and community residents' mental scheme.

Chapter 5 is dedicated to providing explanations of the main findings of my study. Required references were drawn from the existing literature to make inferences as well as to offer clarifications. An attempt was made to examine explanatory factors of various features that appeared to be the major findings of my study.

CHAPTER 2: LITERATURE REVIEW

"Our world is so constructed that the physical and material benefits we most desire are sprinkled with the seed of disaster…People today have some control over the level of risk they face, but reduction of risk often entails reduction of benefit" (Paul Slovic, 2000: 32).

The literature on climate change and environmental hazards is extensive and global in scope. However, research on heat wave hazards is limited and aspects of human risk perception and adjustments to heat wave hazards have not been closely examined from the perspective of climate change. In this chapter, my intention is to critically review the nature of the risk of heat waves associated with recent climate change, with a focus on human morbidity and mortality; to assess the determining factors of heat wave risk in the context of contemporary urban settings; to examine the physiological and psychological effects of heat wave events; and to consider the risk communication problem and of Canadian urban centres to climate change-induced heat waves in general, and the susceptibility of the City of Winnipeg in particular, is then critically reviewed. Such an assessment of the pertinent literature has created a context for pursuing the empirical study of the knowledge and perception of climate change-induced heat wave hazards displayed in the urban Winnipeg community.

Heat waves can be catastrophic in terms of human morbidity and mortality, especially in urban settings. Heat waves are responsible for a large number of deaths in North America. For example, in the United States, the heat wave in 1980 resulted in approximately 10,000 excess deaths. The 1988 heat wave that affected five cities in the Toronto-Windsor corridor of southern Ontario, Canada (an area that often experiences hot and humid weather conditions in the summer) resulted in an estimated 5,000-10,000 deaths. In comparison, the number of deaths resulting from each of the major floods, hurricanes and blizzards in the United States between

1980 and 1999 varied significantly, with an average of 41 deaths per event (National Climatic Data Center 1999). Conservative estimates are that on average 240 heat-related deaths occur annually in the United States (Centres for Disease Control and Prevention, 1995). Clearly, the health risks that heat waves pose to the public warrant major concern. Heat waves are sporadic and recurrent where elevated temperatures during summer months are associated with excess morbidity and mortality.

2.1 Factors of Urban Heat Wave Risk

Major risk factors for heat-related morbidity and mortality include urban living, age, socio-economic conditions, and preventive behaviours.

2.1.1 The Urban Heat Wave Problem

Observational studies indicate that heat wave mortality rates are higher in the urban core than in surrounding areas (Landsberg, 1981). Buechley et al. (1972) attributed the elevation in heat-related deaths in urban areas to the high population density. Clarke suggests that urban areas retain heat throughout the nighttimes more efficiently than the outlying suburban and rural areas (Clarke, 1972). During a heat wave in St. Louis, USA, higher mortality rates were recorded predominantly in the business and urban core areas than in other, cooler sections of the city (Smoyer, 1998). According to the U.S. Bureau of the Census (1997), 29% of the occupied housing units in the United States in 1995 were located in central cities, whereas only 13% were in rural areas. Jones et al. (1982) examined mortality following a 1980 heat wave in Kansas City and the 1995 Chicago heat wave. They found that deaths from all causes increased by 57% and 64% in the major metropolitan areas respectively, but only by 10% in predominantly rural areas.

World Meteorological Organization (1983) insists that urban climate is modified by interactions between the built-up area (including waste heat and the emission of air pollutants) and regional climate and it refers primarily to local mesoclimate (spatial extension about 250 km). The city affects both physical and chemical processes in the atmospheric boundary layer (Marmor, 1975), including a) flow obstacles; b) the area of an irregular, elevated, aerodynamic surface roughness; c) heat islands; and d) sources of emissions, such as sulphate aerosols that affect cloud formation and albedo. Many cities have high levels of outdoor air pollution, especially carbon monoxide, nitrogen oxides, volatile organic compounds and particulate matter. Ground level ultraviolet radiation is often reduced during these severe pollution episodes. Also, the formation of photochemical smog due to such pollution may prevent solar radiation from reaching the ground and reduce the heat loss from long-wave radiation. Air temperature, cloud cover and precipitation are higher in cities than in the surrounding areas. These conditions along with the cumulative effects of heat waves can threaten usual urban livelihoods.

Urban living is an important risk factor for heat wave morbidity and mortality due to the 'urban heat island effect.' (Landsberg, 1981). Urban heat islands exhibit much less nocturnal cooling than that which occurs in rural areas. Hence, large cities do not cool off at night during heat waves as much as rural areas do, and this can be a critical difference in the amount of heat stress within the inner city. Studies of the urban heat island have indicated that it is insignificant during midday, but sizable during severe heat waves (Ackerman, 1985). The various urban heat islands display different characteristics and are controlled by different assemblages of energy exchange processes. For example, evidence of urban heat islands can be found in the air temperature at different heights. Another kind of urban heat island can be distinguished based on the temperatures of urban surfaces.

Depending on settlement structures, not only one urban heat island develops but an urban heat archipelago. Because of different surfaces and building structures, there are different microclimates (such as street canyons, courtyards and parks) within the urban climate. The factors that differentiate urban climates from the surrounding rural area are anthropogenic heat production, airflow and built form (Yannas, 2001). The wind velocity in cities is generally lower than the velocity in the open country. This results in a reduced rate of heat dissipation by convective cooling. Nevertheless, tall buildings and the channelling effect of urban canyons lead to complex airflow patterns and produce turbulence.

2.1.1.1 The size of the town

The larger the urban area and the more people living in the city, the more pronounced is the urban heat island (Chambers & Bazel, 2000). In North America, the magnitude of the urban heat island is related to population size. Under ideal conditions, the maximum urban-rural difference of 2.5 °C for towns of 1000 inhabitants increases to 12 °C for cities of 1 million (Oke, 1973). European cities have lower per capita energy use and hence lower anthropogenic heat production than cities in North America as well as smaller rural-urban differences. Other reasons for the smaller European heat islands may be the lower heat capacity of the urban environment and more evapotranspiration than in North American cities.

2.1.1.2 Topographic and climatic position of the city

Depending on the structure and direction of open rural areas near the city, nocturnal cold air penetration may be induced. This reduces the heat island intensity during the night. The urban heat island may also be reduced by regional wind systems such as sea breezes or wind systems in mountain valleys (Jonsson, 2000). For example, the city of Vancouver frequently experiences reduced urban heat island effects by the Pacific wind systems.

2.1.1.3 Distribution of the urban structures

The hottest zones in the city are those with the tallest buildings and the highest density of buildings, without green spaces and with intense generation of anthropogenic heat (Pinho and Manso Orgaz, 2000). A study of urbanization in Athens found that a rapid increase in population and in the number of motor vehicles, with a decreasing trend in precipitation, caused the maximum temperatures to increase from the 1940s until 1990 (Philandras et al., 1999). Bràzdil & Budiková (1999) analyzed the development of the Prague urban heat island from 1922 onwards. They found an increase in the heat island of 0.06 °C per year in winter and spring and of 0.01 °C per year in summer until 1960. Wilby (2003) attributes the more rapid nocturnal warming in spring, summer and autumn in central London compared with a rural site, between 1961 and 1990, to the presence of polluted air in the urban atmosphere, which absorbs and then re-emits outgoing terrestrial radiation at night, and to anthropogenic heat production in the form of increased air-conditioning in recent decades.

2.1.1.4 Urban Bioclimatic Aspects

Traditional studies of heat islands usually do not include bioclimatic aspects and are therefore of limited use to urban planners. Heat waves present special problems in urban areas because buildings retain heat if ventilation for cooling at night is inadequate. During heat waves, the inhabitants of urban areas may experience sustained thermal stress both in the day and at night, whereas inhabitants of rural environments often obtain some relief from thermal stress at night (Clarke, 1972).

Green spaces, especially those with broad-leafed trees, have an important effect on the bioclimate of an urban area by providing shade. Sun and shade lead to extreme differences in the thermal conditions in a very small space. These differences emphasize the great importance of a microscale view of the bioclimate in an urban area (Jendritzky & Sievers, 1989). Several studies have analyzed the impact of single urban structures on the thermal environment and on human comfort conditions. These studies provide good evidence that reducing building density, planting trees and laying out green spaces reduce heat stress in urban environments. Cities can be planned to reverse the heat island phenomenon (Givoni, 2003). Increasing the albedo of a city (such as painting roofs white) may cause negative radiation balance so that long-wave heat loss will exceed the solar heat gain. Since city size and higher density render the urban area more independent of the regional climate, any such lowering of urban temperature would be more noticeable in larger and denser urban areas.

2.1.2 Age

Epidemiologic studies of heat-related morbidity and mortality during and following heat waves suggest that the elderly and young children are particularly vulnerable (Jones et al., 1982). Regardless of race or gender, individuals 65 years of age or older are more susceptible to the adverse effects of heat than are younger adults (Whitman et al., 1997). The risk for heat-related death increases sharply with age, as those 85 years of age or older are most at risk for heat-related mortality (Centres for Disease Control and Prevention, 1995).

Like the elderly, young children are at high risk for heat-related illnesses (Centres for Disease Control and Prevention, 1995). Young children with certain predisposing illnesses such as diarrhoea, respiratory tract infections, and neurological defects are at especially increased risk for hyperthermia during extreme heat (Jones, 1982). Both the very old and young tend to have reduced heat-regulating mechanisms (Centres for Disease Control and Prevention, 1995). In addition, each of these populations experiences restricted mobility, resulting in diminished control of their environments, including access to fluids (Centres for Disease Control and Prevention, 1995).

Over 90 percent of the victims of the 2003 European heat wave were aged 65 and above. The victims of the 1995 heat wave in Chicago also demonstrated that the elderly were the most vulnerable group. The vulnerability of the elderly and their high mortality rates due to heat waves are also demonstrated by a detailed epidemiological study of a 27-year period in Japan (Nakai et al., 1999). This epidemiological survey analyzed the distribution of deaths among different age groups and their Relationship to the incidence of hot days during the summer. High mortality was markedly found in the over 70-year-old age group.

2.1.3 Socioeconomic Factors

Other risk factors include poverty, social isolation, inadequate English language skills, residence in high-crime areas, use of certain medications associated with aging, and lack of access to media (such as television and newspapers), and thus reduced awareness both of the potential dangers from heat exposure and of the ways to reduce risk. Populations uniquely vulnerable to the impacts of excessive heat exposure include the poor (Applegate et al, 1981) and the socially isolated (Applegate et al, 1981). Populations of lower socioeconomic status may not have access to air-conditioned places because of the cost of an air-conditioning unit or higher utility bills (Applegate et al, 1981). Although opening windows and using fans for ventilation may help reduce stagnant and hot indoor air conditions, the effectiveness of electric fans in reducing the risk of heat-related mortality has not been substantiated (Semenza et al., 1996). Individuals confined to bed or unable to care for themselves are at increased risk (Semenza et al., 1996), whereas those living with others are at decreased risk and are more likely to increase their fluid intake during heat waves. Non–English-speaking or -reading populations, who exemplify the group of individuals lacking access to heat-relieving conditions, are quite vulnerable.

Furthermore, because of neighbourhood crime or violence, urban residents, including the elderly, report a reluctance to leave windows open (Applegate et al, 1981). Patients taking medications or drugs that modify thermoregulatory capacity are also at increased risk (Kilbourne et al., 1981). The urban elderly experience the highest rates of heat-related morbidity and mortality because of both their declining thermoregulatory abilities and the extreme heat conditions in urban areas (Applegate et al, 1981).

Data on the 1995 heat wave in Chicago indicate that mortality among African Americans was 50% higher than among whites (Whitman et al., 1997). The disparity likely reflects residence in inner-city neighbourhoods, poverty, and poorer housing and medical conditions (Applegate et al, 1981; Kilbourne et al., 1982). Similar findings emerged following heat waves in Texas (Greenberg et al., 1983), Memphis, Tennessee (Applegate et al, 1981), St. Louis, and Kansas City (Jones et al., 1982). Another example can be cited from the 2003 European heat wave. Of the four hundred and fifty-two persons in Paris who died at home from the heat wave, 92% lived alone and 41% resided in a one-room apartment, with a surface area of less than $10m^2$ in 12% of the cases. Just over half the victims lived on the two highest floors of Parisian buildings. Thus, socio-economic factors are the major determinants of lethal risk in the case of any heat wave in post-industrial urban contexts.

2.1.4 Preventive Behaviour

Humans exhibit a physiological response to thermal conditions, but clothing, buildings and many other social, economic, contextual and behavioural factors contribute to heat balance. In practice, people do not react passively to the conditions that buildings provide but interact actively with the buildings they occupy. Two typical types of interaction are: i) adapting themselves (by such means as clothing, activity, posture, shivering or sweating) to the conditions they experience; and ii) adjusting the conditions provided (such as, by means of windows, blinds, heating or air-conditioning) to suit the occupants. Provided that the changes to that environment are sufficiently slow and the cultural and social constraints are not too restrictive, people can also make themselves comfortable in a wide variety of environments. In more extreme environments, the need to keep warm (or cool) may require the use of large amounts of energy.

Buildings that are poorly designed can add to this burden through poor insulation, poor planning, and other aspects of building materials and construction. They can also cause occupants to use electric lighting and other equipment more than necessary. Buildings account for about 50% of the energy used in industrialized countries, and much of this is used in building services, especially in air-conditioned buildings, where much of the energy is used as electricity. With good design, buildings can provide conditions that occupants find acceptable or even positively enjoyable.

2.2 Risk Communication Issues and Problems: An Exploration into the "knowledge model"

In order to introduce risk communication issues and problems, it is important to sequentially review the concept of risk, perception of risk, and their differential treatment by experts and community residents. In the following section, these aspects are reviewed in the context of "knowledge model".

2.2.1 Defining Risk

The risk concept itself contains elements of subjectivity that provide insight into the complexities of public perceptions. There are clearly multiple conceptions of risk. In fact, a paragraph written by an expert may use the word several times, each time with a different meaning not acknowledged by the writer. The most common uses are:

- Risk as a hazard. Example: "Which risks should we rank?"
- Risk as probability. Example: "What is the risk of getting AIDS from an infected needle?"
- Risk as consequence. Example: "What is the risk of letting your parking meter expire?"
- Risk as potential adversity or threat. Example: "How great is the risk of riding a motorcycle?"

The fact that the word "risk" has so many different meanings often causes problems in communication. Regardless of the definition, however, the probabilities and consequences of adverse events, the "risks", are typically assumed to be objectively quantified by risk assessment. Many analysts reject this notion, arguing instead that such objective characterization of the distribution of possible outcomes is incomplete at best and misleading at worst. These approaches focus instead on the effects that risky outcome distributions have on the people who experience them. In this tradition, risk is seen as inherently subjective (Slovic, 1992).

During the past quarter century, researchers have been studying risk intensively and from many perspectives. Risk analysis involves the identification, quantification, and characterization of threats to human health and the environment whereas risk management centers on processes of communication, mitigation, and decision making. In this connection, extreme events are pertinent, which by definition means they cause much harm to people, property, and the natural world. Sometimes they result from the vagaries of nature, as in the cases of floods, earthquakes, or storms, and thus are truly the outcomes of play against nature.

2.2.2 Concept of Risk Perception

It is asserted that once the public is aware of the risks, they will take more effective means to address the problem, including demanding policy change (Moser, 2007). For some time now, discrepancies between expert assessments and community residents' or first responders' perceptions of risk, sometimes called the "objective perceived risk dichotomy", have concerned risk managers and theorists (Slovic et al., 1990). Pidgeon et al. (1992) defines risk perceptions as people's beliefs, attitudes, judgments and feelings, as well as the broader social or cultural values and dispositions that people adopt, towards hazards and their benefits. By this definition, risk perceptions appear to be multidimensional and much more context-sensitive than formal measures of risk, which concern a single dimension (e.g., expected loss).

Weber (2001) reviews three approaches by which risk perception has been studied: the psychometric paradigm, the axiomatic measurement paradigm, the socio-cultural paradigm, and. The psychometric paradigm is most germane to the purposes of analyzing people's extreme aversion to some hazards, their indifference to others, and the discrepancies between these reactions and experts' opinions (Slovic, Fischhoff, & Lichtenstein, 1984). Within the psychometric paradigm, people make quantitative judgments about the current and desired riskiness of diverse hazards and the desired level of regulation of each. These judgments are then related to judgments about other properties, such as i) the status of the hazard in relation to characteristics that have been hypothesized to account for risk perceptions and attitudes (for example, voluntarism, dread, knowledge, controllability), ii) the benefits that each hazard provides to society, iii) the number of deaths caused by the hazard in an average year, iv) the number of deaths caused by the hazard in a disastrous year, and v) the seriousness of each death from a particular hazard relative to a death due to other causes.

2.2.3 Experts' and Community Residents' Risk Perception

When experts judge risk, their responses correlate highly with technical estimates of annual fatalities. Community residents can assess annual fatalities if they are asked to (and produce estimates somewhat like the technical estimates). However, their judgments of risk are related more to other hazard characteristics (for example, the potential threat of catastrophes to future generations) and, as a result, tend to differ from their own (and experts') estimates of annual fatalities. Research has shown that community people's risk perceptions and attitudes are closely related to the current level of risk reduction and to the strict regulation employed to achieve the desired reduction in risk. However, experts often fail to take into account the knowledge domain of a community audience. Their highly interconnected, extensive domain of specific knowledge (Schmidt & Boshuizen, 1992) makes it difficult for specialists to anticipate the wholly different perspective of a community resident (Hinds, 1999). One way in which differences between expert and opinions is explained is in terms of "rival rationalities" of the two groups, suggesting that the community resident looks at risk more broadly than the expert, whose expertise is narrow and therefore likely to "miss something" of importance to the broader community (Margolis, 1997). Margolis argues that in fact what is accounting for the stubborn conflicts is less what experts see that other people miss, but what ordinary people feel about risk that experts neglect (Margolis, 1997). Experts' general inclination is to neglect the gap between their own knowledge and the knowledge of community residents (Hinds, 1999), and their methods follow a one-way communication path, which is also known as the *factual information model* or *empty bucket model.*

In contrast, experts' perceptions of risk are not closely related to any of the various risk characteristics or factors derived from these characteristics. Instead, experts appear to see riskiness as synonymous with expected annual mortality (Slovic et al., 1979). Many conflicts between experts and community people regarding the acceptability of particular risks are the result of different definitions of the concept of risk and thus their often different assessments of the magnitude of the riskiness of a given action or technology, rather than differences in opinion about acceptable levels of risk. The practical value of sensitivity to community residents' perceptions is seen in the aura of enlightenment surrounding many excellent recent risk communication guides. (Committee on Risk Perception and Communication, 1989).

2.2.4 Understanding Risk Communication

Risk communication evolved from earlier work in risk perception. It is apparent that simplistic models of risk perception have obscured our view of the social interactions and contexts which define authentic risk communication. Thus, the risk communication paradigm rests on unexamined and unarticulated assumptions about who is communicating what, to whom, and in what context (Committee on Risk Perception and Communication, 1989).

Understanding how people perceive risks and how to communicate risk information effectively are key to improving risk management. Risk communications and risk management decisions are inextricably linked and, because of this, effective risk communication is an essential element in effective risk management. Critical elements in effective risk management and communication are the degree of engagement of community members, trust and credibility of the message source, the quality and clarity of message design, the effectiveness and efficiency of the delivery channel, and the involvement and acceptance of the target audience.

Risk communication problems arise primarily from the information sources (e.g., limitations of risk communicators and risk experts), while many scholars in this field believe that risk communication problems arise primarily from the message design (e.g., limitations of scientific risk assessments), the delivery channel (e.g., limitations in the media or means by which risk information is transmitted), or the target audience (e.g., characteristics of the intended recipients of risk communication). Risk communication can only be effectively implemented through identifying the extent and nature of the public's risk perceptions concerning the nature of the hazard (Morgan et al., 2002).

Apart from these problems, risk communication programs sometimes lack clear objectives (i.e., informing people about risks, motivating individual actions, stimulating emergency response, or contributing to the dispute resolution process) and inadequate planning and evaluation. The principles for effective risk communication are:

1. Planning and evaluation activities should be part of a continuous process aimed at assessing objectives and improving performance.
2. Rigorous evaluation is needed to measure success, identify program witnesses, and improve current and future efforts, particularly concerning programs that deals with little

known or less understood subject matters by the public (for example, climate change and its associated heat wave).

Public involvement and direct exchanges of information are another important yet underutilized source of knowledge for identifying risk communication problems, understanding issues and setting objectives.

2.2.5 Risk Communication through the "Knowledge Model"

In the Canadian Prairies, where it is predicted that extreme environmental events will increase in terms of frequency and intensity (Haque and Burton, 2005), there is an utmost need to communicate effectively the risk posed by climate change-induced extreme environmental events so that pre-disaster efforts can be made to enhance the coping capacity of the community. At a community level specifically, the public's capacity to cope with risk and disasters can be optimized through effective preparedness, prevention and mitigation strategies. These strategies may be inhibited by the very nature of community members' level of risk perception. Improvement in the knowledge and perception of environmental risk through effective risk communication is therefore imperative.

To send effective and efficient advice to community residents and thereby achieve effective risk communication, experts need to adapt their explanations to the community resident's knowledge level (Nűckles, Wittwer, & Renkl, 2003). From both educational and psychological perspectives (e.g., Clark 1992; 1996), adaptation to the communication partner's background knowledge is regarded as fundamental for achieving comprehension and learning. It is suspected that the failure to effectively inform 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 given communication has been effective (Morgan et al, 2002). The notion of two-way risk communication has led to information dissemination processes characterized by mutual understanding and equal and fair participation rather than the exertion of power. Under current practice, the dominance of experts in the two way risk communication system is still prevailing. In order to fulfill these challenges, Morgan et al. (2002) developed a five-step method for creating and testing risk messages in a way that is faithful to the sciences of risk and communication. This method is referred to as the mental model approach and provides a necessary condition for establishing a partnership with the public and laying the foundations for mutual trust.

In the late 1980s and early 1990s scientists began to apply mental models in the climate change communication process since by that time it was recognized that past global warming messages related to climate change had triggered misunderstandings and inappropriate responses. Then various studies in the field of climate change risk communication showed that people's perceptions and beliefs demonstrate that they hold a variety of mental models about the issue, some of which mislead them regarding the causes and solutions of climate change (Bostrom et al., 1994). For example, many people attribute climate change to human activity while others continue to attribute climate change to a natural weather cycle. In general, the usefulness of mental models in climate change research comes from their very strength of giving logical implications of explicit assumptions (Bostrom et al., 1994). As a result, this approach has gradually been widely accepted in the studies of environmental hazards, health impacts and research, perceptions of the temporal unfolding of global warming, conflation between weather and climate, and the role that risk communication plays in extreme weather consequences.

In our research we employed the ‘‘knowledge model’’, based on the mental model approach developed by Morgan et al.. Attempts were made to: 1) identify socio-demographic vulnerability and related psychosocial stresses in the Prairies region; 2) examine the extent and nature of the public’s perceptions of climate change-induced extreme environmental events; and 3) identify the gaps and overlaps in knowledge between experts and community people, in order to facilitate effective risk communication.

The ‘‘knowledge model’’ approach is an option to minimize knowledge gaps regarding climate change-induced extreme events. The ‘‘knowledge model’’ approach focuses on communicating issues that people do not yet know but need to know (Morgan et al., 2002). Unlike the Delphi method, where reliable judgments are made or results are forecast by experts by allowing the sharing of information and reasoning among participants, the ‘‘knowledge model’’ focuses on understanding people’s mental models (e.g., their knowledge, beliefs, perceptions) in order to craft effective risk communication messages that can help them understand complex or unfamiliar phenomena. In comparison with stratified socio-economic survey methods (where participants are targeted for structured interviews rather than obtaining open-ended ideas from each participant), in the ‘‘knowledge model’’ approach, evidence regarding individual differences in both attitudes and knowledge about risks suggests that each message should be tailored to the knowledge set of the targeted audience. Bier (2001) further suggests that risk communication messages using the knowledge model are more effective at conveying both general knowledge and information about risk reduction strategies.

Risk communication in heat wave hazards’ refers to the verbal or other links intended to supply community people with the information they need to make informed, independent judgments about risks to health during a heat wave (Kalkstein and Sheridan, 2007). The knowledge model approach in this regard assists the procurement of information about the extent and nature of the public's perception of heat wave hazards and their associated risks, and it addresses the existing problems in risk communication as well as the public's mitigation and response behaviour. Nonetheless, because the initial versions of the mental models were developed from a psychometric perspective, its scope was constrained by psychological and cognitive variables. In this study, we attempted to broaden the scope of mental model by extending pertinent variables in social, economic, demographic and experiential areas. One of the key socio-economic dimensions of hazards impact is human vulnerability that encapsulates both physical exposure and social vulnerability.

2.3 Heat Wave Vulnerability of Large Cities in Canada with special reference to Winnipeg

Spanning more than 40° of latitude and almost 100° of longitude, Canada occupies a vast geographical area. This characteristic, along with the effects of local and regional topography means that climatologically extreme weather conditions are different for various urban centres and cities across the nation (Bellisario, 2001). In general, Canadian cities are vulnerable to some specific climate and weather-related hazards, including tornadoes, strong wind events, lightning, hailstorms, thunderstorms, cyclones, blizzards, freezing rain, ice storms (Royal Society of Canada, 1994), droughts and heat waves (Royal Society of Canada, 1994). Even though extreme heat events have caused increased deaths in some particular regions in Canada, namely southern Ontario and Quebec (Kalkstein and Smoyer, 1993; Smoyer et al., 2000), this hazard has remained relatively unfamiliar and poorly recognized in the literature. Smoyer-Tomic et al. (2003) cited that the risk to extreme heat events is significant because the death toll accompanying such events is substantially higher in both absolute and relative terms, although heat waves rarely cause the destruction that attracts attention to extreme events such as tornadoes and hurricanes. In the North American context, for example, the U.S National Climatic Data Centre (2001) recorded that the heat wave of 1988 caused an estimated 5,000-10,000 excess deaths in the United States; similarly, the 1980 heat wave resulted in 10,000 excess deaths. Chapman (1995) noticed that despite the large number of deaths in Canada that are suspected to be heat-related, they are not labelled with such a specification, mainly because of inconsistencies in the cause-of-death reporting related to the examination of the effects of heat stress on human health.

Bellisario (2001) argues that, first, because very little attention has been paid so far to studying the past, present, and future trends and effects of heat waves in Canada and, second, due to the specific type of vulnerability and potential impact of such events on the health and welfare of the population, there is a need to place a greater emphasis on the large urban settlements. Large urban centres, with their built-up and modified landscapes, high-density populations, and particular topographic and climatic positions, can be highly vulnerable to the features of climate change, specifically to heat waves. As explained earlier, urban heat islands, their size, bioclimatic characteristics and urban sprawl may augment the effects of heat waves on human health. Although Canadian studies on heat waves in general and their effects on large urban centres have been limited to a few recent works, it is important to review some significant research outcomes here.

The most comprehensive study on heat wave hazards in Canada was carried out by Smoyer-Tomic et al. (2003). They presented an overview of the problems and issues involved in defining heat waves and harmful hot weather events, and followed this with a spatial and historical overview of heat waves across Canada. In terms of experiencing the highest temperatures and most frequent occurrences of heat waves, the Prairies, southern Ontario, and regions along the St. Lawrence River Valley in both Ontario and Quebec are particularly susceptible. Identification of which Canadian urban centres are vulnerable to heat waves has not yet been completed, although a few studies have focused on major cities and selected urban centres where longitudinal meteorological data are available (Bellisario, 2001; Smoyer et al., 2000).

As elaborated by Smoyer-Tomic et al. (2003), it is important to distinguish between an analysis of temperature and heat wave characteristics and heat wave impacts. Heat waves have been defined by Environment Canada (1996) as "a period of more than three consecutive days of maximum temperature at or above 32°Celsius." Because adverse heat effects on humans have been noted at less extreme temperatures and shorter durations (Kalkstein and Davis, 1989; Smoyer et al., 2000), a different measurement has been suggested (i.e., Humidex by Masterton and Richardson, 1979). Heat wave impacts are influenced by several characteristics, which include their frequency (both in a given summer and a number of events during a longer time period), their duration and their intensity. Daily minimum temperatures also play a role in extreme heat events.

Heat stress is related to the aspects of potential physical harm to living things from exposure to heat, and therefore it requires a definition that would differ from heat waves in the meteorological sense (Smoyer-Tomic et al., 2003). Univariate, bivariate and multi-variate (e.g., apparent temperature, wet-bulb globe temperature) indexes are used to define heat stress. Univariate heat stress measures subjective cut-off parameters above which adverse health effects are expected to occur (for example, 30°C, 32°C, 35°C, etc.). Humidex is a bivariate index that integrates the health impact of temperature and humidity, and in which the scale ranges from

30°C to 54°C (Weir, 2002). In determining heat stress in humans, an index that encapsulates relative humidity is critical as the aspects of adaptation to climatic and weather conditions need to be considered.

Examination of the historical heat wave events is critical to understand past trends and their implications for the future. A few works in the literature examine the current situation of heat wave vulnerability across Canada. Such a comprehensive study was completed by Bellisario et al. (2001) for Emergency Preparedness Canada. Since my study deals with heat wave hazards, only aspects of summer temperature are reviewed here.

Both absolute and relative approaches were used in the study; absolute criteria were used to uniformly compare heat events across geographical areas and time periods, and the relative approach was used by applying temperature percentile to facilitate the comparison of anomalous, extreme summer weather conditions for different regions. For example, a temperature of 30°C in Vancouver or Charlottetown would be highly abnormal and could exact a great toll on human health (and possibly infrastructure as well), but the same conditions in Winnipeg (where summer temperatures above 30°C are more common) would be expected to have lesser health impacts. In this report, records from 16 stations, representing major cities in all ten provinces and three territories, and covering 51-104 years of data, were analyzed for the period 1 June–31 August. The relative approach involved plotting the temperature corresponding to the 1st, 5th, 10th, 90th, 95th, and 99th percentiles for each station during the study period (Table 2.1). The absolute approach involved identification of the number of occurrences of two or more consecutive days with maximum temperatures ≥30 °C, including the mean number of events per year (Table 2.2).

The results demonstrate that heat stress events have affected most areas of Canada to varying degrees. More events occur in Ontario and Quebec than elsewhere in Canada. Using the absolute approach to identify the frequency of heat waves lasting 2, 3, 4, and 5 or more days for the same cities, it is evident that the Prairies, southern Ontario, and the St. Lawrence River Valley region of Quebec experience the highest incidence of heat waves (Table 2.2). In contrast, the North, Pacific Coast and Maritime regions experience minimal heat wave events, with no 2-day consecutive episodes of ≥ 30 ∘C in Iqaluit and ≤5 occurrences in Vancouver, Yellowknife, St. John's, and Halifax for the entire period covered by the records. With a record of averaging 4 episodes per year over the 62-year period, Toronto shows the highest count of extreme heat events in Canada.

Table 2.1: Threshold values (°C) used for counting the number of days with extreme temperatures during the summer.

City	Summer maximum and minimum temperature percentiles			
	MAX 5th	MAX 95th	MIN 5th	MIN 95th
Vancouver	16.1	25.9	8.7	15.3
Whitehorse	12.1	26.0	0.4	10.8
Yellowknife	11.3	25.8	3.5	15.1
Iqaluit	3.0	16.8	-2.3	6.2
Edmonton	14.2	28.5	3.6	13.7
Calgary	13.8	29.5	3.3	13.1
Saskatoon	16.0	31.9	4.7	16.3
Winnipeg	**16.9**	**31.7**	**4.4**	**17.7**
Ottawa	17.3	30.9	7.2	19.7
Toronto	18.2	31.1	10.2	21.3
Québec	15.9	29.6	6.0	17.8
Montréal	18.0	30.5	7.5	19.7
Saint John	14.2	27.0	5.8	15.1
Halifax	13.6	26.8	6.9	16.8
Charlottetown	14.1	27.6	5.8	18.3
St. John's	8.6	25.7	1.4	14.9

Data obtained from Bellisario et al. (2001)

(Thresholds were based on average [1961 – 1990] summer maximum and minimum temperature percentiles [5^{th} & 95^{th}] for each city)

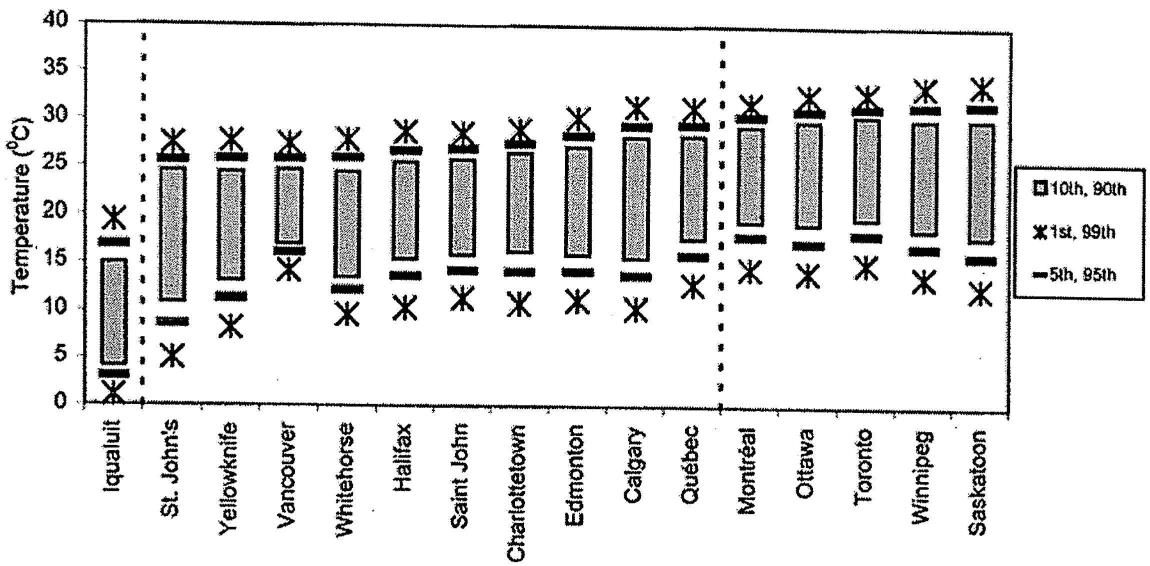
Table 2.2 Number of heat waves that occurred in Canadian cities and their duration in days.

City	Province	Period of Record	Heat Wave Counts 2 Days	Heat Wave Counts 3 Days	Heat Wave Counts 4 Days	Heat Wave Counts 5+ Days	#Events/ Years of Record
Vancouver	BC	1937-1999	2	0	0	0	0.03
Whitehorse	YT	1943-1998	6	0	0	1	0.13
Yellowknife	NT	1943-1998	3	2	0	0	0.09
Iqualuit	NU	1946-1996	0	0	0	0	0.00
Edmonton	AB	1916-1998	48	10	0	2	0.72
Calgary	AB	1895-1998	84	21	12	10	1.22
Saskatoon	SK	1895-1998	165	70	30	29	2.83
Winnipeg	MB	1895-1998	170	92	40	34	3.23
Ottawa	ON	1939-1998	103	48	27	29	3.45
Toronto	ON	1938-1998	105	78	33	33	4.02
Quebec	QC	1895-1994	84	36	18	5	1.43
Montreal	QC	1942-1994	61	29	20	17	2.40
Saint John	NB	1895-1998	6	2	0	0	0.62
Halifax	NS	1945-1998	4	1	0	0	0.09
Charlottetown	PE	1895-1992	17	3	0	3	0.23
St. John's	NF	1895-1998	4	0	0	0	0.04

Data obtained from Bellisario et al. (2001).

An analysis of mean temperature values as percentiles reveals that the Prairies experience the highest maximum temperature range in Canada. Similar to the absolute approach, the relative approach indicates that even the 99th percentile of summer temperatures in the Pacific Coast, the North, and the Maritimes is below 30°C. Notably, Winnipeg and Saskatoon recorded the highest maximum temperatures (Figure 2.1) of the cities analyzed, but experience ≥ 30°C temperatures less frequently and of shorter duration relative to Toronto or Ottawa (Table 2.2).

Figure 2.1. Summer maximum temperature percentiles for various Canadian cities, 1961–1990. Cities to the right of each dashed line have summer maximum temperatures in the 95th percentile that are greater than 25 °C and 30 °C, respectively. All data were recorded at airports within or close to each city. Summer is defined here as 1 June–31 August. (Source: Bellisario et al., 2001)



The aspect of extreme events caused by climate change is of particular interest for my study. The work reviewed above did not consider the effects of incremental change due to global warming or major climatic shifts. Colombo et al. (1999) specifically examined the impact of incremental climatic warming on summer extreme temperature event frequency for nine sites across Canada. A total of nine monitoring stations across Canada were chosen, including four major cities (Montreal, Ottawa, Toronto and Victoria). The selected cities were chosen considering their large population size, significance from an energy consumption perspective, and the potential influence of heat islands on temperature records. The study used statistical parameters to determine how a shift in these parameters (e.g., the mean and the variance) impact upon daily maximum temperatures over a threshold value. It was found that for a nominal change in the mean or variance, "there are increases in the frequency of both single days and runs of 2-5 consecutive days with daily maximum temperatures over a threshold value." For a 3°C increase in the mean daily maximum temperature in Toronto, the model resulted in an increase in the frequency of a five consecutive days run over 30°C by a factor of 8 to 7.1%. More sensitivity to an increase in the mean summer temperature was observed in sites with less variability relative to sites with higher variability. The study further recorded a positive Relationship (R^2=0.718) between daily peak power demand and the cube of the current and previous two days' daily maximum temperature; overall, the results indicated that the average peak power demand does not change drastically, but the number of high energy consumption days may rise considerably due to higher variability, causing stress on the power utility infrastructure to meet the enhanced demand.

Another major study of the potential impact of global warming on various aspects of human health of the Canadian population was carried out by Kalkstein and Smoyer (1993), from an international perspective. Estimates regarding changes in heat-related mortality were made for Canada, the United States, China and Egypt. Ten Canadian cities were assessed between the years 1958 and 1988, and daily mortality sums for the summer and winter were grouped by age and cause of death. Two methods were applied to ascertain historical weather/mortality relationships. The first involved identification of "threshold temperature", which represented the temperature beyond which mortality significantly increases. The second method was dependent on the identification of specific 'air masses' which appear to be associated with particularly high mortality totals. The results of the threshold temperature procedure demonstrated that only Toronto and Montreal of the ten selected cities are subject to strong relationships between summer weather and mortality in Canada. For both cities, the consecutive day variable was found to be directly related to mortality above the threshold, demonstrating that a long string of stressful days creates an adverse physiological response. The time variable was inversely related for both cities, indicating that heat waves early in the season are more damaging than those late in the season. The study concluded that the Canadian population might be able to acclimatize to increased heat. Kalkstein and Smoyer's (1993) examination of the impact of climate on Canadian mortality in terms of present relationships and future scenarios provided some clear perspectives. The study exhibited that a climate change stemming from increasing greenhouse gas concentration would raise the risk of heat-related mortality for the inhabitants of Toronto, Montreal, and the surrounding areas. Such enhanced risks are related to increased exposure to heat stress through more frequent and severe heat waves in the St. Lawrence River Valley regions.

The elderly population (older than 65 years) is specifically vulnerable, particularly in large cities. In the context of Canadian cities that are susceptible to more frequent and severe heat waves, Smoyer et al. (2000) analyzed heat stress-related mortality patterns in five cities (i.e. Windsor, London, Kitchener-Waterloo-Cambridge, Hamilton and Toronto) in Canada for the period between 1980 and 1996. The Toronto-Windsor corridor of southern Ontario experiences hot and humid weather conditions during the summer, exposing the population to heat stress that presents greater risk of mortality. It was presumed that in the event of a climate change, the heat stress condition might become more severe and frequent in southern Ontario. It was revealed that heat stress mortality differs among places with relatively similar weather conditions, indicating the significance of non-climatic factors in mediating the impact of summer weather on human health. As the urban areas continue to experience high temperatures more often than the less built-up areas, the continual urban development in the Toronto-Windsor corridor is likely to increase the vulnerability of the population to heat stress. The impact of demographic composition and socio-economic conditions on vulnerability to heat stress was less clear than the impact of urbanization. Demographic and socio-economic conditions were not found to be consistently associated with the strength of the heat stress-mortality relationship. For example, among the cities with very strong relationships, London had a low percentage of seniors, a low incidence of low income, and a moderate cost of living, whereas metropolitan Toronto had a moderate percentage of seniors along with a high cost of living and a high incidence of low income, and Hamilton ranked high among all three variables. Kitchener-Waterloo-Cambridge and Windsor had the weakest heat stress and mortality relationships while Windsor had the lowest cost of living. It therefore appears that heat stress mortality is not a function of the age structure of the population, but rather that socio-economic factors are significant. The cost of living had a stronger relationship with high stress mortality than the incidence of low income in the Toronto-Windsor corridor. As a lower cost of living allows a larger disposable income, elderly people residing in cities with a lower cost of living would have more options for avoiding heat stress, such as air-conditioning.

2.4 Heat Wave Vulnerability of the City of Winnipeg

As stated above, Winnipeg is one of the most vulnerable cities in Canada to heat wave hazards. Close scrutiny of meteorological data for the period 1943-1998 reveals that Winnipeg experienced the highest average number of heat waves per year (3.35; Bellisario, 2001). In order to comprehend the nature of heat wave hazards, Bellisario (2001) examined heat wave counts by the duration of such extreme events in terms of number of days for the above-stated period. With regard to heat waves of 2 and 3 consecutive days, Winnipeg ranked number one relative to fifteen other cities in Canada. For heat waves of longer duration, such as 4 and 5 consecutive days, Winnipeg did not rank at the top, but it was still one of the highest ranked cities in experiencing heat waves during 1943-1998. The Environment Canada study revealed that, like many other large cities, Winnipeg is now experiencing an increased number of days of extreme heat in the summer.

Table 2.3 Heat Wave Occurrence in Canada (1943-1998)

City	**Province**	**Heat Wave Counts (1943-1998)**				#Events/ Years of Record
		2 Days	3 Days	4 Days	5 Days	
Vancouver	BC	2	0	0	0	0.04
Whitehorse	YT	6	0	0	1	0.13
Yellowknife	NT	3	2	0	0	0.09
Iqualuit	NU	0	0	0	0	0.00
Edmonton	AB	32	11	2	1	0.84
Calgary	AB	40	10	4	2	1.02
Saskatoon	SK	84	40	20	14	2.87
Winnipeg	MB	91	49	25	19	3.35
Ottawa	ON	80	42	26	28	3.20
Toronto	ON	79	45	16	26	3.02
Montreal	QC	63	24	14	22	2.51
Saint John	NB	5	2	0	0	0.13
Halifax	NS	4	1	0	0	0.09
Charlottetown	PE	10	1	0	1	0.22
St. John's	NF	2	0	0	0	0.04

Data obtained from Bellisario et al. (2001)

Table 2.3 illustrates the number of days in Winnipeg with a maximum temperature of more than 30° Celsius during the period 1875-2005. As depicted in the trend line, there has been a steady increase in the number of days of extreme heat, particularly during June-August. During the last 50 years, at three different times Winnipeg has experienced prolonged hot weather in which the maximum temperature was more than 30° Celsius for 25 days or more. In contrast, during 1875-1960, such events occurred only once. The persistence of hot weather (a daily maximum temperature more than 30° Celsius) for 15 to 20 days was also observed in Winnipeg. During 1960-2005, such conditions were recorded at least nine times.

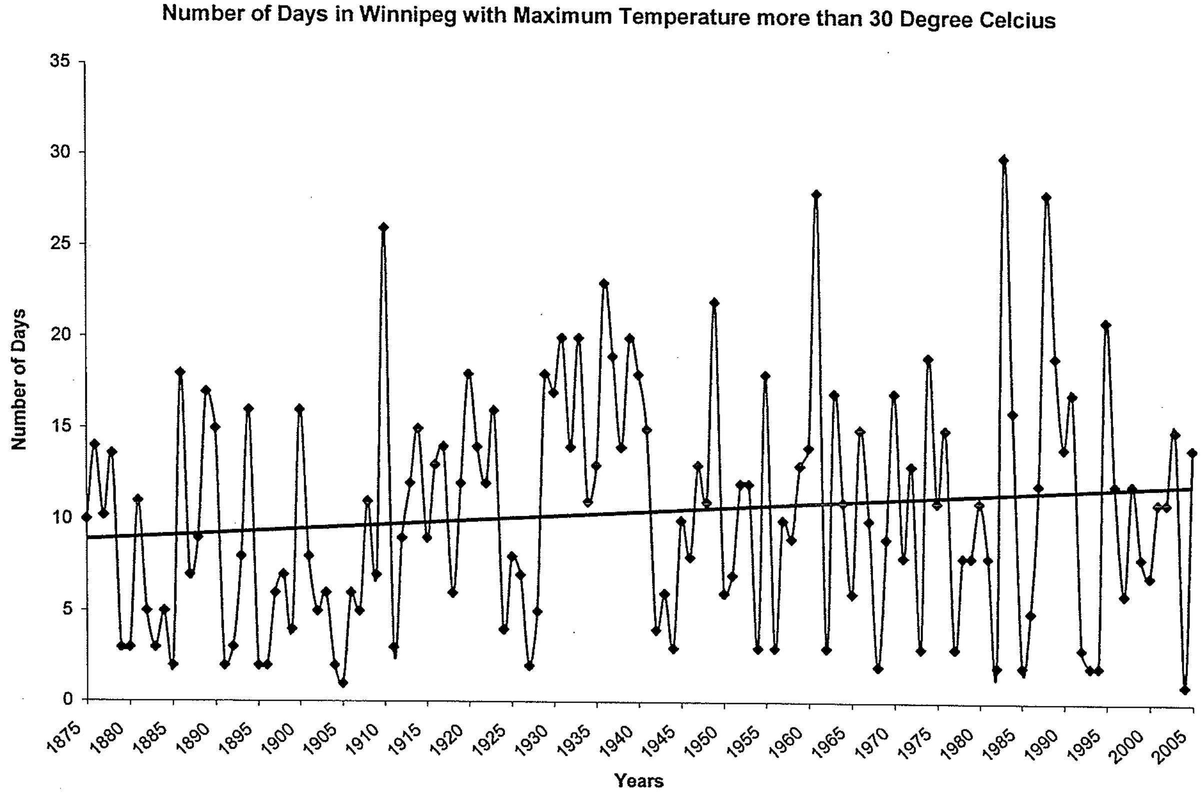
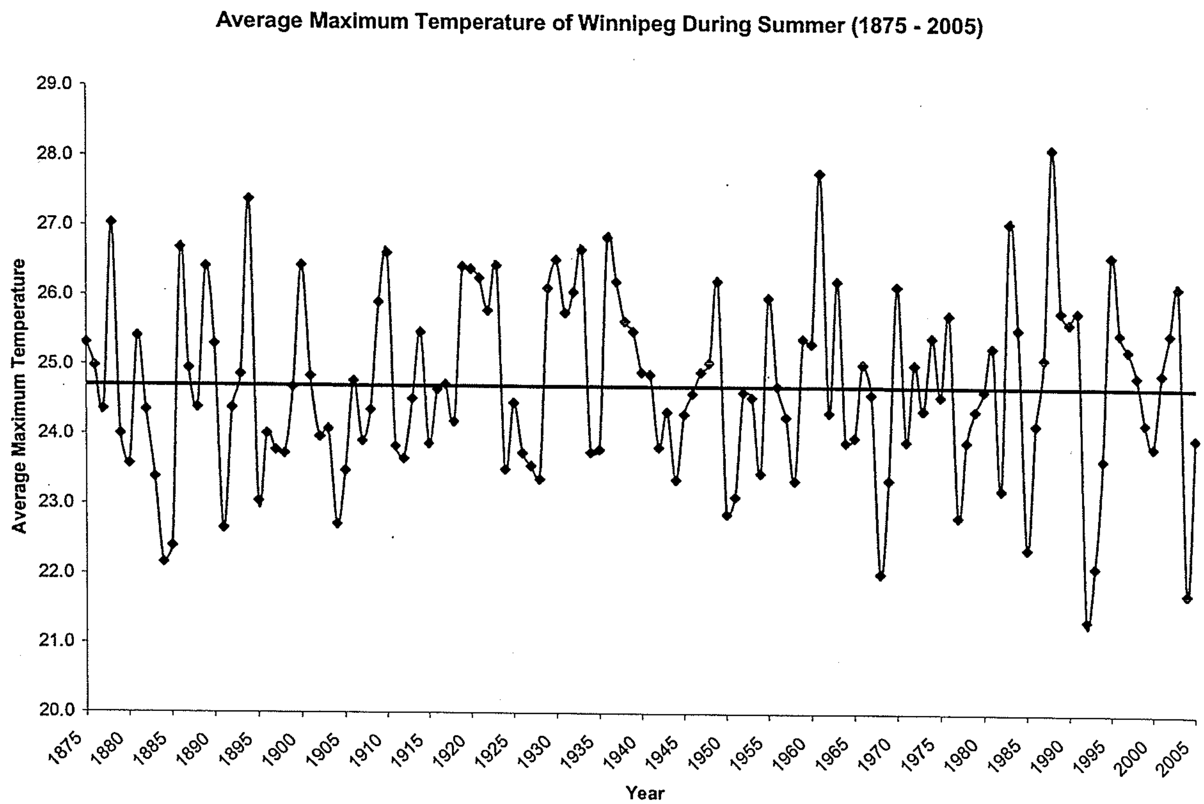


Figure 2.2 Number of Hot Days (Daily Maximum Temperature >= 30° C) in Winnipeg (1875-2005)

An examination of the data for 1875-2005 reveals that the average maximum temperature during summer months in Winnipeg is about 24.71° Celsius, and the corresponding standard deviation is 1.29° Celsius. A comparison was made between the present climatic regime (1976-2005) and the historical past (1875-1975). It appears that the variation in the average maximum temperature during summer months has increased in recent decades (standard deviation=1.57 for the period 1976-2005 and standard deviation=1.20 for the period 1875-1975). Because of such enhanced variation in the distribution of average maximum temperature, the mean of the average maximum temperature for recent decades has lowered slightly.

Fig 2.3 Average Maximum Temperature in Winnipeg (1875-2005)



As explained earlier, an analysis of heat waves based on only thermal properties has serious limitations as humidity plays a paramount role in impacting human health. For this reason a comparison between series requires a much broader treatment of heat wave impacts. In a nutshell, although Winnipeg is one of the most vulnerable cities in terms of average maximum temperature, eastern cities such as Toronto and Ottawa are more prone to adverse heat wave impacts due to their humid conditions during the summer months.

Human vulnerability to environmental hazards is not only a function of physical exposure, but is also related to socio-economic, demographic and other socio-cultural dimensions. It is therefore important to consider these aspects in the context of Winnipeg inhabitants' socio-demographic and socio-economic conditions. Today, Winnipeg is the eighth largest city in Canada, with a population of close to 700,000. The evolution of the development of Winnipeg's core and suburbs has been illustrated succinctly by Carter (1997), in which he described the central core as being the location for institutions and clubs. The North End historically contained low-income households and provided homes for the working class and "foreign immigrants". Residential growth in Winnipeg produced a divided city:

> "A middle- and working-class core was surrounded by working-class and very-slow-income areas to the north, middle-class areas to the west and east, and upper-class area to the south. Ethnically, the core contained fairly large numbers of all ethnic groups; the north was dominated by Slavs, Jews, and Scandinavians; the British lived to the south and west; and the French lived to the east" (Carter 1997: 139).

These patterns are likely to create differentiated patterns in vulnerability of the population of Winnipeg to environmental risks and hazards, particularly to heat waves.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The purpose of this research is threefold. First, the study intends to determine the 'knowledge gaps' that may exist between experts and community residents regarding the health risks related to climate change-induced heat waves, as this is important for developing effective risk communication. Second, the research aims to examine the extent and nature of community residents' (i.e., the public in general) perceptions of climate change-induced heat wave events in light of the scientists' understanding of climate change-induced heat wave events. Third, it also attempts to identify the gaps and conformity in understanding and knowledge between experts and community people concerning the best possible practices in risk communication; public views are incorporated in an attempt to decrease the mortality rate and other adverse health effects during heat waves.

To achieve successful risk communication, it has been suggested that consideration should be given to the possibility that failure to effectively inform the public could be a reflection of the lack of understanding about what people know and need to know (Morgan et al., 2002). In order to fulfil these challenges, Morgan et al. (2002) developed a five-step method for creating and testing risk messages in a way that is faithful to the sciences of risk and communication. This method is referred to as the 'Mental Model' approach and provides a necessary condition for establishing a partnership with the public and for laying the foundations for mutual trust. In this chapter, the fundamental elements of the mental model are first analyzed, and then followed by its field application to the research problem concerning climate change-induced heat wave and its related risk communication issues.

The term Mental Model was introduced first by Kenneth Craik. From a psychometric perspective as he was interested primarily in the cognitive mechanisms of the learning processes in a system. Thus, the focus of the goal was upon human cognition and its elements. However, as the model evolved over time, goal of this framework has widened and incorporated many other dimensions. In the context of the present-day environmental issues, the appropriate term of this framework is knowledge model as it refers to a concept applied to explain the cognitive processes for representing and making inferences about a system or problem, the state of knowledge, and the learning mechanisms that influence both perception and behaviour (Borgman, 1984). In order to reflect the broader contexts and perspectives, the model is being termed as a knowledge model throughout the present study as it basically depicts the state of perception, conception and knowledge of experts and the various stakeholders about the concerned phenomena.

3.2 Overview of the Attributes of the Knowledge Model

Mental models can be seen as "a cognitive representation of the system's internal mechanics, i.e. its component parts and their behaviours" (Halasz and Moran, 1983: 212). Borgman (1984: 31) defines mental model as a "general concept used to describe a cognitive mechanism for representing and making inferences about a system or problem which the user builds as s/he learns and interacts with the system". No matter how diversely defined, the broad meaning of mental model is generally to think in terms of a complex interacting system of beliefs which underpins risk appreciation.

The mental model was first postulated by the Scottish psychologist Kenneth Craik (1943), who wrote that the mind constructs "small-scale models" of reality that are used to anticipate events, to reason, and to underlie explanation. Based on Craik's original insight, cognitive scientists have argued that the mind constructs mental models as a result of perception, imagination, knowledge, and the comprehension of discourse. The concept seemed to be forgotten for many years after Craik's untimely death. Nonetheless, theorizing about mental models made a comeback shortly after the 'birth' of cognitive science. During the 1980s there was an enormous growth in studies of mental models. Mental models reappeared in the literature in 1983 in the form of two books, both titled mental models, but they used the term mental model for different purposes. The Johnson-Laird volume proposed mental models as a way of describing the process which humans go through to solve deductive reasoning problems (Johnson-Laird, 1983). Gentner's mental models proposed that a mental model provides humans with information on how physical systems work (Gentner, 1989). Since then, cognitive scientists have studied how children develop such models, how to design artefacts and computer systems for which it is easy to acquire a model, how a model of one domain may serve as an analogy for another domain, and how models engender thoughts, inferences and feelings.

Because mental models predispose the mind towards particular ways of thinking about a problem, its causes, effects and its solution, in the late 1980s and early 1990s scientists started using mental models in the climate change communication process. It was realized that past global warming messages related to climate change had triggered misunderstandings and inappropriate responses. Further studies in the field of climate change risk communication revealed that people's perceptions and beliefs demonstrate that they hold a variety of mental models about the issue, some of which mislead them regarding causes and solutions related to climate change (Bostrom et al., 1994). For example, many people attribute climate change to human activity while others continue to attribute climate change to a natural weather cycle.

Recognizing that the characteristics of complex mental models are critical in understanding pertinent issues, this approach has gradually been widely accepted in the studies of environmental hazards, health impacts and conflation between weather and climate.

Communicating about extreme events and the involved risks for humans and their assets is a commonplace activity which occurs in a multitude of 'arenas', ranging from systematic campaigns by the authorities to informal exchanges in occupational or private contexts. All these communications aim to deliver to people the information that they need in order to make informed decisions about risk. Here, the notion of risk communication refers to a social process by which people become informed about hazards, and they are influenced towards behavioural change and can participate in decision-making about risk issues (Haque et al., 2004; Committee on Risk Perception and Communication, 1989: 19-23). Informing and communicating about risks is more likely to succeed when treated as a two-way process, when participants are seen as legitimate partners, and when the process focuses on the things that people need to know but do not yet know (Morgan et al., 2002).

Under such conditions, mental models have been studied by cognitive scientists as part of efforts to understand how humans know, perceive, make decisions, and construct behaviour in relation to a variety of extreme environmental events. Bier (2001) further suggests that risk communication messages based on mental models are more effective at conveying both general knowledge and specific information about risk reduction strategies. The mental model approach seeks to identify both correct and incorrect beliefs that are held by a target population for a particular hazard. These are then used as a basis for developing risk communication to correct misunderstandings. The main aim of this approach is to bridge the gap between community residents' and expert models of the risk by adding missing concepts, correcting mistakes, strengthening correct beliefs and minimizing peripheral ones (Morgan et al., 2002).

However, current public opinion and knowledge concerning climate change appears to suggest that the public is either unaware or confused about the precise nature, causes, and consequences (Lorenzoni et al., 2005). The very complex nature of 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 (Lorenzoni et al., 2005).

In order to fulfill the objectives of the present study, the mental model approach was adopted as the methodological approach; the outcomes of the process was a modified version of the mental model prescribed by Morgan et al. The Morgan group, based at the Carnegie Mellon School, advocated the use of the term mental model to capture the risk communication issues and problems for creating and testing risk messages in a way that is faithful to the sciences of risk and communication. A five-step method has been developed by the Morgan group; these steps are summarized in the following table (Table 3.1).

Table 3.1: Mental Model Steps

Steps	**Components and Activities**
Step I : Create an expert model	1. Review of current scientific knowledge about the process that determines the risk 2. A formal representation of explicit summarization of above knowledge in an influence diagram. 3. Final review by technical experts.
Step II : Conduct mental model interview	1. Open-ended interviews eliciting people's beliefs about that particular risk. 2. Interview protocol is shaped by the influence diagram. 3. Analysis of responses to capture the beliefs of respondents.
Step III: Conduct structured initial interviews	1. Create a confirmatory questionnaire to validate the beliefs expressed in open-ended interviews and the expert model. 2. Administer it to the larger groups, in order to estimate the population prevalence of these beliefs.
Step IV: Draft risk communication	1. Use of results from the above two steps to determine which incorrect beliefs most need correcting and which knowledge gaps most need filling. 2. Draft a communication, to be reviewed by experts.
Step V : Evaluate communication	1. Test and refine the communication with individuals selected from the target population.

(Source: After Morgan et al., 2002)

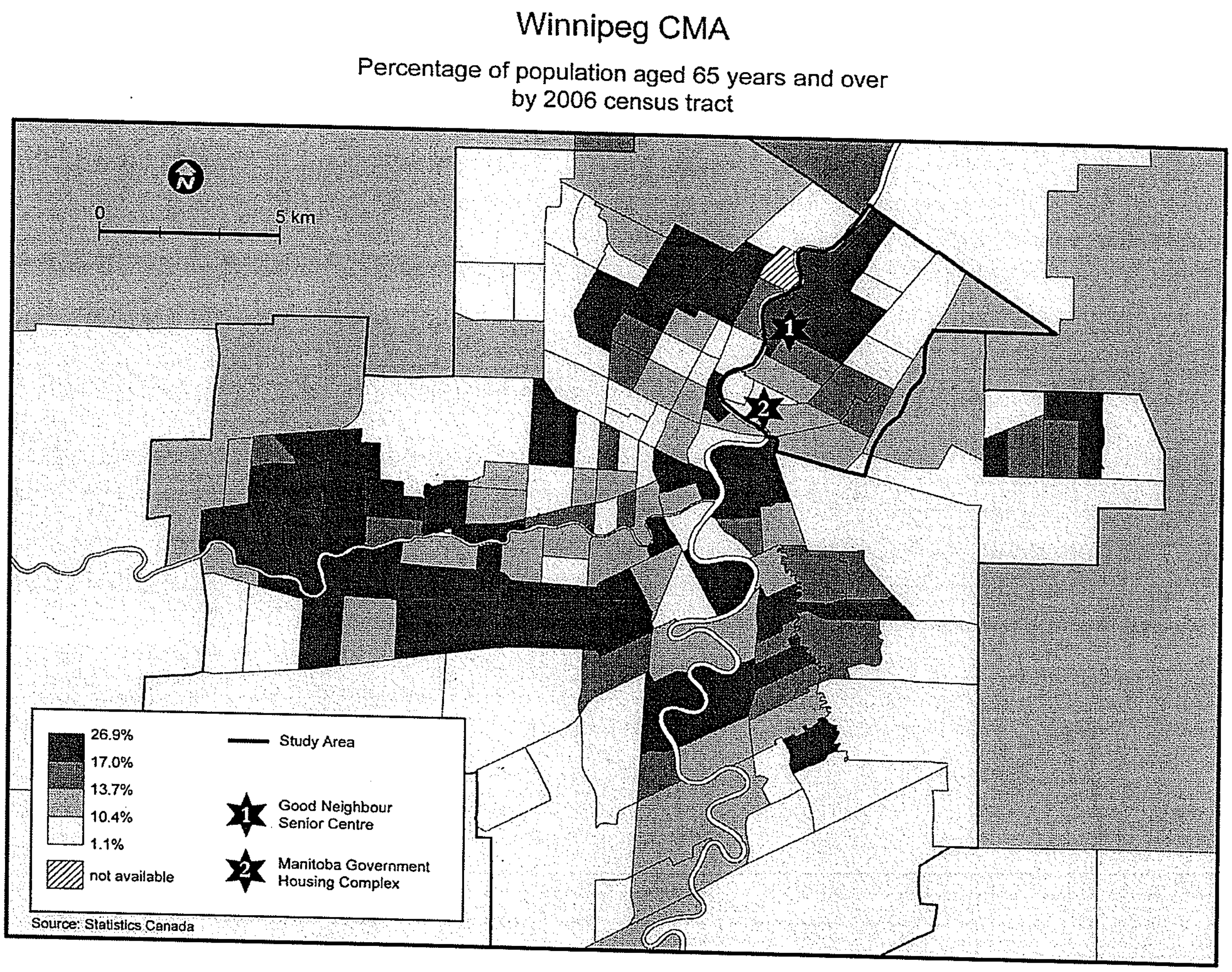
Morgan et al. (2002) concede that a mental model is not a model in the formal sense and it does not involve a strict mapping between things in the real world and elements in the model; nor does it have operations for combining those elements. As a result, they used this model to figure out which things in a complicated situation are worthy of attention. They also used a mental model to recognize how well their abstraction captures the complexities of the actual process. In the present study, the model is applied in a much broader context than merely focusing on the 'mental' or psychological perspectives. As stated earlier, to reflect such a broader perspective, the model is being termed as a knowledge model as it fundamentally depicts the state of perception, conception and knowledge of the various stakeholders about the concerned phenomena. The following section details the mental model methods that were used to fulfill the research objectives of this study.

3.3 Identification of Sampling Frame and Study Area

North Kildonan is an urban ward located in the City of Winnipeg covering 17 square kilometres. According to 2001 census data, the population of North Kildonan at that time was approximately 37,000, of which 63% had lived in the area for the previous five years. In 2001, 80.1% of the population was 15 years or older, and 17.2% was 60 years or older. Figure 3.X illustrates the percentage distribution of the population aged 65 years and over by 2006 census tract for the City of Winnipeg. It is apparent that the North Kildonan ward is among the zones with most elderly population relative to other zones of the city, and therefore can be considered as one of the most vulnerable areas to heat wave and related health hazards. The most common types of employment were manufacturing (13%), health care and social services (12%), and retail trade (11%). The average household income was $66,000 (Statistics Canada, 2006).

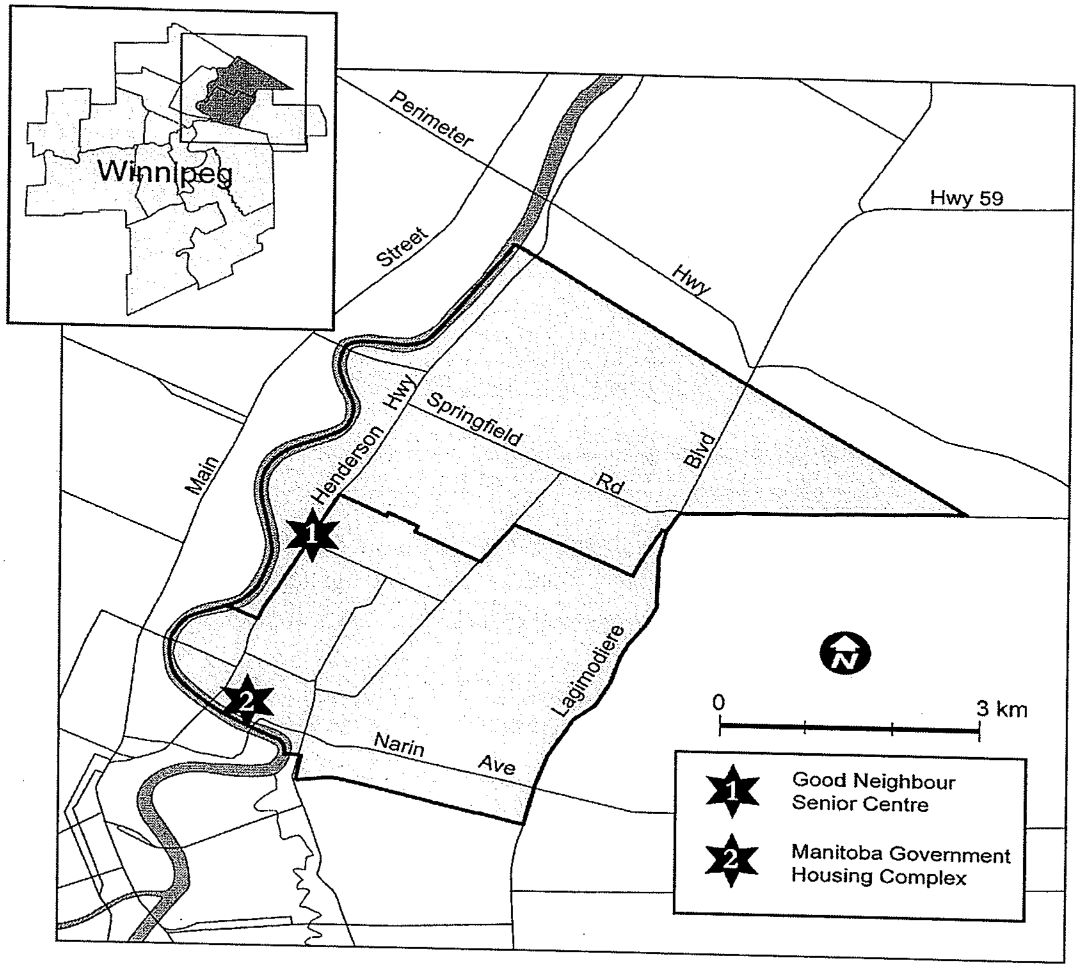
As indicated by Carter (1997), the North End of the City of Winnipeg historically contained low-income households and provided homes for the working class and "foreign immigrants". Presently, the Ward of North Kildonan is characterized by mixed residential neighbourhoods, in which low-income housing complexes are also embodied. These vulnerable groups, both in terms socioeconomic conditions and environmental hazards, such as heat wave events, are often supported by the provincial housing subsidy programs.

Figure 3.1 Study Area with Percentage of Population Aged 65 Years and Over



Considering the above stated criteria and access to the potential respondents and appropriate city authorities, the North Kildonan Ward of the City of Winnipeg was chosen as the study area of the present research. The inferences made from the face-to-face and confirmatory survey (i.e., target population) can therefore be applied to the population of this Ward (i.e., the study population).

Figure 3.2: Study Area: North Kildonan Ward of the City of Winnipeg



3.4 Design of the "knowledge model"

For the purpose of the present study as well as in consideration of the specific objectives of the present research, the formulation of the "knowledge model" (a modified version of Morgan et al.'s mental model) of the concerned phenomena was achieved through the implementation of three distinct steps. These included: i) the development of an Expert "knowledge model", ii) an investigation into the state of awareness and knowledge among target groups as well as the community residents through face-to-face interviews, and iii) conducting a survey of the public to test the validity of the outputs of the face-to-face interviews.

3.4.1 Developing the Experts' Model

The first step in the ''knowledge model'' application involves the construction of an 'expert ''knowledge model''' by creating an influence diagram that captures the pooled beliefs of technical specialists about the heat wave phenomenon. This influence diagram is the formal representation of a ''knowledge model'' (the first step of the mental model tool for an effective risk communication), which is a directed graph, with arrows or "influences" connecting related "nodes". These models were originally developed by decision makers as a convenient way to summarize information about uncertain decision situations, thereby allowing effective communication between experts and decision makers and the analysis of related information (Howard and Matheson, 1981; Shachter, 1988). Usually, two kinds of nodes are included in such an influence diagram: 1) the oval represents uncertain circumstances, with the heavy ovals representing the major factors, and light ovals representing sub-factors, and 2) the rectangle represents choices made by decision makers or mitigation measures that can impact variables and reduce the risk or threat. These mitigation measures represent both individual and institutional level decision making. Arrows connecting nodes symbolize some influence (which is not always a causal relationship) from one node to another node in the direction of the arrow head.

In my research, the model was created by using a focus group of experts from various, yet related, fields and disciplines. In this research, a team of experts representing 12 different stakeholders from across Canada provided their inputs concerning various issues related to the impacts of climate change induced-heat waves on individuals and communities as well as their root causes. A one-day workshop was held on 16th October, 2006 in Winnipeg, Manitoba for the purpose of formulating an expert ''knowledge model'' on climate change-induced heat waves. Specialists from twelve different entities, representing meteorology, health science, geography, education, environmental science and studies, community services, and rural studies, attended the workshop. These delegates were from various governmental institutions, non-governmental organizations, non-profit organizations, City of Winnipeg and post secondary institutions (Appendix 1). The process was iterative as experts from the relevant fields expressed their opinions, reflected upon others' opinions and reviewed their own. A set of linked factors emerged from the discussion; all relevant factors then were assembled with the help of a facilitator. The strategy that the team used was the Assembly Method, where we wrote the factors on post-it notes and then put them on a blackboard, so that they could be moved around easily, and chalk arrows drawn and erased until appropriate structures were formulated. The outcomes of the 'expert ''knowledge model'' exercise will be presented and analysed in Section 4.2 of Chapter 4 of this study.

3.4.2 Organizing Face-to-Face Interviews

In the second step, 25 respondents (N_1=25) were interviewed within the community by using 'open-ended' instruments. I approached a total of 26 individuals; 25 of them expressed interest in my study. The purpose of the open-ended interviews was to capture the targeted community people's beliefs about heat waves on their own terms. For this purpose a survey instrument was developed with 17 guiding questions (Appendix 4). As indicated in the existing literature, the elderly and low-income groups (i.e., with less than $ 35,000 family income per annum) are most vulnerable in a heat wave period; the sampling plan thus required a stratified sampling. Among the 25 direct interviewees, 10 were chosen from the elderly (age>= 65) population and five were from financially challenged groups (annual income <= $35,000). The remaining 10 were selected from the common people within the community. Telephone directories were considered for developing a Sample Frame and used to obtain the names and addresses of potential respondents in the common people category. To conduct interviews with the elderly and low-income groups, a 'snow-ball' contact procedure was followed. The face-to-face interviews were carried out during the months of February and March of 2007.

3.4.3 Creating a Confirmatory Questionnaire

To fulfill the third step of the ''knowledge model'' process, a quantitative confirmatory questionnaire (Appendix 5) was created and distributed among a large sample of the overall community of North Kildonan (N_2 = 300) to estimate the prevalence of these beliefs in the population and to substantiate the initial findings. The response rate was 38% (N_3 = 114). Finally, the results were analyzed applying a mixed (both qualitative and quantitative) method approach, primarily to determine which distorted beliefs needed intervention for improvement and which knowledge gaps required attention for convergence.

3.4 Data Analysis

All responses collected from face-to-face interviews and the confirmatory questionnaire were analyzed by a process of recording, transcribing, tabulating and compiling the data, and finally drawing inferences. First, I compiled the face-to-face interviewees' responses that were collected in narrative descriptions, and I transcribed to summarize them. These were supplemented by a set of follow-up questions. In order to obtain relatively objective responses, a five-point Likert scale was used, with a breakdown of responses as strongly agreed, agreed, neutral (had no comment with respect to the original statement), disagreed and strongly disagreed. In addition, I also analyzed the comments provided by those respondents who had expressed disagreement with the experts' opinion in a particular statement.

Second, in order to check the validity of the face-to-face interview results, I analyzed my larger sample data (gathered from the confirmatory questionnaire) by using SPSS software, and created tables and bar diagrams with the help of descriptive statistics options (product-moment Relationship coefficient, chi-square tests) in that software. Only bivariate statistical analyses were carried out in the present study. Although a multivariate analysis, which provides specific parameters by controlling the relevant explanatory, independent variables other than the targeted explanatory variable, such analysis could not be performed because of both qualitative nature of the data and limited scope of the study. More than one-third (38%) of the total sample returned the mailed-out questionnaire with all questions answered. Since the amount and content of the responses were sufficient to meet the goals of the project, no further questionnaire has been mailed out. The results and discussion of these tables are addressed in the next chapter.

The confirmatory questionnaires were mailed out by following a systematic random sampling method. Considering the potential qualifications, a non-parametric test of significance (i.e. chi-square test) was applied to find out the nature of relationships between the explanatory variables and data on variability in risk perception, risk estimation and selected adjustment behaviour. The level of significance throughout the study was p=0.05. The outcomes are presented in Chapter 5 of this thesis.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 Introduction:

The goal of this chapter is to present and analyze the results of an empirical investigation concerning the knowledge and perception of heat wave risk evident in urban Winnipeg. The key issues explored in this chapter relate to, first, the states of knowledge and perceptions of climate change and associated heat wave hazards displayed by the expert community and by the community members. Second, this chapter examines whether the states of knowledge of climate change-induced heat wave hazards demonstrated by members of the scientific community and by community residents are similar or not. Four particular aspects of climate change-induced heat wave hazards are examined as they are considered the relevant issues. These include i) causes of heat waves, ii) risks associated with heat waves, iii) various effects of heat waves, and iv) potential preventive and mitigation options. In addition, results concerning the study groups (i.e. experts vs. community residents) are reviewed and analyzed for gaps evident within the groups that might then be used to help explain gaps between the groups.

This chapter has three parts: i) expert knowledge of climate change-induced heat wave hazards are analyzed to capture the experts' understanding and opinions; ii) data from the face-to-face interviews and mailed-out questionnaires are examined to encapsulate the knowledge and beliefs of common people; and iii) the results from face-to-face interviews and mailed-out confirmatory questionnaires are used to determine specific cases where gaps may be evident between the experts and community residents.

4.2 Expert Knowledge of Climate Change-Induced Heat Wave Hazards: An Exploration into the Knowledge Model

The first issue under review is the experts' knowledge of climate change-induced heat waves and their associated risk to human health, the environment, infrastructure and other resources. Objective one seeks to examine the state of knowledge and perception of climate change-induced heat wave hazards among the expert community. An expert knowledge model was developed to attain this objective. A focus group discussion was organized on the 16th of October, 2006, involving experts who represented 12 different stakeholders (Appendix 1), and the outcome was a comprehensive knowledge model. The process involved several steps that were described in the previous chapter.

The directed graph (Figure 4.1) shows a simple influence diagram of extreme heat conditions that can cause severe illness and even death. In the middle part of the diagram, the large oval represents the meteorological properties of the heat wave condition. In order for this condition to appear, the sequences of the left portion of the diagram must first occur. The oval nodes show key factors that influence the occurrence of this condition. Our expert panel identified three key factors: a rise in atmospheric mean temperature, changes in surface atmospheric moisture, and changes in atmospheric circulation. Each of these variables is influenced by a set of determining factors (Figure 4.2). For example, changes in atmospheric circulation are caused by tele-connecting frequencies, changes in the pressure system (i.e., the jet stream), shifts in wind patterns, and changes in wind speed (Figure 4.2). It was determined that the rise in mean atmospheric temperature is considerably influenced by the greenhouse gas (GHGs) concentration in the atmosphere. Two variables, namely, consumer lifestyle and population growth, are responsible for the increase in GHGs concentration (Figure 4.3).

Figure 4.1: Simplified Experts' Knowledge Model on Climate Change-Induced Heat Wave Hazards

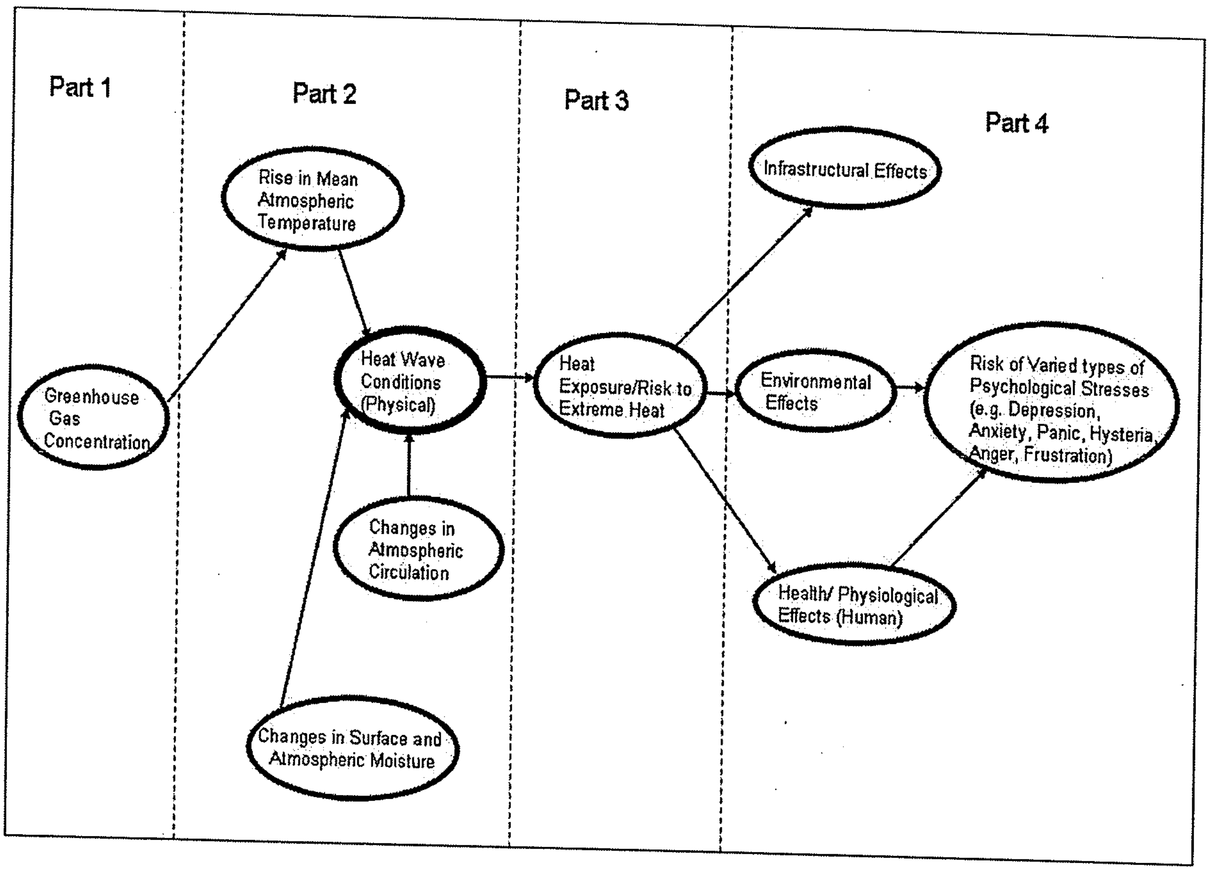


Figure 4.2: Part 1 of the "Influence Diagram" showing the paths of influence on greenhouse gas concentration

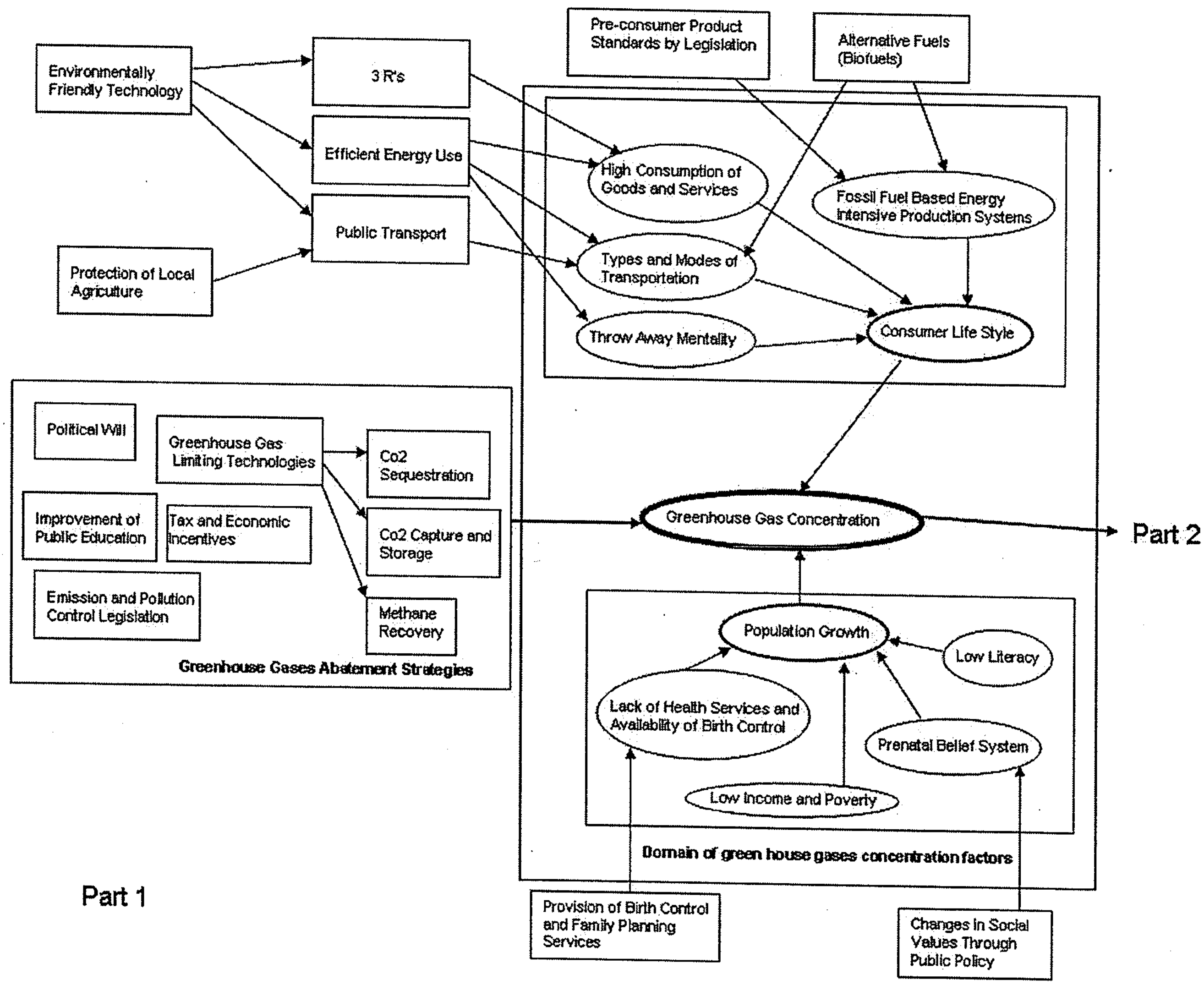
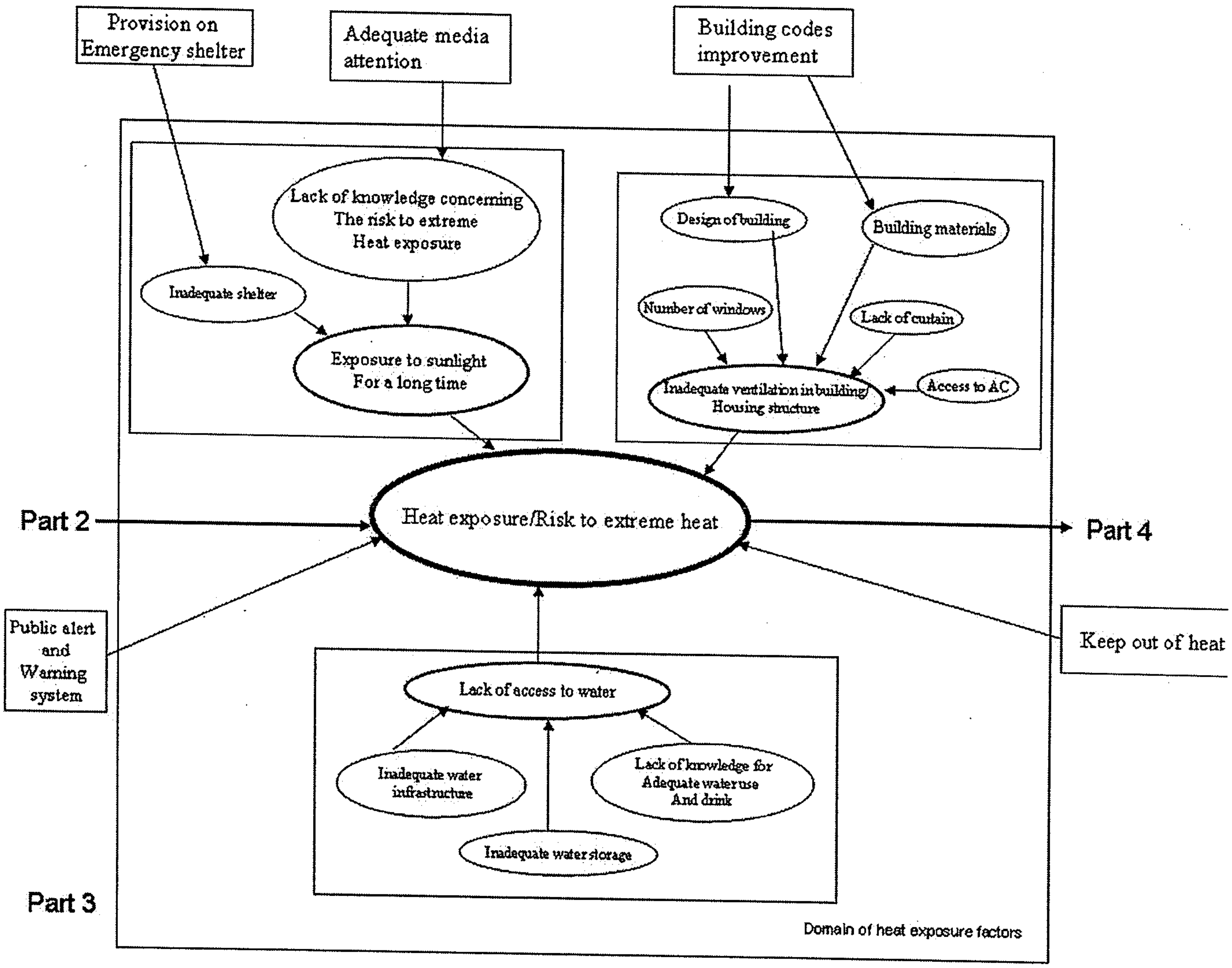
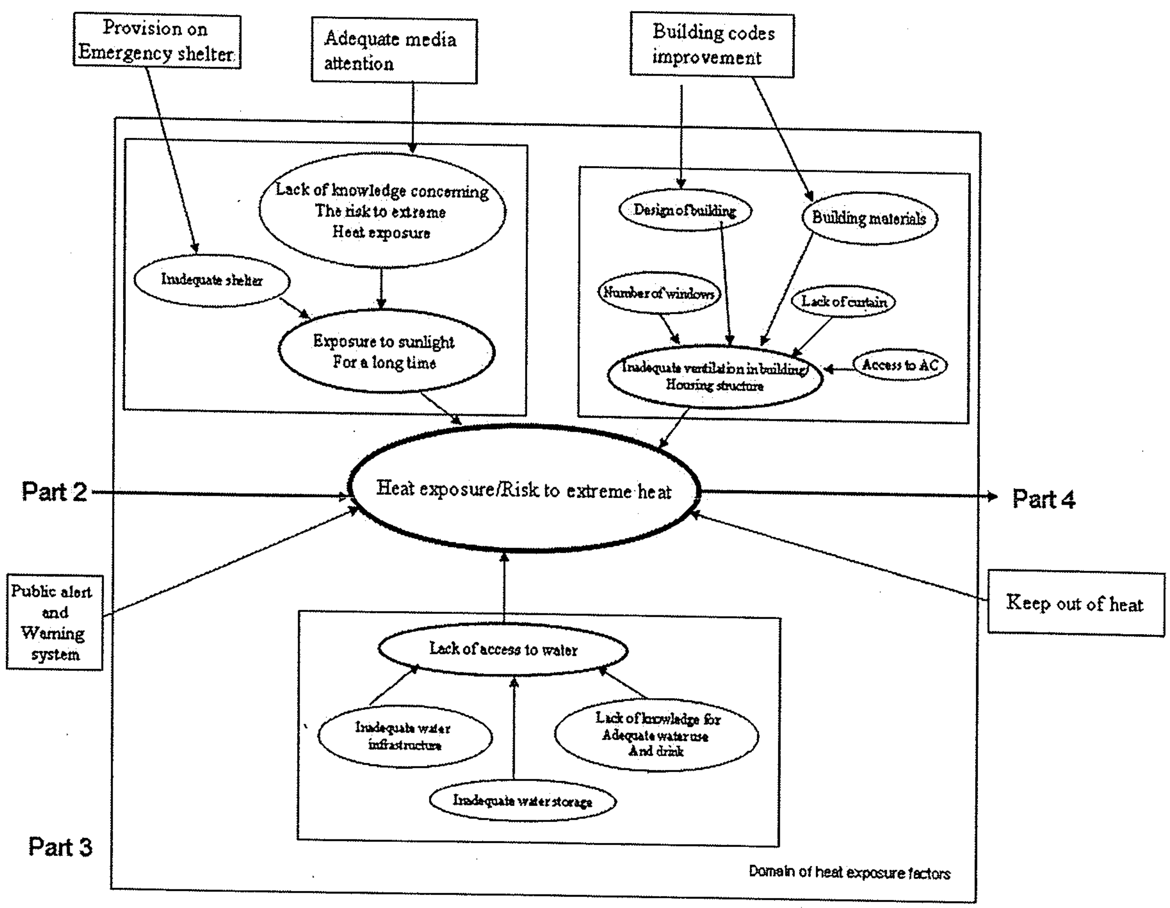


Figure 4.3: Part 2 of the "Influence Diagram" showing the paths of influence (cause of heat waves) on physical heat wave condition



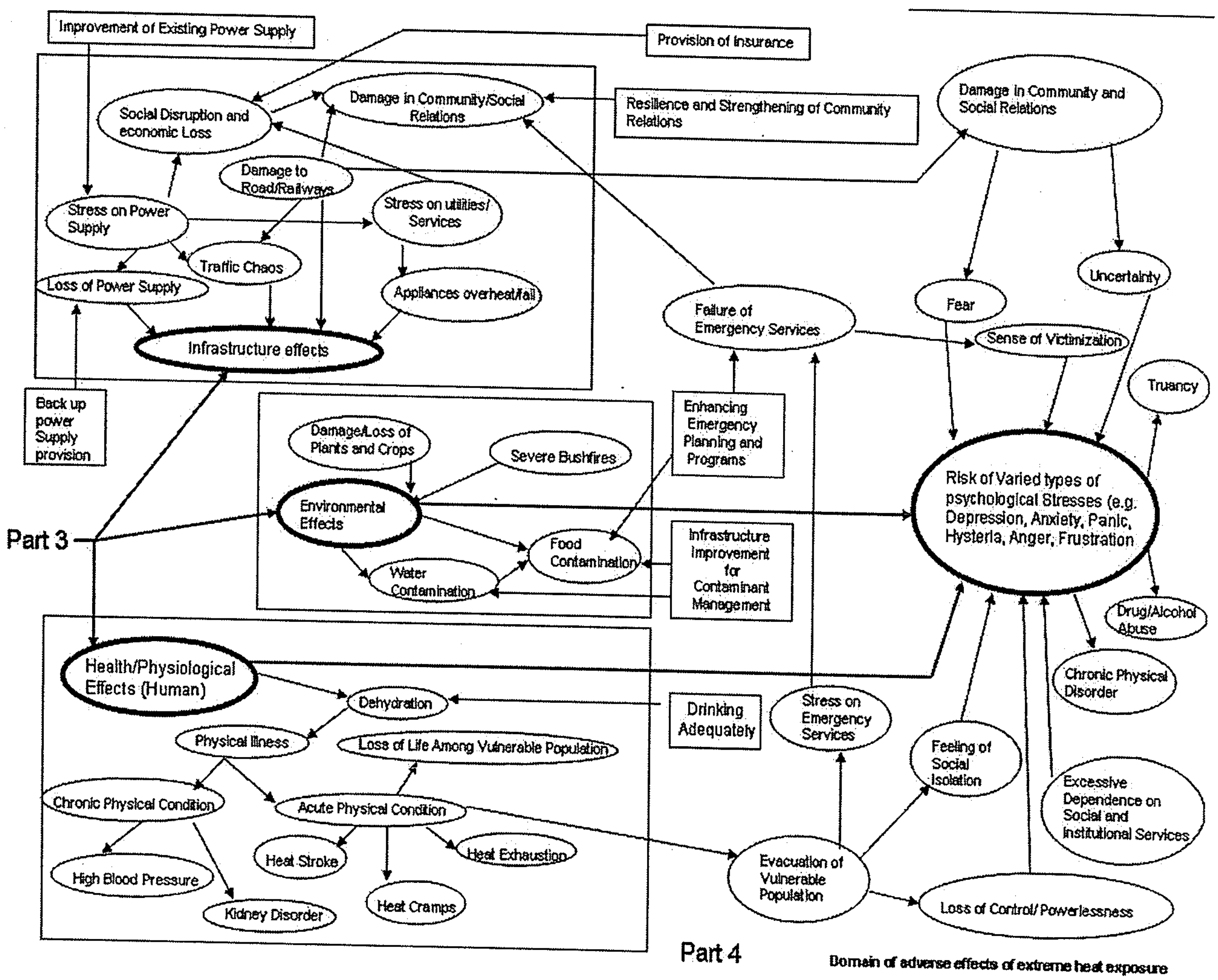
The heat wave conditions result in heat exposure of the human population and generate the risk of extreme heat; this is represented by an oval located to the right of the heat wave conditions oval (Figure 4.4). The model shows that the risk of extreme heat on human health is not only a function of meteorological heat wave conditions, but is also a function of people's exposure to sunlight for long periods, their lack of access to water, and poor housing conditions, where ventilation provision is not adequate. Lack of knowledge about the risk of extreme heat exposure and inadequate shelter can lead to prolonged exposure to sunlight. Similarly, lack of knowledge of the need to use and drink sufficient water can limit people's access to water, which will enhance the risk of extreme heat. Poor understanding of the importance of consuming sufficient water and inadequate water storage infrastructure create constraints against accessing water. In terms of exposure to heat indoors, the number of windows, type of building design and materials, lack of curtains, and lack of access to air conditioners are the prime determining factors.

Figure 4.4: Part 3 of the "Influence Diagram" showing the paths of influence on heat exposure and risk to extreme heat



The right side of this oval represents heat exposure or heat output, as well as the adverse effects of this extreme heat wave condition in various sectors (Figure 4.5).

Figure 4.5: Part 4 of the "Influence Diagram" showing the paths of influence on the effects of heat wave disaster



These include effects on infrastructure, environmental effects and physiological effects. Physiological effects associated with exposure to extreme heat can cause dehydration, physical illness, and even chronic or acute physical conditions. The environmental effects of extreme heat exposure are varied as they include damage and loss of plants and crops, contamination of water or food, and environmental disasters like bush fires. Infrastructural effects resulting from extreme heat exposure can be seen in the loss of power supply, chaos in traffic flows, damage to roads and railways, and overheating of appliances. According to our panel of experts, the risk of varied types of psychological stress and their effects, such as depression, anxiety, anger and frustration, is influenced by both the physiological effects of extreme heat exposure and other environmental effects.

The expert panel further identified various options for interventions to prevent or mitigate the adverse effects of the concerned variables; these measures are shown as rectangular boxes in the diagram. Several mitigation measures were identified that would reduce GHGs concentration in the atmosphere. These included some greenhouse gas-limiting technologies such as CO_2 sequestration, CO_2 capture and storage, and methane recovery. These measures are shown on the extreme left side of the diagram. Pre-consumer product legislative standards and easy access to alternative fuels were identified as means to reduce the use of fossil fuel-based transport mediums and different energy-intensive production systems. Greenhouse gas emissions are ultimately reduced through changes to consumer lifestyle and the proper maintenance of such modifications. Experts determined that population growth is an important factor contributing to increased greenhouse gas concentration. As stated earlier, rises in mean temperature are affected by changed land use patterns. The experts' suggested ideas for mitigation included smart growth planning, urban design and land use, and decentralization strategies.

The experts' strategies for mitigating the risks of heat wave hazards are indicated in the middle of the diagram (Figure 4.4). It can be seen that they identified several key issues to mitigate the risks related to extreme hot temperatures. These include improvement of building codes, adequate media attention, provision of an emergency shelter, keeping oneself away from the heat, and operation of a public alert and warning system. To mitigate the effects of heat wave hazards on various sectors, experts keyed out a few mitigation strategies. It is clear from the diagram that the number of rectangular boxes is higher on the left side of the diagram, up to the middle of the diagram, where the causes and risks related to heat waves are situated. This supports the literature, which indicates that heat wave hazards and mortality are largely preventable by taking precautionary measures. Although a few mitigation and adaptation strategies are identified after determining how heat waves affect different sectors, the number of such strategies is not significant and it is not applicable to every segment.

4.3 Knowledge and Perception of Climate Change and Heat Wave Hazards among Urban Communities:

As explained in Section 4.2, experts' knowledge and judgments in relation to risks, including their understanding of the causes and dynamics of risks and their responses to them, are based on technical aspects of these phenomena and are thus considered relatively objective in relation to real-world conditions (Olczyk, 2005). Research has shown that community people view risk and hazard-related issues from a much broader perspective. Usually, community people's risk perceptions and attitudes are closely related to the measures currently used to reduce risk, such as heat alarm system, rationing of power use, and they advocate the strict application of existing regulations to achieve the desired reduction in risk. Experts often fail to take into account the knowledge domain of a community residents' audience, and therefore the perspectives of experts (who tend to focus on specific knowledge; Schmidt & Boshuizen, 1992) and community residents can vary significantly (Hinds, 1999). In order to analyze these varying perspectives comparatively, it is vital to capture community residents' knowledge, perceptions and judgments.

The North Kildonan ward of Winnipeg was the target community of my study. A total of 25 respondents were interviewed with an 'open-ended' instrument (Appendix 4) to capture the status of community residents' knowledge, perceptions and beliefs concerning climate change and heat wave hazards in their own terms. As stated earlier, the community resident cohort was divided into three main groups: i) 10 were chosen from the elderly population, ii) 5 were from low-income groups, and iii) 10 were selected from the community at large. Community respondents were asked about their knowledge of climate change, its causes, associated hazards, and the risk of heat waves and hazards to the community. Overall, the respondents perceived that the weather pattern, relative to the past, has been changing, and saw this reflected in lesser snow accumulation and milder winters. Some respondents also viewed the existence of El Nino in relation to climate change. Respondents acquired their knowledge of climate change from associated features such as the melting of Arctic and Antarctic ice. One of the respondents expressed such a notion in the following words:

> "I guess this is the overall weather pattern change all over the world, which affects the normal fluctuation of mean temperature…climate change is occurring everywhere,...melting the glaciers, polar ices, etc…causing El Nino."

A few respondents also thought that because there is now a lot less clean air in our cities than before, this shows that the climate is changing. Some distinctive patterns have emerged from the responses made by the elderly and low-income cohorts. It appears that the low-income group recognizes the changing climatic patterns from atmospheric elements such as high temperature and resultant forest fires. The elderly group, in contrast, is of the opinion that climate change can be recognized in the rapid loss of natural habitat, the unprecedented rate of deforestation, and the world-wide shortage of water.

It can be inferred that a significant portion of community people does not perceive climate change and its associated features with clarity. The community members' conceptualization of climate change is not based on a cause-and-effect relationship among the concerned variables. They heavily rely on experiential learning and exposure to various symptoms rather than understanding the relationships between variables. Relative to experts' specific knowledge of the linkages between climate change and global warming, community residents draw upon broader environmental and societal factors to make inferences about climate change.

Why the earth's temperature is rising was explored with all the respondents. This question was pursued because, according to the experts' knowledge, the incremental increase in the earth's mean temperature is the principal factor contributing to the heat wave condition. The causal relationship between global warming and the dramatic increase in greenhouse gases, primarily from human activity-related emissions, was well understood. The burning of fossil fuels and atmospheric emissions from the production of consumer goods were identified as the primary determinants of the rise in global temperature. It is notable that although there is an awareness of the relationship between human activity and the incremental rise in global temperature, there exist some misconceptions about some determining factors. A considerable number of respondents thought that ozone depletion is causing global warming. Morgan et al. (2001), in their study based in the United States, observed a similar misconception, whereby community respondents treated ozone depletion and global warming as synonymous.

Most of the community people interviewed contextualized heat waves in Winnipeg in terms of an increase of daily maximum temperature up to 30 degree Celsius. This parameter conforms to the recommendation made by Environment Canada. Respondents, however, did not recognize the importance of the duration of the periods in which high temperatures occurred. A clear distinction between an extreme hot day and several consecutive days of high temperature could not be made initially by the respondents. However, after a little prompting, several respondents suggested that they considered a heat wave to exist only when the high temperatures prevailed for a prolonged time period, such as two weeks or more. Notably, Health Canada defines heat waves in relation to increased daily maximum temperature in a particular region if it persists for at least three consecutive days. In my study, respondents did link heat waves with a distinct clue in regards to time period. Nonetheless, they considered a very long time period (such as two or three weeks, or sometimes the vague or ambiguous "prolonged period of time") with high temperatures as required for qualification as a heat wave. One respondent expressed such a notion in the following words:

> "I would rather say 30 degree or more than 30 degree temperature for more than two weeks… well…hard to say specifically, but for sure a prolonged period of time with high temperature would define as heat wave in Winnipeg."

Some degree of variability in defining heat waves among the respondents was noticed. A few elderly respondents defined heat waves as an unbearable temperature. They were reluctant to view heat waves in terms of a fixed maximum temperature for a certain time period. In their terms, it would be highly unpragmatic if one defined heat waves in relation to some fixed parameters. Such a notion may be attributed to the fact that high temperature can be perceived below 30 degrees. Sometimes elderly people feel very hot due to outdoor work or they feel hot and exhausted when their physical condition is not well. A very interesting perspective was revealed by one respondent's comment that:

> "I feel more hot, if I need to go outside for grocery or bank or for any other work…I also feel hot and exhausted if I need to access public transport...so, for me it's not a realistic approach to define heat wave in terms of a fixed temperature."

Rather than using an objective criterion or parameter, vulnerable groups such as elderly and low-income groups prefer to define heat waves or other similar hazards in the context of their own lives and experience.

While the scientific community explains the causes of heat waves in terms of atmospheric and oceanic physical processes, the community respondents perceived such causes more in relation to factors that enhanced risk related to heat waves. For example, several community members perceived that overcrowding and unplanned city growth "caused" heat waves. No clear distinction was made between the causes of global warming and heat wave hazards, other than by identifying unplanned city growth and overcrowding of the cities.

When asked about potential climatic hazards that their community is facing, respondents included tornadoes, torrential storms, forest fires, floods, blizzards and droughts. Both the elderly and the community-at-large cohorts included some health hazards, specifically obesity. Water contamination and the spread of diseases were also included as climatic hazards. It therefore appears that community residents did not distinguish between climatic and non-climatic hazards in their community. It is important to cite that none of the respondents included heat wave hazard as a potential risk in their community. This can be attributed to their lack of experiential knowledge, as the City of Winnipeg has not experience any significant heat wave in very recent years.

Awareness of what and how human decisions would reduce the risk of heat wave exposure was high among the respondents. Community members listed several household amenities as well as individual decisions that would affect risk reduction measures. These included proper ventilation, air conditioning and fans, exhaust fans, window blinds, and the existence of a basement in the house. It was recognized that personal efforts to avoid or reduce heat wave impacts have profound implications for addressing heat wave risks. For instance, staying in a shelter, drinking adequate water, shutting off cooking stoves, wearing appropriate clothes, avoiding working under sunlight, and using sunglasses and hats when outside were among the individual actions they mentioned to minimize heat wave effects. Overall, respondents' knowledge and perceptions of options for dealing with the heat wave risk were found to be in conformity with the experts' knowledge; notably, the respondent's ideas were closer to the knowledge of experts in the fields of health studies.

In relation to the experts' model, how heat waves affect people and their community if it persists for a couple of days was explored. As discussed earlier, experts identified three main sectors that would be highly affected by such events (i.e. infrastructure and the environmental and health sectors). Community residents' responses revealed that they identified elements from various fields that would create potential harm, but emphasized particularly on the health sector. It was also noticed that the community members are more concerned about individual loss potential rather than the larger perspective of societal loss. The elderly population and low-income groups expressed common attitudes in their serious concern about health impacts due to heat waves. One interesting finding revealed here was that those people who had gardens were more concerned about potential damage to their garden due to the drying up of the plants. Even respondents from the elderly group were more concerned about their garden rather than the impacts on their health. None of the low-income group respondents, who were not directly involved in gardening, expressed concerns about potential damage to gardens. Concerns about the health impact from heat waves received priority in this low-income group.

Overall, it appeared that although there is a general acknowledgement regarding infrastructural effects and environmental effects, community people are seriously concerned and scared about the potential health impacts of heat waves. It is worth noting that in the experts' knowledge model, the psychosocial impacts of heat wave events received significant consideration. In the study of community residents' knowledge and perceptions of heat wave effects, however, this aspect of psychosocial effects was absent. Without prompting, none of the respondents identified this as an important aspect of heat wave impact.

What an individual and society at large can do about preventing, reducing and coping with climate change and its associated heat wave hazards is pivotal to addressing the concerned issues and problems. Specific questions were pursued with the community members to delineate their ideas on prevention and mitigation measures that could be taken at various scales: individual, community and institutional. My interviews with community respondents revealed that many people have good and considerable knowledge about what can be done to reduce emissions from various sources so as to address climate change or the global warming problem. Echoing a collective response, one of the respondents commented:

> "Adaptive behaviour is necessary and I think this involves recycle, reuse and conservation…public transport need to be improved by government so that people don't need to use car to go remote places or even government motivation is necessary to enforce emission control laws."

The results of my interviews with community respondents showed that they would prefer stricter regulatory measures, particularly the enforcement of governmental laws and regulations to reduce emissions and thereby address the problem of rising atmospheric temperature. These findings are indicative of the fact that at the community level, there is heavy reliance on institutional initiative and implementation to address issues related to large-scale problems, particularly in areas where there is a considerable degree of uncertainty. In contrast to this notion, the expert model that was developed earlier revealed that although institutional measures play a profound role in human efforts to address critical environmental issues (such as climate change and ozone depletion) through public policy measures, individuals' roles and responsibilities cannot be ignored or underestimated.

4.4 Community Responses to the Knowledge Model:

Following the open-ended interviews, a survey was carried out through a confirmatory questionnaire to capture the beliefs and notions expressed in the open-ended interviews and the expert models. As this survey was administered to a larger (300 households) group (i.e. inhabitants of the North Kildonan ward of the City of Winnipeg), it was thought that, with appropriate, randomly sampled units (households), reliable estimates could be made regarding the prevalence of these beliefs in the population. One of the main reasons for carrying out the survey through a confirmatory questionnaire was to test the validity of the notions and patterns captured in the open-ended interview outcomes by taking the representative sample of the population into account. Morgan et al. (2002) cited that, in addition to enabling us to estimate the population prevalence of various beliefs, these questionnaires also offer a form of *convergent validation* (pp. 27). This observation acknowledges the imprecision of the prevalence estimates that can be obtained from the open-ended interviews. However, there would be some crude similarity between the prevalence observed in the two settings.

It is worth reiterating the major observations related to the outcomes of my interviews with the 25 community members. It appeared that relative to the experts, community people are non-specific about climate change and their causal factors. There was a clear recognition among the community people that human activity-induced emissions to the atmosphere, specifically the greenhouse gases, are resulting in incremental rises in global temperature. Nonetheless, their mental models of global climate change suffer from some basic misconceptions. One such major misconception was related to the linkage between the depletion of the ozone layer due to Chlorofluorocarbons (CFCs) and the rise in global temperature. Other misconceptions were embedded in the time duration needed for a heat wave event. Addressing these misconceptions is important because they function as obstacle against public support and mobilization as well as require additional resources to make the public to understand the nature of the problem and their solutions.

The interview results further indicated that community residents' mental models of heat wave risks are reflective of high awareness of the susceptibility of their health conditions. In reference to real-time-based meteorological data, it was determined by Environment Canada that Winnipeg is one of the most vulnerable cities in Canada to maximum daily temperature, heat waves and urban droughts. Despite this vulnerability of the city to heat wave hazards, none of the community respondents of the open-ended interview listed this phenomenon as a potential hazard in their community. When the confirmatory questionnaire survey enquired about the likelihood of heat waves in Winnipeg in the next five to ten years, a similar pattern was observed. The majority of the respondents (52.6%; N=114) indicated that heat waves will not occur in Winnipeg in the next five to ten years; 29.8% did not respond and only 17.5 % thought that such an event might take place.

It appears that community residents' mental models might have relied heavily on experiential knowledge and learning to delineate environmental hazards and risks. In perspective of these beliefs and awareness on the one hand, and some misconceptions on the other hand, several questions relating to climate change-induced heat wave hazards and their associated risks were included in the survey instrument.

While the interviewed community residents did not make any clear distinction between the causes of global warming and heat wave hazards (other than by adding unplanned city growth and overcrowding of the cities), the confirmatory questionnaire survey results revealed that 16.7% (N=114) of the respondents believed that heat waves were occurring due to increased greenhouse gas concentration in the atmosphere. In addition, 71.1% of the community respondents thought that such a causal relationship between increased GHGs concentration and heat waves may hold true and only 12.3 % were uncertain about it. It appears that local community members recognized human activity-related emissions to the atmosphere and their resultant manifestations in the form of enhanced GHGs concentration as responsible for causing heat wave hazards. In terms of obtaining information on climate change and global warming, community members rely on various kinds of sources. While they were asked to indicate and rank their top three sources, television, newspaper and internet were included respectively.

A clear similarity between the open-ended interview results and the confirmatory questionnaire survey was observed in the perceived role of human activity, such as urbanization and deforestation, in causing a rise in the earth's mean temperature and the occurrence of heat waves. On a five-point Likert scale enquiry, it was found that a total of 66.7% (N=114) of the community respondents believed there was a causal relationship between human activities and heat waves. This finding can be viewed as a form of convergent validation of our procedure.

Table 4.1: Percentage distribution of responses to principal sources of information (Multiple response)

Principal source of information	Percentage distribution for rank 1	Percentage distribution for rank 2	Percentage distribution for rank 3
Books	2.4	0	0.8
Newspaper	41.6	39.7	41.2
Television	47.3	43.5	39.8
Internet	8.1	11.4	13.9
Church	0.2	0	0
Magazine	0	1.8	0.4
Journals	0	0.9	0
Movies	0	0	0
Radio	0.4	2.7	3.9

The observed misconception regarding the relationship between the depletion of the ozone and the rise in the earth's mean temperature was tested in the confirmatory questionnaire survey. It was found that such a misconception is well grounded among the larger community population; the majority (55.3%; N=114) of the respondents held true that the earth's temperature is rising because of the depletion of the ozone layer. Another 23.7% of the respondents also thought that such a notion might be true.

Table 4.2: Percentage distribution of responses to statements regarding heat exposure risk (on a 5 point Likert scale)

Statement	True	Maybe True	Don't Know	Maybe False	False
"Heat exposure risk to extreme heat will increase due to long time exposure to sunlight"	54.4%	31.6%	10.5%	3.5%	0%
"Lack of access to water during heat wave time will increase the heat exposure risk to extreme heat"	53.5%	31.6%	13.2%	1.8%	0%
"Heat exposure risk to extreme heat will increase due to inadequate ventilation in building"	59.6%	27.2%	13.2%	0%	0%

A set of questions, on a five-point Likert scale, was used to enquire the respondents' degree of awareness and the nature of their beliefs. A very high degree of awareness of heat wave risks and their associated features was observed among the community respondents. The responses revealed that an overwhelming majority conceded that heat exposure risk is a function of not only the heat *per se,* but is also related to the condition of the housing (inadequate ventilation), the duration of exposure to sunlight, and the lack of access to water; the respective percentages were 86.8, 86 and 85.1 (Table 4.2).

In respect to potential effects of heat waves, health, infrastructure, and social dimensions were explored. The findings of my study revealed that most respondents are aware of, and concerned about, the adverse effects of heat waves. More than 90% of the respondents indicated that there could be an association between high mortality rate and an extreme heat wave condition. About three-quarters of the respondents believed that food and water contamination could occur during the heat wave; a similar proportion was also observed in the case of an increased spread of diseases due to heat waves (see Table 4.3). The overwhelming majority of the community respondents also believed that loss of power supply, power cuts and other similar damages could occur during a heat wave (86.9%).

Although an analysis of responses regarding heat wave events reveals a high awareness of these aspects in the community residents' mental model, a significantly different perspective emerged from the examination of responses regarding prevention and mitigation measures concerning heat wave effects. Notably, less than one-fifth of the respondents believed that precautionary measures can reduce high mortality rates associated with heat waves; 23.7% of total respondents did not answer the question and 57% of the respondents did not believe that such precautionary measures could be taken. Similarly, 61.4% of the respondents did not believe that by improving building codes (design, materials and air conditioners) heat exposure risks could be minimized. Only 9.6% thought that such institutional measures could reduce heat exposure risks. It is important to report here that the data of the confirmatory questionnaire survey reveal that the community respondents did not recognize a vital role of the media in increasing awareness and in providing suggestions for actions and thereby minimizing the heat exposure risk. A total of 77.2% of the respondents thought that heat exposure risk could not be minimized by paying adequate attention to media coverage of the concerned issue (Table 4.4).

Table 4.3: Percentage distribution of responses to statements regarding effects of heat wave (on a 5 point Likert scale)

Statement	True	Maybe True	Don't Know	Maybe False	False
"A heat wave can lead to significant social and economic changes"	51.8%	29.7%	14%	4.4%	0%
"A heat wave can lead to the increased spread of diseases"	33.3%	41.2%	20.2%	5.3%	0%
"Food and water contamination will occur during a heat wave"	34.2%	38.6%	17.5%	8.8%	0.9%
"Loss of power supply, power cuts and other social damages will occur during a heat wave"	51.8%	35.1%	12.3%	0.9%	0%
"High mortality rate are associated with an extreme heat wave condition"	52.6%	37.7%	8.8%	0.9%	0%

Morgan et. al (2002: 84) insist that calculating the frequency of concepts evident in the target population enables policy makers and communicators to determine both widely shared correct concepts upon which a message can be constructed and widespread misconceptions that need to be addressed.

Table 4.4: Percentage distribution of responses to statements regarding heat exposure risk reduction by human interventions (on a 5 point Likert scale)

Statement	True	Maybe True	Don't Know	Maybe False	False
"High mortality rate due to heat wave is largely preventable by taking precautionary measures"	2.6%	16.7%	23.7%	20.2%	36.8%
"Heat exposure risk could be minimised by improving building codes (i.e. design, materials, A.C)"	2.6%	7%	28.9%	17.5%	43.9%
"Heat exposure risk could be minimised by paying adequate media attention".	0%	9.6%	13.2%	31.6%	45.6%

In my confirmatory questionnaire survey results, convergent validation was noticed in relation to the open-ended interview outcomes in at least in four areas. These areas were widely held as shared correct concepts. In general, at the local community level, there was a clear awareness of the human activity-induced atmospheric emissions, their effects on the rise of atmospheric and oceanic temperature, and the resultant change in the climatic regimes. There was also considerable awareness of various social, environmental, and infrastructural features that enhance risk to heat wave hazards. The community residents' mental model was also characterized by clear concepts of heat wave effects, particularly on human health.

Among the identified misconceptions, a primary one was in relation to the concept of a positive relationship between atmospheric ozone depletion and global warming. Considering a high degree of uncertainty on the one hand, and without specific knowledge of possible intervention by institutional measures (i.e. building codes, alert system) on the other hand, the community residents' mental model contains some ambiguities. For instance, community members thought that climate change issues should be addressed primarily by institutional policy measures and programs; in contrast, they also believed that institutional precautionary measures would not be effective in reducing the heat wave risk. As well, there was a lack of acknowledgement of the role of communication, specifically by the media, in enhancing awareness of heat waves and other hazards.

At the community level, it was observed that the community residents tend to deny the existence of the heat wave hazards or do not pay serious attention to such hazards and their associated risks. Despite Winnipeg's high vulnerability to heat wave hazards, there was little recognition that a heat wave could occur within the next decade. This could be attributed to the lack of experiential knowledge and learning since the City of Winnipeg has not experienced major heat waves in recent years.

CHAPTER 5: DISCUSSION

5.1 Introduction:

The results of this research have clearly shown that the experts and regulators' knowledge and perceptions of climate change-induced heat wave risks are based on recent and ongoing research outcomes, scientific reasoning, and real-time and model-based observations. Diverse issues were generated from the community residents as well as from the vulnerable groups; some issues were more notable and emerged as common patterns among the data. The face-to-face interview results indicated some significant patterns in the community residents' knowledge model, as described in Section 4.3 of Chapter 4. A comparison between the expert and community residents' knowledge models has revealed that there are significant gaps. These have profound implications for decision-making and policymaking at all levels.

A key and fundamental question arises concerning the nature of the variability in risk perception and other components of the knowledge model as well as concerning the different factors that influence them. In general, the existing literature, encompassing both disciplinary and interdisciplinary studies, indicates four sets of explanatory variables that influence risk perception, risk estimation, and the associated overt behaviour: experiential, psychometric (e.g., personality traits), socio-economic and demographic factors. Building on the results presented throughout chapter 4, the goals of this chapter are: i) to determine the gaps between the perceptions of experts and community residents of the causes and effects of heat waves and of potential preventive and mitigation measures; and ii) to examine the factors that influence the variability in risk perception and provide a discussion of their pertinence to risk and hazard management in urban areas.

5.2 Gaps between Experts' and Community Residents' Knowledge Models:

The findings of this study have revealed significant gaps between experts and community residents' knowledge models. These gaps are evident in:

i) Understanding the natural processes and climate change dynamics

ii) Comprehending the causes of the rise of global atmospheric mean temperature

iii) Conceptualizing heat waves, particularly in terms of the required duration to be a threat to life and property

iv) Identifying the impacts of heat waves other than on the health sector

v) Heat wave "risk estimation" for the City of Winnipeg and its neighbourhoods

vi) The role of precautionary measures at the individual level in affecting the potential mortality rate due to heat wave events.

Gaps were registered in each of the six areas under study. The most conspicuous difference was recognized in two areas: i) when community members were specifically asked about heat wave "risk identification" and "risk estimate" in the context of the City of Winnipeg, their responses revealed a lack of recognition of heat wave risk in Winnipeg or their lack of interest in such issues; and ii) in the community residents' knowledge model, it was evident that they were aware of the nature of the risk to heat exposure and of the potential adjustment of individuals' behaviour when exposed to hot weather, but they did not believe that the heat wave mortality rate could be minimized by taking personal or institutional precautionary measures.

Several recent studies (Bellisario 2001; Blair 1997) that examined historical data of the number of days with a daily maximum temperature of more than 30° Celsius determined that Winnipeg is one of the most susceptible cities to hot weather and heat wave hazards. The experts' knowledge model concerning climate change-induced heat wave hazards, based on real-time observations, recognized the existence of heat wave risks in large cities (Figure 4.1). As explained by Covello and Mumpower (1985), the experts' knowledge model includes modern risk analysis expressed in terms of mathematical probabilities and confidence intervals, as well as identified causal links between dependent and explanatory variables. In such efforts, the emphasis therefore is on 'rational' and logical reasoning to determine the degree and nature of risk.

Voluminous and rich literature is available which evidently demonstrates that risk identification and risk estimation are linked to the perception of risk (Cutter, 1993). Morgan et al. (2002) have explained that experts therefore often describe "risk" in terms of the expected numbers of deaths. From such a perspective, the "accident risk" of a given technology, for example, can be obtained by multiplying the probability of an accident occurring by the number of people who will be killed if it happens. Nonetheless, what is interesting is that when community members or the public rank hazards, risks, activities and technologies in terms of "risk", the lists could vary considerably from those generated by the best-guess statistical estimate of expected fatalities. Established institutions and many experts view this gap as "evidence of public stupidity or ignorance" (Morgan et al., 2002; 10). In fact, as the community residents' knowledge model has demonstrated, people use a more complex, "multi-attribute" concept of risk, which includes further considerations than the expected number of fatalities.

A comprehensive review of hazard and risk perception studies by Burton et al. (1978) showed that people often do not recognize that they live in a hazardous environment or are not overly concerned with the impact of hazards and indicated this is common across the continent. Examples described the risks faced by urban dwellers living in a floodplain in North America as well as African agriculturalists living in drought-prone regions. Further, the review pointed out that for less probable events, the public and expert judgments and views diverge significantly. It has been observed that individuals' risk estimations or hazard-probability judgments ignore uncertainty as they underestimate the probabilities or pass the blame to others. Two factors can explain such behaviour. First, extreme environmental events that have a recurrence interval within community members' memory provide them with better knowledge and more accurate perceptions of the probability that the hazard will occur and affect them. In this context, Morgan et al. (2002) observed, based on experimental studies, that people often make subjective judgments based on estimating the frequency of an event in terms of how easily they can recall past examples or how easily they can imagine such occurrences. They claimed that this explains some of the systematic errors observed in community residents' quantitative estimates of risk. Second, although some scholars have advocated that underestimation or lack of understanding the risk is often linked with individual or group efforts to maintain certain norms (Douglas and Wildavsky, 1982) as well as with justification expressed by individuals concerning their own behaviour, it can be strongly argued that the community residents tend to be more preoccupied with their day-to-day problems and place less priority to environmental risks.

As stated above, community residents did not believe that heat wave mortality could be avoided or reduced by taking precautionary measures, particularly at the personal level. The majority (57%) of the community respondents thought that although such actions might ameliorate heat wave effects on human health to some extent, they did not share the idea that, first, heat waves can cause considerable fatalities and second, severe effects of heat waves could be managed through human interventions, particularly in the area of health. These perspectives can partially be explained by the variability in personality (Simpson-Housely and Bradshaw, 1978). The elderly, the poor and people with specific types of personality traits may tend to lack life control and may rely on forces outside their own control (Chambers,1983; Ingham,1993)

Besides the two above conspicuous gaps, there were several other gaps in specific knowledge and perceptual areas of climate change-induced heat wave hazards and their effects on health. A recurring issue in the field of climate change impacts and adaptation is uncertainty; there is uncertainty in climate change projections, relatively poorer understanding of how the system would respond, uncertainty concerning how people would adapt, and difficulties in projecting future changes in supply and demand (Lemmen and Warren, 2004). Despite such constraints, experts focus on specifics concerning the causes, processes and consequences of climate change and its associated features, and they look for determinate answers. These notions were clearly reflected in our experts' knowledge model, which was developed based on a brainstorming session. An analysis of the components in the community residents' knowledge model of climate change-induced heat wave hazards and their effects has revealed that the community residents lacked a comprehensive understanding of the relationships between concerned variables. Therefore, many of the cited variables or features were treated as disparate entities. Similar to Morgan et al.'s (2002) study in the USA, the results of this investigation revealed that explanations of the physical mechanisms underlying global climate change were inconsistent and incomplete in the community residents' knowledge model. For example, air pollution and ozone depletion have been mentioned frequently as causes of global warming. It was noticed that misconceptions coexisted with correct beliefs, such as citing both ozone depletion and carbon dioxide emissions from automobiles.

The community residents' knowledge model also revealed that they were unable to recognize the importance of the duration of the period of high temperatures, and thus have had less precise idea about the commencement of a heat wave. Consequently, there could be a reluctance to take precautionary measures at appropriate time. Health Canada defines heat waves in relation to increased daily maximum temperature in a particular region, and if it persists for at least three consecutive days. In my study, however, respondents considered a very long period (two or three weeks, or sometimes a vague or ambiguous "prolonged period of time") with high temperatures to qualify as a heat wave. The community members' lack of knowledge of the severe impact of the occurrence of high temperatures during two or three consecutive days was apparent. Such a distortion in the community residents' knowledge model could be attributed to their lack of experiential knowledge, as well as inadequate and ineffective communication with citizens about the heat wave risk (Committee on Risk Perception and Communication, 1989: 5-6) and about the cumulative effects of hot weather.

Gaps have also been identified in the community residents' perceptions of heat wave effects. There was a general acknowledgement of the effects on infrastructure and the environment, but community people were more seriously concerned and scared about the potential health impacts of heat waves. In the experts' knowledge model, the psychosocial impacts of heat wave events received significant consideration whereas in the community residents' knowledge model psychosocial effects were absent. This pattern of a lack of consideration of psychosocial effects by the community residents could be partly attributed to the fact that such effects are not easily detectable as well as take place in the longer term.

It is apparent that community residents primarily consider their personal experiences and context when they evaluate the effects of hazards rather than assess larger socio-economic, infrastructural and environmental aspects. In this context, it is worth noting Lopez-Vazquez and Marvan's (2003) work, which suggests that, to deal with risk perception effectively, both the individual and social accounts of a dangerous object need to be considered as they determine each person's approach to risk. Thus, the objects that are subject to risk are assessed by the underlying social and individual values. An individual's interpretation of risks is based on his or her values, beliefs, and world-view as well as the immediate environment.

An individual's perception of risk is profoundly influenced by previous experience; this assertion is supported by a substantial volume of literature. The most seminal work on this was carried out by Kates (1962) in the context of perceptions of flooding. He observed that floodplain inhabitants generally perceived a risk from flooding only to the extent or magnitude that they had previously experienced, and hence continued living exposed and vulnerable to the event of a larger flood. It was concluded that individuals are unable to conceptualize the risk of hazards they have never experienced before. The memory of past events presents a significant role in determining how individuals will perceive and respond to future events; "the biasing effects of memorability and imaginability may pose a barrier to open, objective discussions of risk" (Slovic et al., 1979: 15). Qualitative research by Bickerstaff et al. (2004) revealed that individuals in localities that could be considered proximal and potentially susceptible to climate change had difficulties relating to the effects of climate change on their local area. Where local residents did draw connections, they tended to reflect on issues where there was some immediate demonstration of effects. Since the urban community members might have been exposed to media coverage of heat wave effects on health, their general tendency is to personalize the hazardous situation. Furthermore, the preoccupation with health issues, particularly among the elderly population, has resulted in a pattern whereby respondents exhibited overwhelming emphasis on the health effects of heat wave hazards.

The face-to-face interview results indicated that potential heat wave hazards to society arising from climate change at large are evaluated more highly than individual threats. These findings conform with several recent European studies, including the study by Zwick and Renn (2002) in Germany and Lorenzoni (2003) in Italy and the UK. The European studies further revealed that although most Europeans are aware of the potential risk of climate change worldwide and the adverse effects that may befall society in general, they tend to attenuate the risks to themselves personally. In the USA, Bord et al. (1998) also observed that global warming is generally not perceived to be personally threatening. The study inquired about perceived personal threats from various social and environmental factors by asking the respondents to rank them, and registered that global warming was at the bottom among perceived personal threats, whereas heart disease, cancer and car accidents were listed at the top. The authors asserted that respondents distinguished between the personal and societal implications of threats, and that most of the non-context-specific studies which exhibit high concern about climate change, in reality, are indicating concern about social impacts.

I would like to argue that for the same reason, the community respondents in Winnipeg indicated that they would prefer stricter regulatory measures, particularly the enforcement of governmental laws and regulations to reduce emissions and thereby address the problem of rising atmospheric temperature. In other words, they tend to conceptualize climate change issues as broader societal matters unrelated to their personal context. The community respondents of Winnipeg indicated that the public institutions should be primarily responsible for dealing with climate change and the associated risk. In contrast, Zwick and Renn's (2002) research in Germany revealed that the German citizens designated more diverse institutions to control and manage risks. When asked to consider which institutions should be responsible and which would have the highest public confidence, industry and politicians were designated by about 50% of respondents to be responsible, while 42% assigned responsibility to scientists. Only 27.8% of respondents maintained that individuals are responsible, while 23.7% ascribed responsibility to environmental agencies, and only 3.3% to the media. It would be worthwhile to investigate further why citizens in Winnipeg designate public institutions as being responsible for solving or addressing climate change and related issues so overwhelmingly.

5.3 Inter-group Variation in Knowledge:

Gaps between experts and citizens' knowledge and perceptions of risk have been major policy issues since the 1940s, when the US Department of Agriculture began to depart from the conventional probabilistic estimates of consequences and attempted to understand why farmers responded as they did to soil erosion and land management hazards. It was recognized that there were serious limitations to so-called scientific models and prescriptions when they were applied by the resource users or citizens. Comparative assessment of the costs of natural disasters led to a more comprehensive analysis than technical-probabilistic calculations, as well as to the specification of the trade-offs among stakeholders wherever risk was managed (White, 1988). During the last seven decades, a good size of literature on the gaps between experts, decision-makers and policymakers on the one hand, and various stakeholders and the general population on the other hand, in the areas of risk, hazards and acceptable solutions has accumulated. Surveys to capture the preferred options of stakeholders and concerned citizens therefore have received wider attention as they have been used to provide inputs directly into the decision-making.

In contrast, the study of variation in risk perception and assessment between different stakeholders and other social groups has received little attention, although such gaps might have profound implications for understanding the underlying processes in risk perception, particularly in terms of the community residents' knowledge model of climate change-induced heat wave hazards. In my study, the community groups at large were covered through the face-to-face interviews and the confirmatory surveys.

Risk perception is largely influenced by individual personality, social forces, and cultural elements (Cutter, 1993). In addition, experience, ethnicity, gender, and socio-economic status also affect risk perception. The role of these specific explanatory variables will be discussed in the following section. The results of my study have indicated that community residents at the community level have a good understanding of the causal relationship between global warming and the recent increase in greenhouse gas concentration in the atmosphere, which has resulted primarily from human activity-related emissions. Such knowledge among the public reflects general social awareness of climate change issues and their linkage with the emission of greenhouse gases from human activity. It may be presumed that information dissemination and media coverage of relevant issues might have played a significant role in such public awareness concerning climate change. Numerous recent studies have suggested that the media's role in elevating such awareness must be underscored, particularly in areas where the scientific community deals with uncertainty and public engagement is critical (Lorenzoni and Pidgeon, 2006; Morgan et al., 2002; Sandman, 1994).

In my study, I observed that both the elderly and the low-income social groups are more knowledgeable than the community at large about the rise in mean atmospheric temperature. This seems to suggest that the vulnerable groups are more concerned about the global warming problem, and that they might have been exposed more to the media concerning such knowledge and information. A further explanation of the higher level of awareness among the elderly and low-income groups about the global temperature rise can be drawn from social network factors. This explanation is advocated by Short (1984) and Kalkstein and Sheridan (2007). They assert that risk perception and responses to hazards are mediated by social influences transmitted by friends, family, fellow workers and respected public officials. Kalkstein and Sheridan, in a study (2007) based in Phoenix, USA, observed that minorities have a greater sense of perceived risk; Hispanics were far more likely than whites to recognize that heat is very dangerous to them. They concluded that "it is likely that the threat of heat is reinforced socially, through friends and family, leading to a community with increased heat awareness" (Kalkstein and Sheridan, 2007: 51). In the case of Winnipeg, a similar inference can be drawn; it is highly likely that social influences are responsible for an increased awareness of the rise in global mean temperature. Further manifestations of the influences of social forces upon vulnerable groups, particularly in terms of environmental awareness, can be seen in other inter-group variations. In Winnipeg, the low-income group recognized the changing climatic patterns resulting primarily from atmospheric elements (such as high temperature and resultant forest fires), whereas the elderly group believed that climate change can be recognized in the rapid loss of natural habitat, the unprecedented rate of deforestation, and shortage of water. It is obvious that the elderly group possessed a much broader perspective as it demonstrated a high awareness of global issues and environmental elements relative to the low-income groups.

As explained above, the community members in general tend to be concerned about issues that relate to their personal conditions, and this applies to climate change and associated heat wave hazards. It appeared that community residents were more concerned about individual loss potential rather than the larger perspective of societal loss; this finding varies from similar studies in Europe, where respondents expressed serious concerns about the global impact of climate change (Lorenzoni and Pidgeon, 2006).

It is widely accepted that health concerns and issues play an overwhelming role among the elderly populations' mental configuration. As a result, in the discussion on the effects of heat wave hazards, the elderly respondents in my study expressed serious concerns about health impacts. Although the elderly cohorts in the population are more aware of broader global and environmental matters, they tend to personalize their responses to the effects of heat waves. Interestingly, low-income groups also stated that the health impacts due to heat waves were their major concerns. Limited social space and networks among the low-income groups might have resulted in a lack of awareness of other effects of heat waves (such as infrastructural, environmental, and societal effects) and led the low-income groups to limit their concerns primarily to health effects. It can further be argued that the better off groups are less concerned with heat waves because of their capacity to prevent or mitigate the effects such as, by having air conditioners in the house.

Vitek and Berta (1982) and Kalkstein and Sheridan (2007) insisted that perceived risk to a disaster can best be formed through personal experiences of the disaster as well as through education. Due to lack of education, community people may remain unaware that they are at risk in relation to an environmental disaster; they do not realize that they are in danger. In the context of my study, it is worth examining the nature of the Relationship between education and income status so that an inference can be made about the perception of heat wave risk.

Table 5.1: Relationship between Education and Income Status of Respondents (Figures within parenthesis are showing the frequencies)

Income Status	Level of Education		
	High School	Post Secondary	Total
Low ($10,000-$34,999)	25.0% (9)	75.0% (27)	100% (36)
Medium ($35,000-$64,999)	38.9 (14)	61.1 (22)	100 (36)
High (>$65,000)	20.5 (8)	79.5 (31)	100 (39)

A hypothesis that the low-income group would have the least education compared to medium- and high-income groups does not hold true in the case of our confirmatory survey sample (Table 5.1). Nonetheless, the percentage of post-secondary education was highest among the high-income group. Therefore, a direct comparison between the low- and high-income groups is feasible; it reveals that the low-income group, having a lower level of education relative to the high-income group, would be less aware of the disaster risk.

There is ample evidence that the vulnerable groups, such as the low–income and the elderly groups, often lack control ability and self-determination. As explained earlier, these features have direct effects upon individual perception and self-efficacy. The findings of my study reveal that relative to the community at large, low-income groups and the elderly tend to be more accepting the happenings and generally reluctant to undertake preventive and mitigation measures against the threat of heat wave disaster. The elderly may tend to perceive that they are not capable of controlling the situations and therefore tend to be more accepting the given situations. In addition, concerning the responsibility of preparing and responding to the heat wave hazard, the low-income groups referred only to public institutions. They did not indicate a role for themselves to share in such responsibilities or for other institutions to be involved.

5.4 Explanatory Factors in Risk Perception and Potential Adjustment Behaviour:

A considerable volume of research findings have accumulated since the post-Second World War era concerning factors that influence human perception and adjustment behaviour. One of the most comprehensive studies of this kind was carried out by Susan Cutter during the 1990s (Cutter, 1993). In her study, Cutter identified individual personality, social variables, and cultural forces for influencing how individuals, groups, and society perceive risks and render judgments on the acceptability of risk. Slovic et al. (1974) and Burton et al. (1978) registered a linkage between these factors and human adjustments to avoid or reduce disaster risk and impact. One of the most widely discussed explanatory variables for clarifying variations in risk perception and coping behaviour is *previous experience* (Burton et al. 1978; Edelstein, 1988). However, Burton et al. (1978) insisted that multiple factors explain variations in attitudes and coping responses, such as prior experience of the hazards, material wealth status, personality and the role of the individual in the social group. Cross-cultural risk comparisons were also made by several scholars (Kleinhesselink and Rosa, 1991). They confirmed that culture influences risk perceptions considerably. Cutter (1993) insists that environmental philosophies and ideologies assist in shaping individual and societal views towards nature, technology and associated risks. She provided examples of ecocentrist and technocentrist views, where the former sees the world through the lens of natural laws and the latter through a utilitarian lens, where nature is to be used for the betterment of society. Proximity to or distance from the source of risk can also have a direct bearing on the risks that populations are exposed to during or immediately following a hazardous event. Lindell and Earle (1983) argued that distance not only serves as an indicator of danger, but cognized or estimated distance serves as a heuristic anchor for assessing risks and individual vulnerability to threats.

Another set of explanatory variables are the ascribed and non-ascribed attributes of a population as they can both influence risk perceptions and potential adjustment behaviour. These include race, gender, age and socio-economic status. Although earlier "natural hazard studies" did not ascribe much significance to these explanatory variables to clarify variation in risk perception and overt behaviour, several recent studies have refuted this assertion (Cutter, 1993; Haque, 1997). In light of these citations, it is important to explore the potential explanatory variables, especially selected socio-economic and demographic variables, in order to clarify variations in heat wave risk perception and in potential preventive and mitigation measures in Winnipeg. The focus can be on the major questions and issues where significant knowledge gaps have been identified.

5.4.1 Greenhouse Gas Concentration and Heat Wave Linkage:

In my study, community respondents were asked about heat wave hazards and their linkage with greenhouse gas concentration in the atmosphere. The overwhelming majority (87.7%) considered such a relationship either "True" or "Maybe true" and only 12.3% did not know about such a relationship. These responses reflected that community residents are generally aware of the effect that the greenhouse gas concentration in the atmosphere has on extreme environmental events like heat waves, droughts, floods, and tornadoes. Considering the fact that education, income status and age have a direct bearing upon the knowledge of environmental risk and extreme events, their role in explaining the variability in relation to the above question was explored. The percentage distribution (Table 5.2) between the responses to the statement that "heat wave is occurring due to increased greenhouse gas concentration in the atmosphere" and "level of education" clearly supports the notion that highly educated people (university graduates) are more knowledgeable about such relationships relative to high school graduates ($\chi^2_{cal} = 1.50$; χ^2_{crit}=5.99; $\alpha = 0.05$; df = 2).

Table 5.2 Relationship between Education and Responses to the Statement "Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"

"Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"			Question 4			Total
			3 (Don't Know)	4(Maybe True)	5 (True)	
Education	High School Graduate	Count	4	24	3	31
		% within Education	12.9%	77.4%	9.7%	100.0%
		% within Question4	28.6%	29.6%	15.8%	27.2%
	University Graduate	Count	10	57	16	83
		% within Education	12.0%	68.7%	19.3%	100.0%
		% within Question4	71.4%	70.4%	84.2%	72.8%
Total		Count	14	81	19	114
		% within Education	12.3%	71.1%	16.7%	100.0%
		% within Question4	100.0%	100.0%	100.0%	100.0%

In support of the hypothesis that income status influences the level of knowledge concerning the environment and associated features, the data of my empirical investigation reveal that persons with low incomes were least knowledgeable (16.7% elicited "True" and 33.8% elicited "Maybe true") about the potential impact of greenhouse gases on heat wave occurrences (Table 5.3) ($\chi^2_{cal} = 4.30$; χ^2_{crit} =9.49; $\alpha = 0.05$; df = 4). The corresponding percentages for the middle-income groups were 44.4% (elicited "True") and 32.5% (elicited "Maybe true") and for the high-income group were 38.9% (elicited "True") and 33.8% (elicited "Maybe true").

Table 5.3: Relationship between Income Status and Responses to the Statement "Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"

"Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"			Question4			Total
			3	4	5	
Income	$10,000-$34,999/Year	Count	6	27	3	36
		% within Income	16.7%	75.0%	8.3%	100.0%
		% within Question4	46.2%	33.8%	16.7%	32.4%
	$35,000-64,999/Year	Count	2	26	8	36
		% within Income	5.6%	72.2%	22.2%	100.0%
		% within Question4	15.4%	32.5%	44.4%	32.4%
	>=$65,000 /Year	Count	5	27	7	39
		% within Income	12.8%	69.2%	17.9%	100.0%
		% within Question4	38.5%	33.8%	38.9%	35.1%
Total		Count	13	80	18	111
		% within Income	11.7%	72.1%	16.2%	100.0%
		% within Question4	100.0%	100.0%	100.0%	100.0%

An examination between age group and the statement regarding the effects of the concentration of greenhouse gas on heat waves has shown that the adult group is most knowledgeable compared to the young and elderly groups ($\chi^2_{cal} = 5.64$; $\chi^2_{crit} = 9.49$; $\alpha = 0.05$; df = 4). A test of significance was carried out to find out whether the inference from our sample can be applied to the study population (i.e., residents of North Kildonan in the City of Winnipeg), at a certain probability level (e.g., $\alpha = 0.05$). The results have exhibited that none of the selected explanatory variables, namely, education, income or age, is statistically significant at the 0.05 level of significance, to explain the variability in the responses regarding the relationship between greenhouse gas concentration in the atmosphere and heat wave hazards. This implies that the findings of our sample concerning the above issue need to be treated cautiously when applied to the entire population of the North Kildonan Ward.

Table 5.4: Relationship between Agegroup and Responses to the Statement "Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"

"Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere"			Question4			Total
					5	
Agegroup	25-45 Years	Count	7	24	4	35
		% within Agegroup	20.0%	68.6%	11.4%	100.0%
		% within Question4	50.0%	29.6%	21.1%	30.7%
	46-65 Years	Count	7	40	10	57
		% within Agegroup	12.3%	70.2%	17.5%	100.0%
		% within Question4	50.0%	49.4%	52.6%	50.0%
	66-85 Years	Count	0	17	5	22
		% within Agegroup	.0%	77.3%	22.7%	100.0%
		% within Question4	.0%	21.0%	26.3%	19.3%
Total		Count	14	81	19	114
		% within Agegroup	12.3%	71.1%	16.7%	100.0%
		% within Question4	100.0%	100.0%	100.0%	100.0%

Knowledge and awareness of the causal relationship between human activities, the consequent emissions of greenhouse gases into the atmosphere, the rise in the concentration of such gases in the atmosphere and resultant increase in mean temperature, and, finally, the outcomes in the form of environmental changes and extreme events all have been captured in our experts' knowledge model. In the community residents' knowledge model, it appeared that a clear understanding of these relationships is generally absent. However, some parts of this knowledge domain are well understood by the public. The media, particularly since the 1980s (Schoenfeld, 1980; Allan et al., 2000), and public education efforts undertaken by environmental groups have played considerable roles in raising awareness of some specific relationships in the climate change issues and their associated determinants.

The enhancement of public awareness of critical social and environmental issues has taken place in the developed world through a significant contribution made by the media.

However, media reports have an inherent bias towards spectacular events and thus often fail to provide a comprehensive coverage of issues. In this context, Allan et al. (2000) cited that "a focal point for several research inquiries during this period [the 1980s] concerned the ways in which news coverage typically places a priority on spectacular events" (pp. 5-6).

As a result, public knowledge that relies on the media is often found to be segmented, piecemealed, and ambiguous. This explains why my survey results revealed that the community residents' knowledge model contains a good understanding of the role of human activity-related atmospheric emissions and their effects on the atmospheric temperature. Nevertheless, their comprehension of the processes involved in climate change and their effects were found to be relatively poor.

Public education on environmental issues has been greatly influenced by the discourse of environmental movements as effective social and political forces. With varying degrees of influence, environmental interest groups have distinguished themselves into mainstream, greens and grassroots (Kraft, 2001). They have influenced public policy formulation and coordinated public mobilization through public education, direct action, and social change. Kraft denoted that the green groups and grassroots organizations possessed a greater capacity to appeal to the public's identification with local and regional environmental issues. It is obvious that the residents of Winnipeg were likely to have been subject to such efforts undertaken by the local and regional environmental interest groups.

The role of public policies and programs in developing environmental education and enhancing awareness cannot be underestimated. In this context, Kraft (2001) insists that:

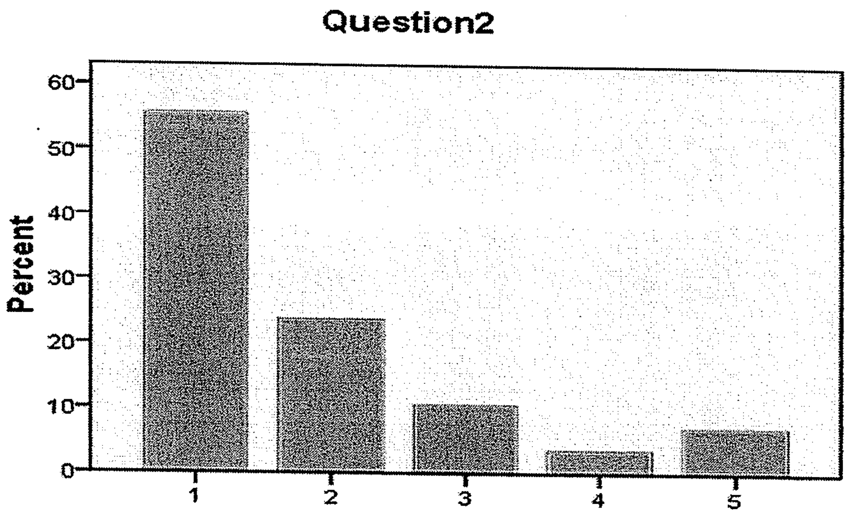
> "Government policies affect the design and use of economic incentives and changes in society's environmental values (e.g., through educational programs). We look to government for such policies because environmental threats represent public or collective goods problems that cannot be solved through private action alone" (p. 9).

Public education and awareness of environmental issues and problems have been profoundly influenced by the discourse in governmental policies and programs that has developed in many European (Lorenzoni and Pidgeon, 2006) and North American countries (Morgan et al., 2002). Many recent efforts by the governments of the European Union and its national entities to raise public awareness on climate change and its associated impacts are noteworthy. For example, in 2004 the British Prime Minister was directly involved in public mobilization to recognize that there are inherent difficulties in moving towards a carbon-neutral society and in calling for collective concerted action. In Canada, the Climate Change Impact and Adaptation Program of Natural Resource Canada is a good example of a public institution's initiative to advance research, knowledge and public awareness of pertinent issues concerning collective goods.

5.4.2 Misconception about the Rise in Global Temperature and Ozone Depletion Relationship

There is a widespread misconception in both Europe (Lorenzoni and Pidgeon, 2006) and North America (Morgan et al., 2002) about a causal relationship between the depletion of the stratospheric ozone layer due to the production of CFCs and climate change. The findings of my study conform to such a notion, implying that the residents of Winnipeg neighbourhood communities also hold a similar misconception. In our confirmatory survey, I enquired whether the respondents believe that the earth's mean temperature is rising because the stratospheric ozone layer is rapidly depleting.

Figure 5.1: Bar graph showing the percentage distribution of the responses to the statement that "The earth's mean temperature is rising because of a hole in the ozone er" (1=True, 2=Maybe True, 3=Don't Know, 4= Maybe False, 5=False)



An overwhelming majority of the community respondents were found to have a strong misconception; 55.3% of the respondents indicated that such a statement was "True" and 23.7% believed it was "Maybe True". Only one-tenth of the respondents had a good conceptualization that such a causal relationship is not scientifically supported and therefore is not logical (See Figure 5.1; columns 4 and 5). Inconsistency and the lack of systematic organization of thoughts on complex systems in the community residents' knowledge model concerning climate change have been identified by many investigators, including Morgan et al. (2002), Cutter (1993) and Lorenzoni and Pidgeon (2006). Risk perception and understanding of the causal link between phenomena among the public vary considerably from scientific rationality (Freudenburg, 1988). They often tend to take a broader, more comprehensive and experiential notion and rely heavily on their own belief and value systems. These could lead them to be subject to *dissonance* (Wade et al., 2004) as well as to misconceptualize causal relationships between physical phenomena in natural and social processes. It is relevant to cite here the major factors that influence misperceptions of risk, as put forward by Slovic (2000) in his seminal work on the perception of risk. From a psychometric perspective, he identified that availability bias, imaginability, news media and uncertainty denial plays critical roles in constructing such misperceptions.

It was hypothesized that the more educated a person is the less likely he or she will have a misunderstanding of the causal relationship between variables related to climate change. This implies that educated people will have a lesser magnitude of misconception. The findings of the confirmatory survey data, however, do not support such a notion. A statistical test, at the 0.05 level of significance, has exhibited that this finding is statistically significant ($\chi^2_{cal} = 13.69$; $\chi^2_{crit} = 9.49$; $\alpha = 0.05$; df = 4).

Table 5.5: Relationship between Education and Responses to the Statement "The earth's mean temperature is rising because of a hole in the ozone layer."

"The earth's mean temperature is rising because of a hole in the ozone layer"			**Question 2**					
			1 (True)	2 (Maybe True)	3 (Don't Know)	4 (Maybe False)	5 (False)	Total
Education	High School Graduate	Count	13	9	1	3	5	31
		% within Education	41.9%	29.0%	3.2%	9.7%	16.1%	100.0%
		% within Question2	20.6%	33.3%	8.3%	75.0%	62.5%	27.2%
	University Graduate	Count	50	18	11	1	3	83
		% within Education	60.2%	21.7%	13.3%	1.2%	3.6%	100.0%
		% within Question2	79.4%	66.7%	91.7%	25.0%	37.5%	72.8%
Total		Count	63	27	12	4	8	114
		% within Education	55.3%	23.7%	10.5%	3.5%	7.0%	100.0%
		% within Question2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

From Table 5.5, it appears that 81.9% of highly educated (university graduate) respondents believe that the earth's mean temperature is rising because of a rapid depletion of the ozone layer; the corresponding percentage for high school graduate was 70.9. Based on this observation, it can be argued that education is not an important explanatory factor to clarify the concerned variability in the statement regarding the link between increasing atmospheric temperature and the depletion of the ozone layer. Rather the underlying belief and social value systems may explain such a misconception and dissonance.

A further test was carried out to investigate the explanatory capacity of the level of income to clarify the concerned misconception among the community members. The assertion that the misconception about the causal link between the earth's mean temperature and ozone depletion is correlated with lower level of income was not valid. The percentage of respondents holding the misconception was much higher among the middle- and high-income groups; 79.5% for the higher-, 80.6% for the middle- and 75% for low-income groups (See Table 5.6; $\chi^2_{cal} = 6.68$; $\chi^2_{crit} = 15.51$; $\alpha = 0.05$; df = 8).

Considering the fact that the level of income is a poor predictor for the stated misconception, I would like to argue that, in addition to other factors relating to the media, both psychometric factors that focus on individual personality traits and social values and belief systems are largely responsible for such a misconception

Table 5.6: Relationship between Income Status and Responses to the Statement "The earth's mean temperature is rising because of a hole in the ozone layer"

"The earth's mean temperature is rising because of a hole in the ozone layer"			**Question 2**					
			1	2	3	4	5	Total
Income	$10,000-$34,999/Year	Count	22	5	4	2	3	36
		% within Income	61.1%	13.9%	11.1%	5.6%	8.3%	100.0%
		% within Question2	36.1%	19.2%	33.3%	50.0%	37.5%	32.4%
	$35,000-64,999/Year	Count	19	10	2	1	4	36
		% within Income	52.8%	27.8%	5.6%	2.8%	11.1%	100.0%
		% within Question2	31.1%	38.5%	16.7%	25.0%	50.0%	32.4%
	>=$65,000 /Year	Count	20	11	6	1	1	39
		% within Income	51.3%	28.2%	15.4%	2.6%	2.6%	100.0%
		% within Question2	32.8%	42.3%	50.0%	25.0%	12.5%	35.1%
Total		Count	61	26	12	4	8	111
		% within Income	55.0%	23.4%	10.8%	3.6%	7.2%	100.0%
		% within Question2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

5.4.3 Heat Exposure Risk

As presented in Chapter 4, there is a clear gap between regulators or experts and community-based community residents in the understanding of the health risk related to heat waves. It was reflected in the findings that a vast majority of the respondents considered heat wave occurrence only when hot weather continues over a very long time, specifically, for more than a week. In contrast, for example, Environment Canada uses a parameter of two consecutive days of hot weather with an average daily maximum temperature of 30° Celsius for Winnipeg. Further, it was emphasized that temperature alone does not determine adverse health impact, as humidity and other physiological conditions also play major roles. Although public institutions and regulators have recently recognized these aspects by incorporating such parameters in the heat wave risk, the public may not be aware of such distinctions. A test was conducted to determine people's beliefs whether the heat exposure risk to extreme heat would increase if someone were exposed to sunlight over a long period. It is apparent from Table 4.2 that the vast majority (86%) of the community respondents lacked the knowledge that long-time exposure to sunlight alone does not generate heat exposure risk, particularly in terms of health. Instead, many other factors, such as access to water and clothing habits, are also responsible for causing such risks.

Three explanatory variables, namely, level of education, level of income and gender differentials, were selected to test their influence upon the concerned issue of heat exposure risk and exposure to sunlight over a long period. It was observed that although more university graduates (87.9%) have a misconception of the stated issue than the high school graduates (80.7%), the variation is found to be nominal ($\chi^2_{cal} = 2.15$; $\chi^2_{crit} = 7.81$; $\alpha = 0.05$; df = 3). The level of income was also found to be a poor predictor of the variation in the understanding of the heat exposure risk in relation to long-term exposure to sunlight ($\chi^2_{cal} = 6.51$; $\chi^2_{crit} = 12.59$; $\alpha = 0.05$; df = 6). In Canadian society, men are usually more exposed to outside work relative to females, and this phenomenon could make a difference in risk perception between genders. The results of our confirmatory survey have revealed that there is no significance difference between males and females with regard to the stated concept of heat exposure risk ($\chi^2_{cal} = 4.26$; $\chi^2_{crit} = 7.81$; $\alpha = 0.05$; df = 3).

Based on the above analysis, it could be inferred that the community members lacked clarity on heat exposure risk to extreme heat, irrespective of their level of education, level of income and gender differences. The findings also affirm that more vigorous public education and improved risk communication are needed, especially in the area of health risk to extreme heat exposure.

5.4.4 Precautionary Measures to Make a Difference in Heat Wave Mortality Rate

The results of taking precautionary measures for the purpose of reducing the heat wave-related mortality rate were presented in Section 4.4 of Chapter 4. It is apparent that the majority of the respondents did not believe that precautionary measures can be effective in reducing heat wave-related mortality. About one-quarter of the respondents are totally unaware of such precautionary measures as well. Overall, the data revealed that the community members either lack knowledge of such vital issues relating to heat wave hazards or do not have the confidence that individual responsibility or collective responsibility could save a considerable number of lives. In this context, the findings of a study in the USA conducted by Bord et al. (1998) are worth citing. They concluded that the low salience of global warming and the persistent misunderstanding of the problem were likely to create hindrances against behaviour change towards mitigation measures.

The perspectives evident in the findings of the present study, as explained in Section 5.2 of this Chapter, can be seen in terms of the variability in personality (Simpson-Housely and Bradshaw, 1978). The elderly, the poor and people with specific types of personality traits may lack life control and rely on forces outside their own control. Chambers (1983) and Ingham (1993) asserted that marginalized people's lack of control over basic economic and social mechanisms reinforces their situation of disenfranchisement, powerlessness, passivity and apathy. Recent studies revealed that they rather are less engaged with such issues.

In reference to the above discussion, a test of independence was carried out between age groups and the issue of the role of precautionary measures in preventing heat wave-related mortality. It was found that the young group possessed an optimistic view of life and felt that it was worth undertaking precautionary measures to attempt to prevent heat wave-related mortality. More than one-third (34.3%) of the young respondents believed that by taking precautionary measures heat wave-related mortality could be prevented. In contrast, both adult and elderly groups have relatively less optimistic views about the ability of human actions to affect heat wave-related mortality. None of the elderly respondents held a view that precautionary measures could make a difference, and only 17.6% of the adult group indicated that such precautionary measures would work to prevent heat wave-related mortality. Such a response was likely to have been influenced by the fact that the elderly tend to be more accepting given situations as they feel not to be able to change the factors; these result in the reluctance to become proactive in undertaking preventive, mitigation or precautionary measures.

Education positively influences knowledge-gathering and awareness of health, the environment and society. In light of this assertion, it can be hypothesized that persons with a higher level of education are likely to have more knowledge and awareness of the positive role of precautionary measures than persons with a relatively lesser level of education.

The data of our confirmatory survey have revealed no significant difference in the statement concerning the role of precautionary measures by the level of education. Such a nominal role of education in motivating community respondents to take precautionary measures might have been influenced by the fact that they generally lack comprehension of climate change and other complex processes. The statistical test also showed that, at the 0.05 level of significance, the relationships between these two concerned variables are not significant (Table 5.7) ($\chi^2_{cal} = 8.12$; χ^2_{crit} =9.49; $\alpha = 0.05$; df = 4).

Table 5.7: Relationship between Education and Responses to the Statement "High mortality rate due to heat wave is largely preventable by taking precautionary measures"

"High mortality rate due to heat wave is largely preventable by taking precautionary measures"			Question14					
			1	2	3	4	5	Total
Education	High School Graduate	Count	11	2	12	5	1	31
		% within Education	35.5%	6.5%	38.7%	16.1%	3.2%	100.0%
		% within Question14	26.2%	8.7%	44.4%	26.3%	33.3%	27.2%
	University Graduate	Count	31	21	15	14	2	83
		% within Education	37.3%	25.3%	18.1%	16.9%	2.4%	100.0%
		% within Question14	73.8%	91.3%	55.6%	73.7%	66.7%	72.8%
Total		Count	42	23	27	19	3	114
		% within Education	36.8%	20.2%	23.7%	16.7%	2.6%	100.0%
		% within Question14	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In reference to Rotter (1966) and Simpson-Housely and Bradshaw's (1978) use of the concept of capability, it can be suggested that individuals or families with privileged and higher economic well-being, specifically with a higher level of income, will have the characteristics of being proactive and optimistic and hold a more pragmatic view of life. It is worth examining the hypothesis that there is a positive Relationship between income and the view that supports the positive role of precautionary measures. Data presented in Table 5.8 indicate that community residents with a very high income level ($65,000/year) have the confidence that precautionary measures can prevent human mortality due to heat wave. A total of almost one-quarter (23.1%) of the respondents agreed that a statement suggesting that precautionary measures are effective in preventing human mortality was "True" or "Maybe True", while the corresponding percentage in the middle-income group was 13.9% and for low-income group it was 19.4%. Further evidence of a passive attitude towards precautionary measures among the low- and middle-income groups relative to the high-income group was also found in our confirmatory survey results. Reflected in the response as "False", the percentage for the low-income group was 55.6% and for the middle-income group it was 36.1%, while for the high-income group it was only 23.1%. Our non-parametric test results revealed that these findings are statistically significant at the 0.05 level of significance ($\chi^2_{cal} = 18.50$; $\chi^2_{crit}=15.51$; $\alpha = 0.05$; $df = 8$).

5.4.5 Heat Wave "Risk Estimation" in Winnipeg

"Risk estimation" is one of the critical aspects of risk assessment, and it requires knowing what is the probability of each event as well as what is the nature of the consequences. The estimation of such human vulnerability (i.e., to lives and resources) thus attempts to measure the likelihood of an event occurring, as well as the likelihood and nature of the impacts that follow. Nonetheless, there are limitations in risk-estimation methodologies that are based upon human experience (Ferrier and Haque, 2003). As a collective entity, humans encounter risks from threats greater than their individual or separate group experiences. Irrespective of ingenuity, these limits would place us in what Kates (1962) termed the "prison of experience". Therefore, in some cases, human perception is larger than objective reality; in other cases, the perceived experience of hazard is less than the reality. Human cognition is also inclined toward ordered and determinate phenomena, and attempts to avoid unorganized phenomena.

Table 5.8: Relationship between Income Status and Responses to the Statement "High mortality rate due to heat wave is largely preventable by taking precautionary measures"

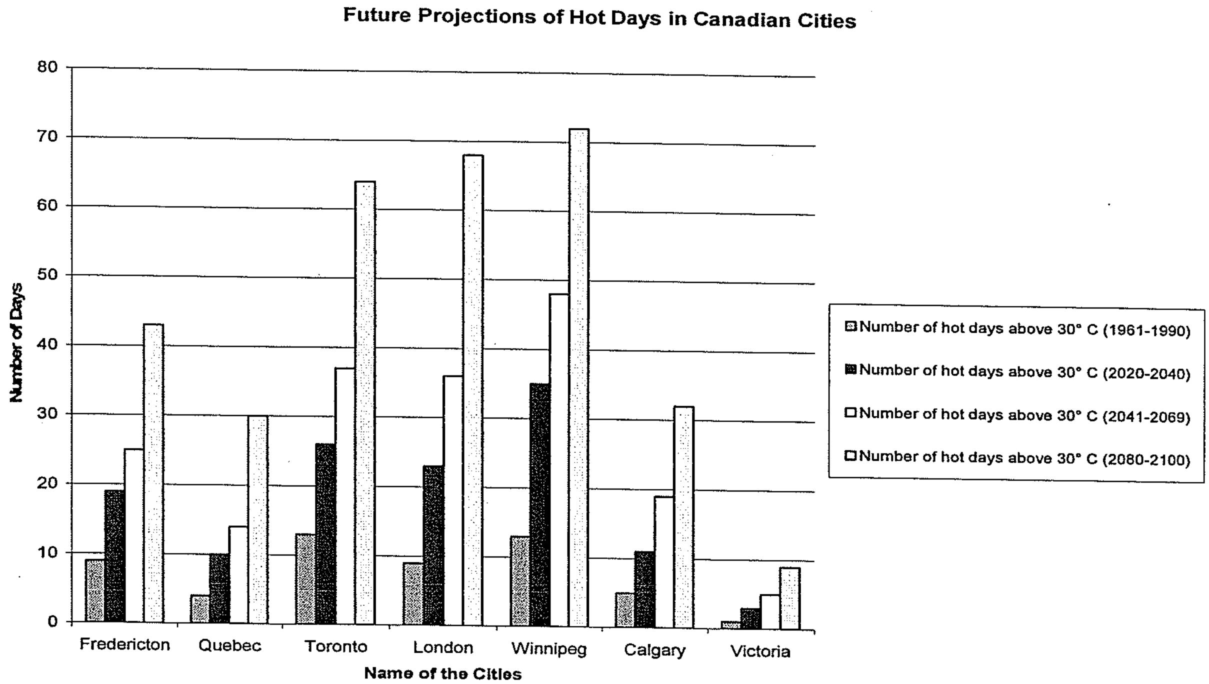
"High mortality rate due to heat wave is largely preventable by taking precautionary measures"			Question14					
			1	2	3	4	5	Total
Income	$10,000-$34,999/Year	Count	20	3	6	7	0	36
		% within Income	55.6%	8.3%	16.7%	19.4%	.0%	100.0%
		% within Question14	47.6%	13.0%	24.0%	38.9%	.0%	32.4%
	$35,000-64,999/Year	Count	13	7	11	5	0	36
		% within Income	36.1%	19.4%	30.6%	13.9%	.0%	100.0%
		% within Question14	31.0%	30.4%	44.0%	27.8%	.0%	32.4%
	>=$65,000 /Year	Count	9	13	8	6	3	39
		% within Income	23.1%	33.3%	20.5%	15.4%	7.7%	100.0%
		% within Question14	21.4%	56.5%	32.0%	33.3%	100.0%	35.1%
Total		Count	42	23	25	18	3	111
		% within Income	37.8%	20.7%	22.5%	16.2%	2.7%	100.0%
		% within Question14	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Due to these cognitive limitations, as Ferrier and Haque (2003) suggested, objective reality is not reflected most of the time in our efforts to share our perceived experiences. In light of this discussion, one can expect variation between the probabilistic heat wave risk estimation in Winnipeg and the perceived risk expressed by the community residents. One of my questions in the confirmatory survey instrument looked into this matter.

The basis of quantitative risk analysis and the application of probability theory in risk estimation have been succinctly analyzed by Covello and Mompower (2003). They suggested that the pertinent historical discourse followed the evolution of probability theory through the contributions made by Pascal, Bernoulli, Grier, and Halley. In practice, decision-makers throughout recent centuries have extensively applied both probability theories, which have relied primarily on observations of frequency and on the magnitude of past events. In order to estimate the magnitude of the risk, experts have applied the probability of the occurrence multiplied by the potential consequences.

Based on historical observation of hot weather and heat wave events, on the one hand, and considering the fact that there are some degrees of uncertainty, on the other, Health Canada has prepared future projections of hot days (temperature above 30° C) for selected cities of Canada (Berry and Paszkowski, 2005). Projections have been made for four distinct time periods: 1961-1990; 2020-2040; 2041-2069; and 2080-2100. Relative to Fredricton, Quebec City, Toronto, London, Calgary and Victoria, Winnipeg was identified as the most vulnerable city in terms of the number of hot days above 30° Celsius. Winnipeg was ranked at the top for all three study periods (2020-2040; 2041-2069; and 2080-2100) other than the 1961-1990 period (Figure 5.2). Keeping these probability-based projections in mind, community residents in Winnipeg were asked whether they perceived a heat wave occurrence in Winnipeg within the next 5- to 10-year span.

Figure 5.2: Future projections of hot days in Canadian cities, prepared by Health Canada

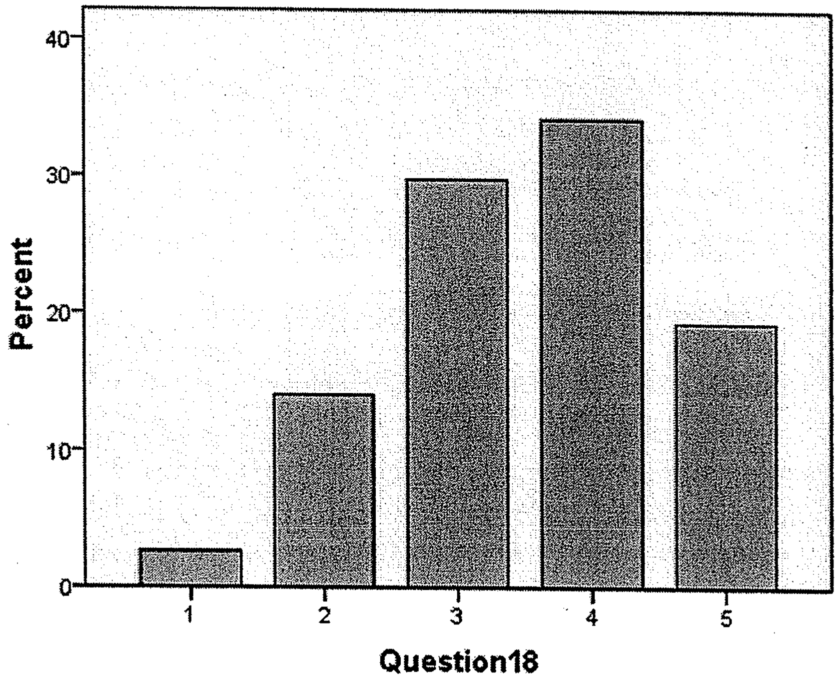


:

[Data obtained from: Berry and Paszkowshi (2005)]

As indicated above, a high degree of distortion can be expected in the public perception of future heat wave occurrence, especially in regions or areas that have not experienced similar extreme events in the recent past. The results of our confirmatory survey have revealed that, despite Health Canada's prediction of high frequency of the number of hot days above 30° Celsius in the near future, community respondents did not anticipate similar events in Winnipeg within the next 5-10 years. From Figure 5.3, it is apparent that the majority (52.6%) of the respondents believed that a statement suggesting "Winnipeg will experience heat wave in next 5-10 years" was "False" or "Maybe False". In addition, 29.8% of the respondents had no idea about such a heat wave risk.

Figure 5.3: Bar graph showing the percentage distribution of the responses to the statement that "Winnipeg will experience heat wave in next 5-10 years" (1=True, 2=Maybe True, 3=Don't Know, 4= Maybe False, 5=False)



A non-parametric test of the significance of the heat wave projection for the community residents at the community level in Winnipeg has indicated that the degree of variation in responses to the concerned statement was statistically "significant" at the 0.05 level of significance ($\chi^2_{cal} = 38.3$; $\chi^2_{crit} = 9.49$; $\alpha = 0.05$; df = 4).

In light of existing literature as well as considering the importance of some key explanatory variables, age, level of education and gender differentials were tested to explain the variability in the heat wave risk estimation evident among the community residents. As hypothesized, the experiential factor, reflected in age, was found to be a forceful predictor for heat wave risk estimation. The confirmatory survey data revealed that both adults and the elderly perceived future events in a similar fashion and more than 22% of each of these demographic groups believed that within the next 5-10 years a heat wave would occur in Winnipeg. Because the younger generation lacks previous experience of heat waves, their perceptual configuration suffers from an underestimation of heat wave risks. Our data have clearly indicated that such an assertion is valid in the case of urban Winnipeg communities, as 80% of the young group indicated that the statement that a heat wave will occur in Winnipeg in next 5-10 years was "False" or "Maybe False".

As the level of education is well recognized as a contributing factor to social and environmental awareness, as well as to relatively rational risk estimation, a test to determine the level of education and risk estimation was pursued. The results of our confirmatory survey indicate that the level of education significantly influenced the nature of heat wave risk estimation by the community residents. It was evident that the university graduates were more aware of scientific predictions concerning heat wave occurrence in Winnipeg in the coming decades compared to high school graduates; 19.3% of university graduates agreed that within the next 5-10 years Winnipeg would experience heat wave events, whereas the corresponding percentage for high school graduate was only 9.7%. In addition, the percentages of respondents who suggested that such a projection was either "False" or "Maybe False" accounted for the majority of both university and high school graduates; they were 54.2% and 51.6%. The influence of the level of education on heat wave risk estimation was also evident in the percentage distribution for those who indicated that they "Don't know" about the issue; the percentages were 26.5% for university graduates and 38.7% for high school graduates.

In perspective of the objectives of this research, the knowledge gaps and the public misconception about critical environmental and discussions on the heat wave hazard risk were given special emphasis. In this connection, key areas of knowledge gaps were first identified, followed by enquiries on the explanatory factors that influenced such gaps or variability. An extensive review of the concerned literature has offered a systematic understanding of the approaches used in the explanatory factors of risk perception and assessment. The three delineated approaches are: i) experiential factors, as emphasized by Burton et al. (1978), Kates (1962), Cutter (1993) and Haque (1997); ii) psychometric perspectives that emphasize personality traits, as indicated by Slovic (1993; 2000), Rotter(1966) and Simpson-Housely and Bradshaw (1978); and iii) socio-economic and demographic status, as identified by Cutter (1993), Olczyk (2005) and Hutton and Haque (2003). In our study, age was used as a proxy to previous experience because people gather experience over time and only qualitative data on the previous experience of heat wave events were available.

Overall, our analysis of the socio-economic, demographic and other descriptors of the knowledge gaps in issues of climate change, global warming, heat wave hazards, health stress and risk, and risk estimation has revealed that none of the selected explanatory variables (age, level of education, level of income and gender differentials) can explain all types of misconceptions and gaps. The results were mixed. Some of the knowledge gaps between experts or regulators and community members were found to be deeply embedded in the existing knowledge models. For example, a significant gap was identified in heat wave risk estimation between the community members' and the experts' knowledge models. In this regard, Cutter (1993) insisted that, as a result of our understanding of such divergence in perception of risk between the public and experts, and given the ensuing debates over the acceptability of such risks, the field of "risk communication" has only recently evolved. Conventionally, risk communication was regarded as a process that develops and delivers a message from the experts or agencies to the public, and such a one-way flow is designed to enable the community residents to better understand the risk of a particular phenomenon or option. Nonetheless, the scope of risk communication is widening to incorporate a two-way dialogue between experts or regulators and the public. Risk communication is therefore now viewed as a process of interactive exchange of information that offers the content of risk messages as well as balance between views and the accuracy of the message (Cutter, 1993: 47).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

The primary goal of this study was to identify the knowledge and perception gaps between experts' and community residents' regarding climate change induced heat wave hazards. The first objective was to assess the *state of knowledge and perception of climate change-induced `heat wave hazards among the expert community.* This assessment involved the construction of an 'expert knowledge model' by creating an influence diagram (a directed graph, with arrows or "influences" connecting related "nodes") that captured the pooled beliefs of technical specialists about the heat wave phenomenon. In this study, the model was created by using a focus group of experts from various, yet related, fields and disciplines. They provided their inputs concerning various issues related to the impacts of climate change induced-heat waves on individuals and communities as well as their root causes. These are as following:

i) rise in mean atmospheric temperature is considerably influenced by the greenhouse gas (GHG) concentration in the atmosphere;

ii) heat wave related different risk factors;

iii) adverse effects of this extreme heat wave condition in various sectors;

iv) various options for interventions to prevent or mitigate the adverse effects of heat wave

The second objective of this research was to analyse the *state of knowledge, perception and awareness of climate change in general and its associated heat wave hazards among the community members* at the local level. As outlined in Chapter 3, face-to-face interviews and confirmatory questionnaires mail out survey were implemented to identify knowledge gaps and risk perception difference between experts and community respondents. The findings reveal that a significant portion of community people does not perceive climate change and its associated features with clarity. Also, the community members' conceptualization of heat wave is not based on a cause-and-effect relationship among the different variables of climate change and physical heat wave phenomena. In my study, respondents considered a very long time period (such as two or three weeks, or sometimes the vague or ambiguous "prolonged period of time") with high temperatures as required for qualification as a heat wave. They were also more worried about heat wave induced health hazards rather than any other effects (i. e. environmental, infrastructural etc.). The most important factor in their domain of risk perception is that the heat wave mortality rate could not be minimised by taking precautionary measures as well as Winnipeg is not at vulnerable to heat wave phenomena.

The third objective of this research was to *identify the gap that exists between 'scientific/technical' and 'local community' knowledge regarding heat waves.* Chapter 4 encapsulated these knowledge gaps by analyzing face-to-face interviews and confirmatory questionnaires. Findings of my study revealed that there were significant gaps between experts' and community residents' knowledge model in six major areas. As discussed in Chapter 5, these gaps were in i) basic understanding gaps in climate change processes; ii) misconception about the rise of global atmospheric mean temperature, iii) conceptualizing heat waves, particularly in terms of required duration; iv) identifying impacts of heat waves other than on health sector; v) heat wave risk estimation for the City of Winnipeg and its communities and finally; vi) in the role of precautionary measures at the individual level in affecting potential mortality rare due to heat wave event.

The study was also intended to provide a basis to formulate effective risk communication strategies could help increase community coping capacity. This involved an exploration of how better risk messages could be created for the effective risk communication. As can be seen in chapter 5, an analysis of the findings of my inquiry has revealed that risk messages need to address three major knowledge-gap areas:

i) in community members' lack of recognition of heat wave hazards "risk identification" and "risk estimation" in Winnipeg;

ii) in community residents' believe that heat wave mortality rate could be minimized by taking personal precautionary measures; and

iii) in community members lack of clear understanding of the cumulative effects of hot weather if it stays for at least two to three days over a region because respondents considered a heat wave in terms of a very long time period (two weeks or three weeks, or sometime vague or with ambiguity by saying "prolonged period of time") with high temperature.

6.2 Implications from the existing gaps between experts and community residents

An important step in addressing the knowledge gap in decision making concerning risk reduction and management is to investigate the perceptions of risk that local residents apply to personal decision making processes as well as to support institutional decisions. In addition, it is also significant to investigate the perception of institutional experts who monitor, explain, and make the decisions that affect community residents. As was illustrated by Morgan et al. (2002) and Kalkstein and Sheridan (2007) studying the cases in the United States, the gaps in the knowledge model of experts and community people create serious challenges in risk reduction and management policies and programs. It was further noticed that the factor of uncertainty in climate change scenarios make such challenges more difficult for the decision makers. It is therefore utmost important that those responsible for managing risk and disaster situation are aware of how residents perceive and estimate risks, particularly by the most vulnerable groups. Without an understanding of these perspectives by experts and decision makers, efforts aimed at reducing greenhouse gas emissions, the pace of global warming and heat wave risk as well as vulnerability at the local level is less likely to be successful.

This study found that while some major gaps do appear to exist between experts' and community peoples' knowledge models, there are at least three areas of their knowledge models overlap. The majority of the community residents are aware and concerned about climate change, however, they do not regard it as a priority issue. At the local level, public perception of heat wave risks is quite high and a majority of the residents are knowledgeable about what measures can be taken personally to reduce heat wave or hot weather impacts. Community members are also aware of health effects of exposure to heat wave events.

Nonetheless, there are significant knowledge gaps between experts and community people that can be attributed in part to deficient communication. Many urban residents perceive that institutional experts are preoccupied with technical aspects of climate change and effects and thus fail to encapsulate real life oriented issues and problems. In contrast, some experts feel that local residents do not accurately understand cause and effect relationships in atmospheric and earth system as well as incorporate subjective judgment in perceiving heat wave risk and hence are not aware of real risk. These features imply that both experts and community residents have misconceptions of the other that have evolved because of a lack of meaningful risk communication as well lack of motivation to change on the part of local residents. As opposed to information and education, motivation is the psychological element that triggers interest, concern and action; awareness of risk and strategies may reduce risk but may not necessarily transform into direct action (Ronan and Johnston, 2005).

It is crucial to recognize that the motivating element to promote adaptive behaviour toward climate change and other threats to people's health and livelihoods, may lie beyond the immediate scope of climate change or risk mitigation. Therefore, coping and adaptation to climate change be framed within a broad strategy to which intends to strengthen the capacity of people to cope and adapt more effectively to living demands generally, not merely environmental and severe weather impacts (Hutton et al., 2007).

Analysis of the findings of my inquiry has revealed that risk messages need to address three major knowledge-gap areas, with clear and explicit statements with all of the intended points. These areas include: i) community members' lack of interest in heat wave hazards "risk identification" and "risk estimation" in Winnipeg; ii) in community residents' believe that heat wave mortality rate could not be minimized by taking precautionary measures, which implicitly indicate that their differential priorities which focus more on immediate worries; and iii) the community members lack a clear understanding of the cumulative effects of hot weather if it stays for two to three days over a region.

A potential solution may be a communication process involving personal meetings, public education through supplies of communication materials, informal workshops, and other means to disseminate heat wave related information and to receive residents' feedback. Any communication problems or concerns should be addressed through programs during non-emergency time and be given the due attention that would not be possible during the constrained time lines of an emergency. A more innovative approach to address the concerned issues is to develop a two way communication system whereby state of local knowledge and resources will be emphasised to inform the decision makers so that their knowledge base embodies local concerns and priorities. In turn, communication efforts by the decision makers to inform community residents will be characterized by a dialogue and negotiation between specialists and the residents. In this way, misconceptions that may exist among experts as well as community residents will be addressed.

6.3 Implications of knowledge and perceptions among the vulnerable groups

As illustrated by Hutton et al. (2007), it is critical that the diversity of both climate change and community are taken into account in attempts to improve risk perceptions and promote more adaptive behavior. The vulnerability of social and demographic groups and places to hazards and disasters is not equally distributed, but differs across regions and takes varied significance and different hazard zones.

Notably, the elderly were found to be more aware of the environment and broader global issues, however, they were generally passive in terms of life control and undertaking precautionary measures to prepare and reduce risks. In addition, the elderly who are living by themselves are particularly vulnerable to heat wave hazards which build up gradually and cumulatively. Targeted programs are therefore necessary for such special needs groups. As low income groups are generally preoccupied with personal and immediate worries, such as financial and health concerns, as well as local conditions which affect them more directly, policies and programs concerning climate change effects and heat wave risks must be designed for them in such a way so that they relate to the personal and community conditions of this vulnerable group. One of the potential institutional actions is to support and mobilize community based, local level organizations who have direct access and trust from the local community residents. An example here can be cited from the efforts in emergency management whereby public communication materials related to natural hazard risks were vetted by a coalition of organizations involved in developing and disseminating public awareness materials (www.disastereducation.org).

6.4 Implications from the factors influencing heat wave risk perception

This study identified some of the key factors that influence urban residents' knowledge and perception of climate change, global warming, and heat wave hazards in Winnipeg. Research findings indicated that respondents' knowledge and perceptions of heat wave risk varied in part based on their age, level of income and level of education. Lack of experience of serious heat wave events in recent years might have resulted in underestimation of heat wave risk among Winnipeg residents.

Climate change itself was often seen in relatively abstract terms, taking place in other areas and affecting other persons. This may in part reflect community residents' level of knowledge and understanding of climate change; nonetheless, many also did not see a personal obligation to change their behaviors without first recognizing scientific and political consensus and commitment (Hutton et al., 2007: 38). These findings indicate a greater need for taking into account local residents' beliefs, ideas and values in developing messaging and programs. It can be counterproductive to assume that the residents will place the same priority on climate change and emergency preparedness as experts and decision makers, nor will they necessarily act on information and advice when they are received. The need to identify community people's' motivation to change takes on particular relevance here. An increased in participatory approaches emphasised on local involvement in the identification of risks and remedial actions will not only make risk communication activities better and more effective, they will also promote a sense of ownership to such efforts among the local residents. These will require greater involvement of local and non-governmental organizations which are critical to ensuring social issues and risk related matters are addressing local level concerns.

6.5 The Need and Options for Improvement in Risk Communication

Gaps in knowledge and risk perception between experts and community residents can be addressed by various types of interventions, of which improvement in risk communication is a pivotal one. It is generally agreed in the literature that experts focus on specifics while the public adopts a complex, broad set of variables in their mental models, resulting in wide gaps in the corresponding approaches. One of the key issues that policy- and decision-makers commonly face relates to the acceptability of risk mitigation and management measures that scientists and/or experts prescribe for the local communities. In recent years, remarkable efforts have been made to inform the public about the potential interventions or activities prior to making final decisions. However, in such an approach, the spontaneous public participation has been absent because public interests and priorities were not considered. Because of the failure of this approach, many government agencies, such as Public Health Agency of Canada, have recently adopted a different alternative, involving the public directly in the decision-making through better and more effective communication. Effective communication, particularly in the areas of environmental hazards and risk, has been therefore considered a vital tool to address the above-stated gaps and problems. Recent evidence from the United States has shown that without involving multiple local level or non governmental organizations, the goals of communication efforts can not be achieved. Therefore, supporting and mobilizing such grassroots level organizations are critical to make risk communications effective.

In attempting to change the risk-related behaviours of vulnerable populations, it has been advocated that the current risk communication practices need to focus, in addition to linking with local level and/or non governmental organizations, on preparing appropriate messages, selecting communication techniques and implementing risk communication programs (Haque et al. 2004). The main obstacle to effective risk communication may lie in the mistrust of risk messages. For example, a locally respected old farmer may be credible to neighbouring farmers as a source of information on pesticide risks but may not be credible to the officials who convene a regulatory hearing. Similarly, any scientific representative of a hazardous waste disposal company may be credible to a federal regulator but not to the neighbours of a proposed waste site. In both cases, it can be concluded that due to lack of trust, officials do not credit the farmer because of his or her lack of technical expertise, and neighbours do not credit the company's scientist because of lack of credibility. The options for effective risk communication then lie in improving the community residents' credibility, understandability and involvement in such an approach that will serve their interests.

To communicate effectively, risk messages from decision-makers and emergency managers must include an awareness and understanding of the cultural context. "The content of any message must be sensitive to the receiver's frame of reference for the problem … there are many publics within a society each with possibly different worldviews and frameworks for approaching risk problems" (Royal Society, 1992: 121). People view risk messages as incorporating scientific, political and cultural elements. Appeals to scientific quality and veracity alone on the part of risk communicator may not always win the approval of the skeptic (Committee on Risk Perception and Communication, 1989).

Effective risk messages need to be designed in ways that communicate clearly and in an interesting manner to the community people as well as to experts; the recipients also need to find such messages useful to them (i.e., utility). Though risk messages can be carried by a variety of media—face-to-face interaction, direct mailings, advertising, hot lines, television and radio interviews, newspaper or journal articles—it has been cited that messages with less visual and interaction impacts are less successful (Committee on Risk Perception and Communication, 1989).

6.6 Concluding Remarks

The actions undertaken prior to the occurrence of a disaster event through mitigation and preparedness are aimed at reducing the effects at the personal, local community and regional levels during and after the occurrence of a disaster through the means of response and recovery. One of the vital elements to establishing successful mitigation and preparedness strategies that ameliorate the effects during response and recovery is incorporation of the local issues as well as personal aspects present at the community level. Without accounting for local aspects particularly vulnerability characteristics, mitigation and emergency responses strategies can not be fully materialised. An important component of this comprehension is awareness of how the local residents that would be impacted by the programs and policies perceive, identify and estimate heat wave hazards and their associated risks. Although Winnipeg is regarded as one of the most vulnerable cities in Canada to climate change induced heat wave hazards, a vast majority of its residents do not perceive and predict occurrence of such hazard here; this significant gap in community residents' risk estimation requires serious public policy and program attention.

This research exemplified the nature of climate change induced heat wave risk knowledge and perception in Winnipeg and potential implications for risk hazard and disaster management decision making. Among several approaches, behavioural, socio-economic and demographic aspects were incorporated in this study. As "psychometric knowledge may not ensure wise or effective decisions, but [a] lack of such knowledge certainly increases the probability that well-intentioned policies will fail to meet their goals" (Slovic et al., 1982:89), further study that will incorporate psychometric variables such as personality traits, and cognitive processes, will fill in a gap left by the present study.

The present study focused primarily on the aspects of knowledge and information gathering, cognitive processes and explanatory variables of perception of risks, specially in the area of climate change induced heat wave hazards. A future study on how the local belief and value systems influence both perceptual and behavioural dimensions of community residents will enhance our understanding on these issues. My study used the case of only one city ward, namely North Kildonan, to examine local residents' perceptual characteristics on climate change and its associated extreme environmental events such as heat waves. Further study covering more diverse residential zones of the city of Winnipeg will assist us to make generalizations with more reliability and higher degree of confidence. Finally, future research should focus on how a two-way interactive risk communication system can be developed and implemented successfully.

REFERENCES

Ackerman, B. (1985). "Temporal march of the chicago heat island." J. Climate Appl. Meteor **24**: 547-554.

Allan, S., Ed. (2000). Risk and the common sense of neuclearism. The risk society and beyond: Critical issues for social theory. London, Sage.

Applegate, W. B., Runyan, J. W. Jr., Brasfield, L., Williams, M.L., Konigsberg, C., Fouche, C. (1981). "Analysis of the 1980 heat wave in Memphis." J Am Geriatr Soc **29**: 337-342

Bellisario, L. M. (2001). Temperature extremes in Canadian urban centres: when and where are we at risk? Canadian Meteorological and Oceanographic Society 35th Congress. Winnipeg, Manitoba.

Berry, P. a. P., D. (2005). Assessing the capacity of individual Canadians to adapt to the health impacts of climate change. Natural Resource Canada Speaker Series. Ottawa, Environment Canada.

Bickerstaff, K., Simmons, P. and Pidgeon, N.F. (2004). Public perceptions of risk, science and governance: Main findings of a qualitative study of five risk cases. Norwich, UK, Centre for Environmental Risk, University of East Anglia.

Bier, V. M. (2001). "On the state of the art: Risk Communication to the public." Reliability Engineering and System Safety: 139-150.

Blaikie, P. C., T.; Davis, I.; Wisner, B (1994). At Risk-Natural Hazards, People's Vulnerability and Disasters. New York, Routledge.

Blair, D. (1997). "Short period temperature variability at Winnipeg, Canada,1872-1993: Characteristics and trends." Theoritical and Applied Climatology **58**(3-4): 147-159.

Boardman, J. (2004). "Stress and physical health: The role of neighbourhoods as mediating and moderating mechanisms." Social Science and Medicine **58**(12): 2473-2483.

Bord, R. J., Fisher, A. and O' Connor, R. E. (1998). "Public perceptions of global warming: United States and international perspectives." Climate Research **11**: 75-84.

Borgman, C. L. (1984). The user's mental model of an information retrieval system: effects on performance. Ann Arbor, University Microfilms International, Ann Arbor, Michigan.

Bostrom, A., Atman, C., Fischoff, B., Morgan, M.G. (1994). "Evaluating risk communications: Completing and correcting mental models of hazardous processes." Risk Analysis **14**: 789-798.

Bràzdil, R., Budiková, M. (1999). "An urban bias in air temperature fluctuations at the Klementinum, Prague, the Czech Republic." Atmospheric Environment **33**: 4211-4217.

Buechley, R. W., Van Bruggen J., Truppi, L.E. (1972). "Heat island equals death island?" Environ Res **5**(85-92).

Burton, I. K., R.W. and White, G.F. (1978). The Environment as Hazard. New York, Oxford University Press.

Carter, T., Ed. (1996). Winnipeg: heartbeat of the province. Winnipeg, University of Manitoba Press.

CDCP (1995). Heat-related illnesses and death-United States, 1994-1995, Centres for Disease Control and Prevention: 465-468.

Chambers, F. B., Bazel, A. J. (2000). Heating and cooling in Colorado mining towns. In. Preprints of the Third Symposium on the Urban Environment, August 2000. Boston, American Meteorological Society: 119-120.

Chambers, R. (1983). Rural development: Putting the last first. New York, Longman.

Chambers, R., Blackburn, J. (1996). "The power of participation: PRA and policy." IDS Policy Brief(7).

Chapman, B. (1995). "When is death heat-related?" CAP Today: 56-61.

Clark, H. H. (1992). Arenas of Language Use Chicago, University of Chicago Press.

Clark, H. H. (1996). Using Language. Cambridge, England, Cambridge University Press.

Clarke, J. F. (1972). "Some effects of the urban structure on heat mortality." Environ Res **5**(85-92).

Colombo, A. F., Etkin, D., Karney, B. W. (1999). "Climate variability and the frequency of extreme temperature events for nine sites across Canada: Implications for power usage." Journal of Climate **12**(8): 2490–2502

Covello, V. T. a. M., J. (1985). "Risk analysis and risk management: an historical perspective." Risk Analysis **5**(2): 103-120.

Craik, K. J. W. (1943). The nature of explanation. Cambridge, Cambridge University Press.

CRPC (1989). Improving Risk Communication. Washington D.C, National Academy Press.

Carter, T. (1997). Winnipeg: Heartbeat of the province. The Geography of Manitoba-Its Land and Its People. J. E. Welsted, J.; Stadel, C. Winnipeg, The University of Manitoba Press: 136-151

Cutter, S. L. (1993). Living with risk. London, Edward Arnold.

Douglas, M. a. W., A. (1982). Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers. Berkeley, University of California Press.

Edlestein, M. (1988). Contaminate communities: The social and psychological impacts of residential toxic exposure. Boulder, Westview Press.

EnvironmentCanada (1996). Climate and weather glossary of terms. Ottawa, Atmospheric, Climate and Water Systems Branch.

Ferrier, N. a. H., C. E. (2003). "Hazards risk assessment methodology for emergency managers: A standardized framework for application." Natural Hazards **28**(2-3): 271-290.

Freudenburg, W. R. (1988). "Perceived risk, real risk: social science and the art of probabilistic risk assessment." Science **242**: 44-49.

Gan, T. Y., Xu, Q. (1999). Hydroclimatic trends and possible climatic warning in the Canadian Prairies. Annual Conference of the Society for Civil Engineering, Regina, Proceedings.

Gentner, D., Ed. (1989). The mechanisms of analogical learning. Similarity and Analogy in Reasoning and Learning. Cambridge, England, Cambridge University Press.

Givoni, B. e. a. (2003). "Outdoor comfort research issues." Energy and Buildings **35**: 77-86.

Greenberg, J. H., Bromberg, J., Reed, C. M., Gustafson, T.L., Beauchamp, R. A. (1983). "The epidemiology of heat related deaths, Texas-1950,1970-79, and 1980." American Journal of Public Health **73**: 805-807.

Halasz, F. G., Moran, T.P. (1983). Mental models and problem solving in using a calculator. Conference on Human Factors in Computing Systems Boston, Massachusetts, USA, Association for Computing Machinery, NY.

Haque, C. E. (1997). Hazards in a fickle environment: Bangladesh. Dordrecht, Boston, London, Kluwer Academic Publishers.

Haque, C. E., Lindsay, J., Lavery, J., and Olczyk, M. (2004). Exploration into the relationship of vulnerability and perception to risk communication and behaviour: Ideas for the development of tools for emergency management program, Office of crirical infrastructure protection and emergency preparedness, unpublished report.

Haque, C. E., Burton, I. (2005). "Adaptation options strategies for hazards and vulnerability mitigation: An international perspective." Mitigation and Adaptation Strategies for Global Change **10**: 335-353.

Hinds, P. J. (1999). "The curse of expertise: The effects of expertise and debiasing methods on predictions of novice performance." Journal of Experimental Psychology: Applied 5: 205-221.

Howard, R. A., Matheson, J., Ed. (1981). Influence diagrams. The Principles and Applications of Decision Analysis. California, Strategic Decision Group.

Hutton, D., Haque, C.E., Dhar Chowdhury, P., and Smith, G. (2007). Impact of climate change and extreme events on the psychosocial well-being of individuals and the community, and consequent vulnerability. Ottawa, Climate Change Impacts and Adaptation Program, Natural Resources Canada.

Ingham, B. (1993). "The meaning of developmenty: Interactions between 'new' and 'old' ideas." World Development **21**: 1803-1821.

IPCC (2001). Climate change 2001: Synthesis report-summary for policy makers. Wembley (U.K).

IPCC (2007) The AR4 Synthesis Report (IPCC Fourth Assessment Report), Valencia, Spain: Intergovernmental Panel on Climate Change.

Jendritzky, G., Sievers, U. (1989). Human biometeological approaches with respect to urban planning. Proceedings of the 11th International Congress on Biometeorology, Amsterdam, SPB Academic Publishing.

Johnson-Laird, P. N., Ed. (1983). Conditionals and mental models. On Conditionals. Cambridge, England, Harvard University Press.

Jones, T. S., Liang, A. P., Kilbourne, E. M., Griffin, M.R., Patriarca, P. A., Wassilak, S. G. et al. (1982). "Morbidity and mortality associated with the July 1980 heat wave in St. Louis and Kansas City." JAMA **247**: 3327-3331.

Kalkstein, A. J., Sheridan, S. C. (2007). "The social impacts of heat-health watch/warning system in Phoenix, Arizona: Assessing the perceived risk and response of the public." Int J Biiometeorol **52**: 43-55.

Kalkstein, L., Smoyer, K., (1993). The impact of climate on Canadian mortality: Present relationships and future scenarios. Centre for Climatic Research. Downsview,Ontario, Atmospheric Environment Service, Canadian Climate Program.

Kalkstein, L. S., Davis, R.E. (1989). "Weather and human mortality: An evaluation of demographic and interregional responses in the United States." Ann. Assoc. Am. Geogr **79**: 44-64.

Kasperson, R. E. e. a. (1988). "The social amplification of risk: a conceptual framework." Risk Analysis **8**(2): 177-187.

Kates, R. W. (1962). Hazards and choice perception in flood plain management,Department of Geography Research Report No. 78. Chicago, University of Chicago.

Katsouyanni, K. e. a. (1988). "Athens heatwave." Lancet **ii**(573-573).

Kilbourne, E. M., Choi, K., Jones, T. S., Thacker, S. B. (1981). "Risk factors for heatstroke: A case control study." JAMA **247**: 3332-3336.

Kleinhesselink, R. R. a. R., E. A. (1991). "Cognitive representation of risk perceptions: A comparison of Japan and the United States." Journal of Cross-Cultural Psychology **22**(1): 11-28.

Kraft, M. E. (2001). Environmental policy and politics, Addison-Wesley Educational Publishers Inc.

Kumar, S. (1998). "India's heatwave and rains result in massive death toll." Lancet **351**: 1869-1869.

Landsberg, H. E. (1981). "The urban climate." New York:Academic Press **28**.

Larsen, J. (2003). Record heat wave in Europe takes 35,000 lives. Washington,DC, Earth Policy Institute.

Lemmen, D. S. a. Warren., F. J., Ed. (2004). Climate change impacts and adaptation: A Canadian perspective. Ottawa, Climate Change Impacts and Adaptation Directorate, Natural Resource Canada.

Lindell, M. K. a. E., T. (1983). "How close is close enough:public perc eption of the risk of industrial facilities." Risk Analysis **10**(3): 393-399.

Lopez-Vazquez, E. a. M., M. L. (2003). "Risk perception, stree and coping strategies in two catastrophe risk situations." Social Behavior and Personality **31**(1): 61-70.

Lorenzoni, I., Pidgeon, N. F., O'Connoer, R. E. (2005). "Dangerous climate change: The role for risk research." Risk Analysis **25**(6): 1387-1397.

Lorenzoni, I. a. P., F. (2006). "Public views on climate change: European and USA perspectives." Climate Change **77**: 73-95.

Margolis, H. (1997). Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues Chicago, University of Chicago Press.

Marmor, M. (1975). "Heat wave mortality in New York city, 1949-1970." archives of Environmental Health **30**(130-136).

Masterton, J. M., Richardson, F. A. (1979). "A method of quantifying human discomfort due to excessive heat and humidity." AES:Environment Canada: CLI 1-79.

Mitchell, B. (1997). "Resource and environmental management." Addison Wesley Longman Limited.

Morgan, M. G., Fischhoff, Baruch., Bostrom, Ann., Alman J., Cynthia (2002). Risk Communication: A Mental Model Approach, Cambridge University Press.

Moser, S. C., Ed. (2007). More bad news: The risk of neglecting emotional responces to climate change information. Creating a climate for change: Communicating climate change and facilitating social change, Cambridge University Press.

Nakai, S., Toshiyuki, I., Taketoshi, M. (1999). "Deaths from heat-stroke in Japan:1968-1994." Int J Biiometeorol **43**: 124-127.

NCDC (1999). Probability of temperature extremes in the USA, National Climatic Data Center, NOAA. **1**.

NCDC (2001) "Billion dollar US weather disasters 1980-2001.DOI: http://lwf.ncdc.noaa.gov/oa/reports/billionz.html#LIST

NOAA (2003) DOI: www.spc.noaa.gov/faq/tornado/f-scale.html

Nuckles, M., Wittwer, J., and Renkl, A. (2003). Supporting computer experts' adaptation to the client's knowledge in asynchronous communication: The assessment tool. Proceedings of the European Conference of the Cognitive Science Society, 2003 NJ: Erlbaum.

OCIPEP (2004) "Tornado information." Office of Critical Infrastructure Protection and Emergency Preparedness, DOI: www.ocipep.gc.ca/disaster/default.asp

Oke, T. R. (1973). "City size and the urban heat island." Atmospheric Environment **7**: 769-779.

Olczyk, M. E. (2005). Flood risk perception in the red river basin, Manitoba: Implications for hazards and disaster management. Natural Resources Institute. Winnipeg, Manitoba, University of Manitoba.

Patz, J. A. (2002). "A human disease indicator for the effects of recent global climate change." Proceedings of the National Academy of Sciences of the United States of America **99**(20): 12506-8.

Philandras, C. M., Metaxas, D. A., Nastos P.T. (1999). "Climate variability and urbanization in Athens." Theoritical and Applied Climatology **63**: 65-72.

Pidgeon, N., Hood, C., Jones, D., Turner, B., Gibson, R., Ed. (1992). Risk Perception. Risk: Analysis, perception and management. London, The Royal Society.

Pinho, O. S., Manso Orgaz, M.D. (2000). "The urban heat island in a small city in coastal Portugal." International Journal of Biometeorology **44**: 198-203.

Robinson, P. J. (2003). "Atmospheric circulation and inland flooding in twentieth century North Carolina, USA." Natural Hazards **29**: 155-172.

Ronan, K., Johnston, D. (2005). Promoting Community Resilience in Disasters: The Role of Schools, Youth, and Families. New York: Springer.

Rotter (1966). "Generalized expectancies for internal versus external control of reinforcement." Psychological Monographs **80**(1): 1-28.

RoyalSociety (1992). Risk: Analysis, Perception and Management. London, Royal Society Study Group.

RSC (1994). Canadian National Report. C. A. o. Engineering, Royal Society of Canada.

Sandman, P., Sachsman, D., Greenberg, M. and Gochfeld, M. (1987). Environmental risk and the press. New Brunswick, Transaction Publishers.

Sauchyn, D., Kulshreshtha, S. (2008). Prairies. From impacts to adaptation: Canada in a changing climate 2007. D. S. Lemmen, Warren, F. J., Lacroix, J. and Bush, E. Ottawa, Government of Canada.

Schimidt, H. G., Boshuizen, H. P. A. , Ed. (1992). Encapsulation of biomedical knowledge. Advanced models of cognition for medical training and practice. Berlin, Springer.

Schoenfeld, A. C. (1980). "Newspersons and the environment today." Journalism Quarterly **57**(3): 456-462.

Semenza, J. C., McCullough J. E., Flanders, W.D., McGeehin, M. A., Lumpkin J. R. (1999). "Excess hospital admissions during the July 1995 heat wave in Chicago." American Journal of Preventive Medicine **335**: 84-90.

Shachter, R. D. (1988). "Probabilistic inference and influence diagrams." Operations Research **36**(4): 589-604.

Short, J. F. (1984). American Sociological Review **49**(711).

Simpson-Housley, P. a. B., P. (1978). "Personality and the perception of earthquake hazard." Australian Geographical Studies **16**: 65-72.

Slovic, P. F., B.; Lichtenstein, S. (1982). "'Why study risk perception?'" Risk Analysis **2**: 83-93.

Slovic, P., Kunreuther, H., and White, G. F., Ed. (1974). Decision processes, rationality and adjustment to natural hazards. Natural Hazards: Local, National, Global. New York, Oxford University Press.

Slovic, P. K., N.; Covello, V. T. (1990). "'What should we know about making risk comparison?'" Risk Analysis **10**(3): 389-392

Slovic, P. (2000). Perception of risk. London, Earthscan.

Slovic, P., Ed. (1992). Perception of risk: Reflections on the psychometric paradigm. Social theories of risk. New York, Praeger.

Slovic, P., Fischhoff, B and Lichtenstein, S. (1979). "Rating the risks." Environment **21**(3): 14-20, 36-39.

Smoyer, K. E. (1998). "Putting risk in its place: Methodological considerations for investigating extreme event health risk." Soc Sci Med **47**: 1809-1824.

Smoyer, K. E., Rainham, D.G.C. and Hewko, J.N., (2000). "Heat stress mortality in five cities in southern Ontario: 1980 to 1996." International Journal of Biometeorology **44**(190-197).

Smoyer-Tomic, K., Kuhn, R., Hudson, A. (2003). "Heat wave hazards: An overview of heat wave impacts in Canada." Natural Hazards **28**: 463-485.

USBC (1997). American housing survey in the United States in 1995. Washington, DC, U.S. Bureau of Census.

VanAalst, M. K. (2006). "The impact of climate change on the risk of natural disasters." Disasters: 5-18.

Vitek, J. D., Berta, S. M. (1982). "Improving perception of and response to natural hazards: the need for local education." Journal of Geography: 225-228.

Wade, C., Tavris, C., Saucier, D. and Elias, I. (2004). Psychology. Toronto, Prentice Hall.

Walker, B. e. a. (2004). "Resilience, adaptibility and transformability in social-ecological systems." Ecology and Society **9**(2): 5.

Weber, E. U., Sharoni, S., Blais, A. R. (2001). "Predicting risk-sensitivity in humans and lower animals: Risk as variance or coefficient of variation." Psychological Review.

Weir, E. (2002). "Heat wave: first, protect the vulnerable " Canadian Medical Association Journal **167**(2).

White, G. F. (1988). "Paths of Risk Analysis." Risk Analysis **8**(2): 171-175.

Whitman, S., Good, G., Donoghue, E. R., Benbow, N., Shou, W., Mou, S. (1997). "Mortality in Chicago attributed to the July 1995 heat wave." American Journal of Public Health **87**: 1515-1518.

Whitman, S. e. a. (1997). "Mortality in Chicago attributed to the July 1995 heat wave." American Journal of Public Health **87**(9): 1515-1518.

Wilby, R. L. (2003). "Differential acclimatisation as a function of duration of exposure." Internationale Zeitschrift fur Angewandte Physiologie **27**(2): 198-211.

Wilde, J. S. (1994). Target Risk: Dealing with the danger of death, disease and damage in everyday decisions. Toronto, PDE Publications.

WMO (1983). Abridged final report,8th session. Geneva, World Meteorological Organization

WMO (2004). WMO statement on the global climate in 2004. Geneva, WMO Press Release.

Yannas, S. (2001). "Toward more sustainable cities." Solar Energy **70**(3): 281-294.

Zwick, M. M. a. R., O. (eds) (2002). Perceptions and evaluation of risks:Findings of the Baden-Wurttemberg risk survey 2001. Joint working report by the centre of technology assessment in Baden-Wurttemberg and the university of Stuttgart, Sociology of Technologies and Environment. Stuttgart, University of Stuttgart, Germany.

APPENDIX 1

List of Experts who attended the Workshop on the Development of a "Experts' Model"

Name	**Affiliation**	**Specialization**
Dr. Peter Berry	Health Canada, Ottawa	Public Health
Kristina Hunter	University of Manitoba	Geography and Health
Elish Cleary	Manitoba Health	Medicine & Health
Jody Kelloway	Canadian Red Cross	Community Services
Barbara Crumb	Manitoba Health	Public Health
Dr. Danny Blair	University of Winnipeg	Meteorology
Mr. Joe Egan	City of Winnipeg	Community Services
Irene Hanuta	Agriculture Canada	Disasters
Ron Frontier	Family Service and Housing	Social Work
Dr. Elane Enerson	Brandon Universty	Disaster Management
Pat Lachance	Public Health Agency of Canada	Public Health
Dr. C. Emdad Haque	University of Manitoba	Risk Managament

APPENDIX 2

APPENDIX 3

UNIVERSITY OF MANITOBA | Natural Resources Institute
Clayton H. Riddell Faculty of
Environment, Earth, and Resources

303-70 Dysart Road
Winnipeg, Manitoba
Canada R3T 2N2
Telephone (204) 474-8373
Fax (204) 261-0038

Mr. Jerry Tom
Tenent Service Coordinator
Family Services and Housing
Government of Manitoba
Winnipeg, Manitoba

Ref: The Impact of Climate Change and Extreme Weather Events On the Psychosocial Well-Being of Individuals and Communities;Strenthening Community Capacity to Prepare for Climate Change Events.

I am requesting hereby to provide us with the permission to interview a sample of ten residents in North Kildonan ward from your Family services and Housing beneficiaries.

The Natural Resources Institute, University of Manitoba, is conducting this research project, to investigate how individuals and communities are prepared to deal with environmental extremes such as heat wave in the face of climate change induced environmental changes.

The project is also focusing on the factors that strengthen the resiliency of people to cope with stressors in a changing environment. The specific focus of this interview is to examine the gaps exist in risk communication between responsible authorities, experts, and community residents. We expect that the research will help communities to better prepare for and cope with these new weather challenges as well as influence government policy in these areas.

As part of the research, we are conducting some open-ended interviews, which will be about one hour in length. These interviews are face to face and comprised of between ten to twenty members of your community. The purpose of this interview is to examine the knowledge of general people regarding environmental extreme events and what motivates them to take proactive and preventive measures as well as whether general people can identify the key indicators, which influence their risks on environmental extreme events. These questions will be directed at individual participants but in no way will be asked in a manner which may cause emotional discomfort.

All information gathered from the participants will be **confidential**. That is, the collected information will be available only to the research team and no individual names or other identifying information will used in any of research documents and reports. The produced information will be stored in secured at University of Manitoba facilities, and will be destroyed in due time.

APPENDIX 4

Questions for face-to-face interview:

1.What are the potential hazards your community is facing now?

2.Can you please rank them (in magnitude scale)?

3.What are the main factors causing these hazards ?

4.Do you have any idea about extreme environmental events ?

5.How would you define heat-wave?

6.Can you please tell me what are the potential causes of heat wave?

7.Tell me everything that you know about environmental change.

8. Do you have any idea about global climate change?

9.Do you have any idea about earth's mean temperature ?

10.Can you please tell me something (i.e. causes,effects) about greenhouse gases (GHGs)?

11.People and their properties are at risk because of our exposure to hazardous events (for example-people get flooded because they leave in flood prone areas). In case of heat wave what human decisions affect peoples' risk to heat wave exposure?

12.Can you please tell me something about the various effects of heat wave?

13.How else can heat wave affect
(A) You and (B) Your community?

14.Do you have any idea about psychological stresses whether they are associated with the effects of heat wave?

15.Can you guess what will happen ultimately if heat wave induced stress condition persists for long time?

16. What can be done to limit the risk of heat wave?
(A) Personal level (B) Community level (C) Institutional/Organizational level

17. In your opinion what kind of responsibility is necessary to limit the GHGs emission?
(A)Personal level (B) Community level (C) Institutional/Organizational level

APPENDIX 5

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 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 (like heat waves, flood etc.) have been increasing in frequency and intensity in recent years.

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

2. The earth's mean temperature is rising because of a hole in the ozone layer.

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, 5 – least threatening)

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

4. Heat wave is occurring due to increased Greenhouse gases concentration in the atmosphere.

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

5 Increased urbanization, deforestation etc are indirectly helps in rise in earth mean temperature and thereby helps in occurring heat waves-

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

6. Heat exposure risk to extreme heat will increase due to long time exposure to sunlight.

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

7. Lack of access to water during heat wave time will increase the heat exposure risk to extreme heat.

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

8. Heat exposure risk to extreme heat will increase due to inadequate ventilation in building .
True **Maybe True** **Don't Know** **Maybe False** **False**

9. A heat wave can lead to significant social and economic changes.
True **Maybe True** **Don't Know** **Maybe False** **False**

10. A heat wave can lead to the increased spread of diseases.
True **Maybe True** **Don't Know** **Maybe False** **False**

11. Food and water contamination will occur during a heat wave.
True **Maybe True** **Don't Know** **Maybe False** **False**

12. Loss of power supply, power cuts and other social damages will occur during a heat wave.
True **Maybe True** **Don't Know** **Maybe False** **False**

13. High mortality rate are associated with an extreme heat wave condition-
True **Maybe True** **Don't Know** **Maybe False** **False**

14. High mortality rate due to heat wave is largely preventable by taking precautionary measures.
True **Maybe True** **Don't Know** **Maybe False** **False**

15. Heat exposure risk could be minimised by improving building codes (design, materials, A.C).
True **Maybe True** **Don't Know** **Maybe False** **False**

16. Heat exposure risk could be minimised by paying adequate media attention.
True **Maybe True** **Don't Know** **Maybe False** **False**

17. On a scale of 1 to 10 how are you concerned about (1-not concerned, 10-very concerned) about heat wave?
1 2 3 4 5 6 7 8 9 10

18. Heat wave in Winnipeg will occur in next 5 to 10 years.
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.

19. First, please indicate your gender.

1 ….. Male 2 ….. Female

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

21. How would you describe your living situation?

1 ….. Single, never married
2 ….. Married
3….. Living with a partner
4 ….. Divorced or separated
5 ….. Widowed

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

1 …. Yes 2 …. No

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

1. ….. One person (you live alone) 2. ….. With family/others

24. Please indicate your sources where you get information on global climate change.

1. Books & Journals____
2. Newspaper ____
3. Television & Radio ____

25. Would you please indicate your religious belief? ____________________

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

1. ….. High school graduate 2. ….. University/college graduate

27. Please indicate your occupation.________________________________

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

1..... $10,000 - $35,000
2......$35,000 - - $65,000
3......more than $65,000

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

_____ months   _____ years   _____ Entire Life (please check)

30. Would you please indicate your ethnic background? (i.e. Anglo Saxon, French, First Nations) ______________________

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