FLOOD-RISK COMMUNICATION: INSIGHTS FROM CANADIAN HOUSEHOLDS

ENHANCING FLOOD-RISK COMMUNICATION AND AWARENESS: INSIGHTS FROM CANADIAN HOUSEHOLDS

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LAY ABSTRACT

This research focuses on how people in Canada receive information about flood risks and how we can improve it. In Chapter 2, we talked to Canadian households to learn about their experiences with flood-risk information. We found that the current way of giving this information might not meet everyone's needs. People want information that fits their specific situations, and they stressed the importance of fairness in how the information is shared. In Chapter 3, we conducted a survey among households at risk of flooding in Canada to find out what kind of information they prefer. We discovered that people like to get clear and direct messages with detailed risk information that is customized for them. We also noticed that some people who think they are at higher risk of flooding are more informed about the risks. This means it's essential to consider how people see their own risk levels when communicating with them effectively.

Overall, this research shows that flood-risk information needs to be tailored to people's different preferences and values. By doing this, we can help individuals and communities better understand and prepare for flood risks. We recommend working together with different groups involved in flood-risk management to improve how we communicate these risks. By doing so, we can create a more informed and inclusive

flood-risk communication system that helps communities stay safe during flood events in the future.

ABSTRACT

This research investigates flood-risk communication challenges in Canada, emphasizing the need for tailored strategies to address diverse household preferences and values. In Chapter 2, we examine Canadian household experiences with flood-risk information, aiming to identify new communication needs and bridge the gap between households and flood-risk managers. The interviews reveal previously overlooked flood-risk information needs. The importance of tailored communication strategies was highlighted by household participants as they emphasized the need for information that caters to their unique circumstances and requirements. Moreover, fairness emerged as a crucial aspect of flood-risk communication, prompting a call for equitable practices to address vulnerabilities affecting specific households. In Chapter 3, we investigate household values and preferences on flood-risk information through a survey of at-risk households in Canada, uncovering diverse preferences, values and needs for tailored risk information. Additionally, significant differences in flood-risk knowledge, accessibility, and transparency are observed among risk-status groups, with higher awareness among those who perceive themselves at risk. Overall, this research emphasizes the importance of understanding diverse values and preferences within households regarding flood-risk information. Strengthening flood-risk communication strategies and addressing information gaps can lead to more informed risk perceptions and improve awareness among at-risk households in Canada.

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LIST OF ALL ABBREVIATIONS AND SYMBOLS

FRM	Flood Risk Management	Strategic planning and implementation of measures aimed at reducing the adverse impacts of floods on communities, infrastructure, and the environment.
PLFP	Property Level Protection Measures	Involve the application of specific actions or technologies to safeguard individual properties from flood damage, such as installing flood barriers, pumps, or flood-resistant building materials.
FRC	Flood-Risk Communication	The dissemination of relevant information and warnings to the public, local authorities, and stakeholders about potential flood hazards, preparedness, and response strategies.
FRI	Flood-Risk Information	Flood-risk information comprises data, maps, and assessments that characterize the likelihood and potential consequences of flooding, helping individuals and communities make informed decisions regarding flood-related risks and planning.

DECLARATION OF ACADEMIC ACHIEVEMENT

I, Ashley Kruchka, declare this thesis to be my own work. I am the sole author of this document. No part of this work has been published or submitted for a higher degree at another institution.

To the best of my knowledge, the content of this document does not infringe on the copyright of anyone.

My supervisor, Dr. Niko Yiannakoulias, has provided my guidance and support at all stages of this project. I completed all of the research work and writing for this thesis.

CHAPTER 1: INTRODUCTION

Due to climate change and a history of extensive development along floodplains, communities in Canada are projected to face more frequent and severe flooding (Burn et al., 2016; Honegger & Oehy, 2016). When multiple flood drivers coincide, like high river flows and rising sea levels, the impacts can worsen, leading to catastrophic damages (Wang et al., 2021). Additionally, climate change is contributing to changing rainfall patterns, more extreme storms, rapid snowmelt and seasonal changes are contributing to this rise in flood-risk (Burch et al., 2010; Pryce & Chen, 2011; Teufel et al., 2017).

Several severe flood events have occurred in Canada. The southern Alberta floods in 2013 was the costliest flood disaster in Canadian history, exceeding $6 billion in damages and forcing thousands to leave their homes (Teufel et al., 2017). In 2021, southwestern British Columbia experienced catastrophic floods due to two days of intense rainfall, leading to the cutoff of road and rail access for Vancouver to the rest of Canada. The BC flood was a 1 in 500-year event, where climate change is estimated to have raised the likelihood of events of this scale by approximately 45% (Gillett et al., 2022).Additionally, Alberta experienced flood-risk communication challenges that were exacerbated not only by risk management failures and planning practices, but also was due to inadequate risk knowledge and awareness (Agrawal et al., 2022; Kovacs & Sandink, 2013).

The increasing risk of flooding in Canada raises important questions about household awareness of flood risks and the effectiveness of current risk communication approaches in flood-risk management. Recent studies have shown that among households living in flood-risk areas in Canada, only 6% were aware of their risk (Ziolecki et al., 2020). Effective flood-risk communication plays a vital role in equipping households with the right information and strategies to deal with these challenges (O'Sullivan et al., 2012). It remains unclear, however, risk awareness can be improved due to the various factors that influence risk awareness (Mondino et al., 2020).

Risk Communication

To effectively address flood-risk communication challenges, it is important to recognize risk communication plays an important role in flood-risk management, through its involvement in preparedness, mitigation, response and recovery. Traditionally, flood-risk communication has followed a top-down approach, with limited input from communities and households at risk, leading to ineffective risk communication (O'Sullivan et al., 2012; Snel et al., 2019). To bridge this gap, researchers have explored alternative approaches, like bottom-up and two-way communication strategies, which prioritize community input and two-way interactions (Intrieri et al., 2020; Ping et al., 2016; Stewart & Rashid, 2011).

Moreover, adopting a "one-size-fits-all" approach to risk communication, which entails conveying standardized flood risk information to all households and communities regardless of their unique characteristics, needs, and vulnerabilities, has limitations (Attems, Thaler, et al., 2020; Snel et al., 2019). Instead, effective flood-risk

communication requires a nuanced approach that considers the diverse needs and preferences of households. Customizing the information to match specific contexts and characteristics enhances the relevance and effectiveness of risk communication, enabling households to make better-informed decisions and improve their flood preparedness (Attems, Thaler, et al., 2020).

Additionally, local governments play a crucial role in flood-risk communication, but they often encounter resource constraints, which can hinder their ability to provide comprehensive flood-risk information (Golnaraghi et al., 2020; Thistlethwaite & Henstra, 2017; Ziolecki et al., 2020). To address these challenges effectively, it is essential to gain insights into the information gaps and communication challenges faced by households in diverse flood contexts across Canada. This understanding will help in developing a more robust communication strategy that considers the capacity limits of local flood authorities, as they are the primary agents engaged in flood-risk communication (Burch et al., 2010; Stewart & Rashid, 2011).

Risk Awareness

As risk awareness remains low in Canadian households, strategies to improve risk awareness through improved risk communication approaches have been frequently recommended by literature, such as through the use of bottom-up and two-way communication approaches (O'Sullivan et al., 2012; Ping et al., 2016; Ziolecki et al., 2020). Due to the lack of knowledge that Canadians have about flood risk to their home and/or property being at risk, fewer than 30% of Canadian households report taking action through property-level flood-risk protection measures (Thistlethwaite et al., 2017;

Ziolecki et al., 2020). Additionally when it comes to how climate change will impact the frequency and intensity of floods in Canada, a major share of at-risk households do not think their flood-risk will change in the next 25 years (Ziolecki et al., 2020).

Improved risk awareness has the potential to spur risk-reducing behaviors among households, such as purchasing flood insurance and implementing property-level flood protection measures, ultimately contributing to increased flood resilience (Golnaraghi et al., 2020; Maidl & Buchecker, 2015). However, to improve awareness, flood-risk information needs to be accessible, comprehensive, and useful to households in order to achieve this goal (Attems et al., 2020; Oubennaceur et al., 2022). Obtaining perspectives and needs of information from households may help improve accessibility, comprehension and usability of risk information when there is more comprehensive understanding of what those needs are.

Purpose of Study

The purpose of this study is to gain a comprehensive understanding of the diverse needs and preferences of households regarding flood-risk information. By doing so, this research aims to support the development of more effective risk communication strategies that can help close the risk awareness gap in Canada.

In Chapter 2, gaps in flood-risk communication needs of households are assessed through interviews with flood impacted households across Canada. This approach aims to gain insights into the strengths and weaknesses of current flood communication approaches and uncover new perspectives on household risk communication needs not previously identified. The interviews would help inform the

design of a nation-wide survey in chapter 3 that includes these preferences of flood-risk information that can further be analysed to support a tailored communication strategy. The research seeks to answer two key questions: 1) What is important to households with regard to flood-risk information? and 2) What household flood-risk communication needs are being overlooked?

In Chapter 3, we conducted a survey of at-risk households aimed to further provide an understanding of household risk information preferences and values. This survey not only assessed the diversity of preferences regarding various types of flood-risk information but also investigated how these preferences and information values might be shaped by the level of risk awareness, particularly in terms of how at-risk households perceive the potential impacts. This research explores two general questions: 1. Are there varied flood-risk information values and preferences in households? 2. Do those values and preferences change, depending on perceived flood-risk status?

Significance of the Study

This study holds significant importance due to several reasons. Firstly, flood-risk communication approaches are still focused on top-down strategies where experts assume the needs of households, leaving needs to be unmet. This study aims to identify unmet needs to not only close gaps in risk communication, but also contribute to a bottom-up or two-way engagement strategy that uses perspectives obtained from households. Where additionally, assessing the diversity of information needs of households in Canada can help inform a more robust tailored communication approach.

Secondly, the study contributes to understanding the challenges of risk awareness, exploring how values and information preferences may be influenced by the alignment or misalignment of perceived flood risk with actual flood risk. This may help uncover additional gaps in risk communication between flood-risk management authorities and households in Canada.

Lastly, this study adds further consideration that flood risk communication challenges at the local level cannot be addressed without acknowledging the limited capacities of local flood-authorities. This is done through the evaluation of available literature regarding capacity challenges and issues relating to these capacities, such as failures in management or communication identified by households.

CHAPTER 2 UNCOVERING UNMET NEEDS: INSIGHTS FROM CANADIAN HOUSEHOLDS FOR ENHANCED FLOOD-RISK COMMUNICATION STRATEGIES

Abstract

This study examines Canadian household experiences with flood-risk information to discover new communication needs that can better inform strategies that attempt to close the flood-risk communication gap between households and flood authorities. Flood-risk communication in Canada needs improvement, and literature has largely determined that household perspectives and contributions are the key to closing the flood-risk communication gap when addressing the mechanisms that improve household flood-risk awareness. This qualitative study uses the experiences, concerns, and perspectives from 14 semi-structured interviews of households in varying geographic and flood-contexts in Canada to derive new perspectives of flood-risk information needs not previously identified or are understudied in the literature. This study challenges the idea that improved collaboration between households and private enterprises, alongside increased flood-risk responsibilities for households, will automatically lead to better flood-risk preparedness. Instead, we investigate household flood-risk information needs and the underlying factors that create knowledge divisions, information imbalances, and inequalities in access to this information. Findings derived new household flood-risk information needs, as well added further insights of existing needs that can contribute to a more significant understanding of current inadequate flood-risk communication approaches.

Background

Introduction

Flood-risk communication is vital for flood resilience, which refers to the capacity of an individual, community, city, or nation to withstand, absorb, recover from, or adapt to unexpected shocks, adverse events, or changing conditions in a prompt and effective manner (Sayers et al., 2013). Flood-risk communication encompasses first, the identification of flood-risk areas and secondly, the communication of that risk to those who are at-risk (Rollason et al., 2018). Flood-risk communication is important for all stages of the disaster management cycle, which includes the stages of preparedness, response and recovery (Ping et al., 2016). Unfortunately, most existing literature suggests that current flood-risk communication (FRC) is not resulting in improved awareness or changes in preparedness behaviours (Rollason et al., 2018). Moreover, with climate change, ongoing development in flood-risk areas, the increasing shift of responsibility for flood-risk burdens from government to households in Canada, flood-risk management and communication require improvements (Thistlethwaite et al., 2018). This research focuses on understanding household flood-risk information needs by reviewing the current practices of Canadian flood-risk management (FRM), and by assessing the gaps in flood-risk communication in the literature and in the interviews. By doing so, we aim to provide recommendations that reflect the nuanced experiences of households and improve the effectiveness of flood-risk communication.

Failures in Flood-Risk Communication Identified by Literature

This section discusses the following failures in flood-risk communication: 1) top-down communication strategies, and 2) one-size-fits-all solutions.

In traditional flood-risk management, communication strategies have primarily followed a top-down approach, where decisions about what information to include, language use, framing of message, and distribution channels are made by top flood-authority actors (e.g. federal, provincial and municipal governments, conservation authorities) with limited input from the recipients, such as households relying on risk messaging (O'Sullivan et al., 2012). However, top-down approaches have been widely regarded as ineffective in flood-risk communication, as they fail to meet the communication needs of communities and individuals at risk (Stewart & Rashid, 2011). In contrast, researchers have explored alternative approaches, such as bottom-up and two-way communication strategies, which involve incorporating insights from communities and at-risk individuals in the decision-making process and for the design of risk communication strategies. These approaches have shown potential in bridging the gap between experts and non-experts, as they prioritize the input of communities and aim for two-way communication (Intrieri et al., 2020; Ping et al., 2016; Stewart & Rashid, 2011).

The layperson/expert gap, where information is understood differently between experts and non-experts and often results in top-down communication, poses a significant challenge in flood-risk communication, hindering necessary flood awareness and preparedness (Attems, Thaler, et al., 2020). For example, the design of flood maps,

intended for flood-risk management, can be confusing or difficult for residents in flood-prone areas to comprehend. This highlights the need for communication tools, such as flood maps, to be tailored to the specific needs of the user (Minucci et al., 2020).

To implement bottom-up approaches, it is essential to involve those at risk in the decision-making process of flood-risk communication. Participation from households at risk, including gathering their input on preferences, concerns, and needs, can contribute to improved flood-risk resilience when used to inform flood-risk management decisions (Perera et al., 2020). Participatory approaches such as community projects, public consultation and flood programs have been frequently recommended by literature where one study showed how the data gathered through the participatory approach provided a more comprehensive understanding of the challenges faced by the local population, compared to strategies imposed from flood-authorities that did not fully account for the specific context and needs of the area (Sinthumule & Mudau, 2019).

The failure of one-size-fits-all (‘blanket’) approaches to flood-risk communication is another contributing factor to the unmet communication needs of households. It also relates to the inadequacies of top-down communication where blanket solutions are implemented by flood-authority actors that fail to address the diversity of needs of at-risk households and communities that a single solution will not address (Attems et al., 2020; Snel et al., 2019). One example of how a blanket method of risk communication failed was when older adults and seniors were not adequately informed of a flood warning because of their communication needs reflected a more face-to-face engagement or phone-calling preference (Walkling & Haworth, 2020). Aid measures decided by the

government left out many flood victims due to the requirements needed for the aid. Implementing a one-size-fits-all approach neglects the diversity of individual circumstances, leading to potential discrimination against different situations (Oubennaceur et al., 2022). The main reasons for the failure of this approach identified by the literature are that households respond and understand risk differently based on their perception of risks, knowledge, preferences of information, values and experiences, and socioeconomic and demographic characteristics (Attems, Schlögl, et al., 2020; Kellens et al., 2012; Stewart & Rashid, 2011). The consensus is that a more tailored approach to risk communication would be more successful in achieving adequate flood preparedness by households.

Overview of Risk Communication within Canada's Flood-Risk Management

Floods are the most frequently occurring disasters in Canada, putting approximately 1 in 5 homes at risk of flooding (Government of Canada, n.d.). Moreover, Canada is experiencing warming at a rate twice as fast as the global average, leading to increased flood risks due to more frequent and intense extreme weather events (Burn et al., 2016; Honegger & Oehy, 2016). Additionally, the development of almost 80% of Canadian communities on floodplains contributes to the growing flood risks (Golnaraghi et al., 2020). This highlights the importance of effective flood-risk communication, particularly concerning housing and development in these vulnerable areas, as they significantly contribute to the exposure to risk.

Surprisingly, only 6% of homeowners in flood-prone areas are aware of their flood risk (Government of Canada, n.d.). This lack of awareness can be attributed to the

way flood-risk information is communicated and managed within Canada. This can be explained by the complex and decentralized nature of how this information is handled across multiple levels of government, the frequent use of top-down communication approaches and the responsibility of communicating risks being delegated to local governments (Golnaraghi et al., 2020; Henstra et al., 2019). Therefore, it is essential to evaluate flood-risk communication strategies through understanding the share of responsibilities among government bodies to address this awareness gap effectively.

Canada's flood-risk management (FRM) operates under a multi-level structure with federal, provincial/territorial, and municipal authorities sharing responsibilities. The federal government provides financial resources for mitigation and recovery efforts, flood predictions, warning systems, and flood-map development. The Government of Canada distributes flood-risk information materials to households and collaborate with provinces or territories when needed (Golnaraghi et al., 2020). On the provincial/territorial level, there is a more involved role in FRM, with control over land-use planning policies, structural building codes, and regulations. Provinces/Territories establish regulatory flood standards that guide development in flood-risk areas, maintain websites with risk information resources, set expectations for municipal emergency management programs, and provide financial assistance to individuals and organizations affected by disasters (Golnaraghi et al., 2020).

Municipal governments have the most direct responsibilities in enforcing and implementing FRM standards. However, their efforts are often hindered by financial constraints due to limited access to tax revenue, making it challenging to implement

FRM measures (Golnaraghi et al., 2020; Thistlethwaite & Henstra, 2017). To address these financial burdens, risk-sharing mechanisms involving stakeholders like developers, real estate, and insurance companies have been proposed to assist local flood-risk management efforts (Thistlethwaite & Henstra, 2017). The adoption of these measures could lead to enhanced risk communication, including the improvement of flood warning systems and hazard disclosure.

Despite municipal governments' more direct involvement in flood-risk management and share of responsibilities in communicating risk, their limited financial resource capacities compared to other levels of government hinder effective flood-risk management such as adequate risk communication, contributing to the lack of awareness among households at risk of flooding (Agrawal et al., 2022; Burch et al., 2010; Thistlethwaite & Henstra, 2017). The limited resources may impact their ability to communicate flood risk adequately, creating a gap in awareness among households exposed to flood hazards.

Flood-Risk Communications Role in Canada's FRM Transformation

Effective flood-risk communication can play a crucial role in transforming Canada's flood-risk management (FRM) by influencing risk-reducing behaviors among households (Golnaraghi et al., 2020). These behaviors may include purchasing flood insurance or implementing property-level flood protection measures that reduce the risk at the household level. Existing research and initiatives, such as Partners for Action, emphasize the significance of bottom-up communication strategies and continuous engagement among households, local government, and private enterprises. They

highlight the importance of considering local contexts, addressing community needs, and providing action-oriented information tailored to specific audiences (*Partners for Action 2018 Annual Report*, 2018).

According to the most recent report from the University of Waterloo research initiative Partners for Action, a national survey involving 2,500 respondents identified a lack of awareness as a major reason why households fail to take steps to reduce their flood risk, often because they are unaware of the risk itself. Respondents expressed that relevant stakeholders, including all levels of government, real estate agencies, and insurance companies, should share the responsibility of communicating flood risks (Ziolecki et al., 2020). This finding indicates the need for tailored risk information, such as during property purchases, insurance processes, or general awareness and safety, and highlights the importance of considering households' communication preferences. In practice, meeting the communication needs of households and ensuring effective exchange of risk information between key participants requires a critical examination of the underlying structures that govern this exchange.

Relevancy of this Research

There is a need to obtain further understanding of various contexts of households in order to inform tailored communication strategies. As flood-risk communication is commonly designed from the expert viewpoint, the comprehensibility of that information varies at the household level due to the complexity of needs, backgrounds, and preferences and may impact the level of household resilience to floods (Snel et al., 2019). There is a gap in this body of research regarding studies that use interviews in

Canadian Communities, diversity in flood-events and contexts as well as obtaining potential unknowns needs from household perspectives. In this research, I interview households to explore and understand their experiences with flood-risk information. This research aims to answer the following questions: 1) What is important to households with regard to flood-risk information? and 2) What household flood-risk communication needs are being overlooked? This research targets various at-risk communities throughout Canada that have been impacted by recent flood-events reported in Canadian news media reports as well as communities identified as at-risk in previous studies, and interviews were designed to be semi-structured and include questions designed to initiate potential unknown needs in flood-risk communication (Golnaraghi et al., 2020).

Methodological Approaches

This qualitative study uses interviews to highlight the perspectives, needs, and experiences of households regarding flood-risk information and risk communication. The purpose of this work is to assess the communication and information needs of households and where needs are unfulfilled by current risk communication approaches. The methodologies used and procedures are described in this chapter, including the recruitment methods, selection criteria, interviewing procedures, and the thematic analysis of the coded interview data. This study was reviewed and received ethics clearance through the McMaster Research Ethics Board (MREB#5818).

Interview questions were formulated by examining the existing literature, which highlighted the deficiencies in current flood-risk communication practices. Originally, the

study aimed to recruit participants from Calgary and Toronto, focusing on the 2013 floods. However, due to the possible limitations in participants accurately capturing experiences from events that occurred eight years ago and the significance of more recent disasters like the 2021 BC flood and other various flood events across Canada, the recruitment was expanded to encompass the entire country. This expanded recruitment approach also introduced a multi-context aspect to the study, aligning with its objective of identifying unknown household needs and exploring the diverse range of flood circumstances that are encountered throughout Canada.

The study includes a small sample of 14 interviews describing individual experiences and preferences of flood-risk information and is not generalizable or a statistically significant sample; instead, the results are meant to provide new perspectives and contexts of household experiences with flood-risk. The interview study results are also meant to inform the survey design in phase 2 of this study that is meant to provide a more representative sample in understanding households preferences for flood-risk information. The interviews are meant to provide new insights to various context-specific perspectives from households that experienced a flood-event for the purpose of generating new communication needs not already discussed in flood-risk communication literature or can provide further understanding of existing flood-risk communication needs based on household experiences.

Interview Objectives

The interviews aimed to

1. Understand the successes and failures of flood communication approaches based on household accounts of various flood contexts.

2. Explore new and previously understudied perspectives of household risk communication needs.

Interview Participants

Study Sample

Several flood-prone communities in Canada were considered for participant recruitment with no specific attached flood event. There were 14 interview participants across 5 Canadian provinces that included varying degrees of flood-impacts and flood-contexts. The target was to reach 14-20 interviews, with diversity in location and flood-contexts, which was achieved by the 14 interviews conducted online across 5 Canadian provinces. The community targets were based on a scan of flood reports in Canadian news media as well as communities identified as at risk in existing literature (Agrawal et al., 2022; Emdad Haque, 2000; Gillett et al., 2022; Golnaraghi et al., 2020) Refer to *Table 2* in Appendix A for selected communities.

Inclusion/Exclusion Criteria

Inclusion criteria included households that experienced a flood-event directly, households located in Canada, and participants that were over 18. A survey screening tool was used to identify households in Canada by respondents declaring postal code, who are at least the age of 18. as well as whether respondents' property or home were directly impacted by floods (screening question used examples such as floods occurring

in basements, buildings, properties, or access to street being flooded for additional clarity). This screening tool excluded respondents who were located outside of Canada, are underage or had not been directly impacted by flooding. The screening tool url was attached to the studies recruitment advertisements and online social media posts where screening results would be reviewed and selected participants would then be contacting for an interview by email. This study assumed that those impacted directly from flooding are in flood-risk areas, which is confirmed by postal codes provided in the screening tool.

Recruitment

The timeline for recruitment began in April of 2022 until July of 2022 and included the use of a website, social media ads, and Facebook community groups to obtain interested participants. The website included the basic details of the study, including the letter of information and the link to the screening survey through the LimeSurvey platform. Social media ads were initially used at the beginning recruitment phase and were not as successful as the targeted posts done in online Facebook community groups. Few participants were obtained through social media-sponsored ads based on the screening tool response rates. The ads were run on Facebook and Instagram (now Meta) in the geographic areas in *Table 2* in Appendix A.

Additionally, Facebook community groups across various known flood-at-risk communities were used to post a recruitment script that included a link to the study website where study information could be reviewed before entering the screening survey link. This method achieved much more success in finding participants that not

only are in areas of interest but had a higher probability of experiencing a flood in the past. Facebook community groups that were prioritized for sharing study information included flood-support or flood-information groups, general community groups in flood-risk areas, and storm/weather/hazard-related groups. Groups that were selected were based on communities used for targeted ads in public groups that permitted research study recruitment posts. Refer to *Table 2 in* Appendix A. Other recruitment strategies that failed to attract interested participants include snowball sampling from already interviewed participants, as well as a hashtag search of notable recent flood events to directly recruit participants that may be interested based on publicly posted photos of floods on social media. No participants were obtained through these methods.

Interview Analysis

The interviews took place over the online conferencing software Zoom, where participants answered 10 main questions in a timeframe of 15-20 minutes. Participants were permitted to go over the allotted time if they wished to do so. Interview transcription data were analyzed thematically, whereby patterns of occurring themes were assigned various codes. Interview transcription was completed through the built-in Microsoft word transcription tool and verified for accuracy by the researcher. The interview analysis was performed manually, where the first step was to divide initial interview questions with associated answers that were assigned a code based on occurring themes. Themes were not based on interview questions but on the responses across the interview data as advised by thematic analysis procedures (Braun & Clarke, 2006). Since the interviews went often beyond the scope of the question due to a semi-structured approach, codes were assigned for of all interview data, both for interview

question answers and further discussions. The interview questions were very flexible, where it allowed participants to elaborate on their specific accounts of accessing, seeking, and receiving flood-risk information. This often led to participants going into detail on the issues that mattered to them.

The interview thematic analysis was guided by Braun & Clarke (2006) 6-step process of performing a thematic analysis, which included 1) Familiarize with the data 2) generate initial codes 3) search for themes 4) Review themes 5) Define and Name Themes 6) Produce report. A thematic analysis was an analytical method chosen based on its strengths in identifying established themes, interpreting meaning based on circumstances and contexts that fit the aims of this research in understanding diverse household experiences, concerns, needs, and preferences (Castleberry & Nolen, 2018). A bottom-up approach to the data allowed the dataset to determine the themes, but themes were screened to keep the study focus on flood-risk information. This bottom-up approach was preferred because the research aims to establish new perspectives that may be missed in a top-down approach that comes with pre-established themes (Braun & Clarke, 2006). The themes for this study were determined not only by the occurrence of codes that fit into a theme, but also by its content value of interview data based on its relevancy to the overarching research questions that address household flood-risk information needs.

Since the analysis was being performed using an inductive approach, there needed to be flexibility was needed in the themes derived from codes in the data. It was expected that with a semi-structured interview process and participants that may have

experienced socio-psychological impacts of a flood-event, the data may guide itself towards what's important according to households. This means going beyond the topic of flood-risk information and into household concerns over risk management, disagreements with flood-authority approaches, and inequities faced. Since the aims of this research was to understand the needs of households regarding information, interpretation and selection of household perspectives underwent flood-risk information relevance prioritisation but maintained reference to the background context to ensure there is reference to the researcher's comprehensibility.

The analysis revealed data-driven themes that highlight important points, offering new perspectives or identifying existing needs. These themes can be compared with existing literature or examined in the context of current knowledge to gain insights from the data. However, it is important to consider some limitations of these interviews. There may be a bias in participant selection, as those with a prior interest in floods are more likely to participate. Since this study focuses on households directly affected by floods, participants may have a higher level of flood-risk awareness and knowledge compared to the average household. It is important to note that this study does not aim to cover all household flood-risk needs comprehensively. Instead, it seeks to discover new or less-explored needs across different flood contexts in Canada. Although the number of interviews conducted for this study may be relatively small, this approach allows for a closer examination of the context and nuances within the interview data. Prioritizing quality over quantity can provide valuable insights into the complex and subjective nature of household needs.

Results

After completing a thematic analysis of the interview data, 4 key themes were identified. These included resource and support information, communication failures, information asymmetry and information accessibility. The interview excerpts are based on the perspectives of the participant and were compared with existing findings and data to provide internal validity to the researcher's comprehension and add real-world understanding to the larger context of interview participant experiences.

Theme 1: Resource and Support Information

The severity and impact of flood-event experiences varied among the interviewees, leading to diverse information needs that may have been insufficient during these household flood experiences. For example, when a flood to occurs in an area with a smaller population size as an example, information regarding supports such as where and how to access sandbags may be more limited than in a large urban centre. By contrast, larger communities with a higher number of residents affected by floods may have more resources and support information readily available. This is the case with participant ON2, where flooding along the Lake Ontario shoreline had vast impacts across the watershed but due to few impacted residents in their community, flood support information was scarce, making it challenging for the participant to find a place to purchase sandbags.

ON2 "in 2017 when the new high-water level was hit, and we had a lot of erosion. We were looking for resources to do sandbagging. We couldn't find anything. No one would fund it, so at the same time there was flooding all along Saint Lawrence and the government was supporting them with sandbagging, efforts and stuff. But we couldn't

even get sandbags. We had to find our own source to purchase them and get our own sand and do it all ourselves. There were no resources whatsoever to help us with that"

The experiences of ON2 contrasted the experiences of interview participant ON1 that endured the same flood event in 2017 but with greater severity and a larger number of people affected. ON1 was located in the upper Ottawa River area and was able to find information regarding support from their local authorities.

ON1 "here was basically monies available that we discovered both near term like things like sandbags, infrastructure assistance, the Canadian military got involved, they were locally available."

There were challenges with trying to access financial support information for some interviewees, such as the complexities of completing the necessary paperwork and finding working links navigating online government sites.

ON1: "No. It was complex paperwork, logistics rules, obviously I understand that the government would have to have some kind of level of control over the disbursement of funds, but you know if you had insurance, you were not eligible. There was a lot of complications."

AB3: "hard to find, links wouldn't work for supports that were financial assistance in Alberta"

Supports and aid for participant MB3 required an evacuation order to occur first, but communication of that information regarding aid requirements before households evacuated was not effective, leaving households who evacuated early without flood support aid.

MB3 "The irony was they hadn't called an evacuation order and most of us were moved out already because we didn't want to drive through floodwaters and damaged our vehicles. There were already floodwaters on our roads. And we were driving through them for a little bit and then we just evacuated ourselves. So until they call the evacuation orders, we are not able to get compensation for anything"

MB3 ": What we found is the after communication is really horrible, so once you're not evacuated once, you're basically no sorry you're off social assistance or any help"

Theme 2: Communication Failures

Different examples of communication failures were found within the interviews, with communication issues such as unhelpful risk information, timing of information and telecommunication infrastructure issues or issues related to FRM decisions regarding communication such as the specific information needs of certain demographic characteristics (e.g. seniors, disabled). This participant BC1 highlighted the lack of concern for seniors, or those with disabilities when flood planning decisions sent out information that did not serve the needs for some households.

BC1: "And so government needs to make certain that when they communicate information, or even when they are, you know, planning for their communities. People have to have somewhere to go, but they have to be able to afford to do it"

BC1: "People on disability don't have cars and can't get out of their apartments to go down the street"

Unhelpful risk information can also be regarded as a failure in risk communication as it may not lead to adequate preparedness. Participant BC1 also highlighted how challenging it was to be presented with a recommendation from flood-authorities to prepare for a 3-day emergency, when their community of Chilliwack BC ended up being cut-off from the rest of the province for 5 weeks. The consequences of this 3-day preparation recommendation meant not being able attend the care of their elderly mother, disabled son, and his girlfriend undergoing cancer treatment in Abbotsford as it was part of their commute from Chilliwack BC. Therefore, their ability to cope was limited during an emergency as a result of vague and unhelpful risk information such as a 72 hour/3-day preparedness recommendation.

BC1: "I needed to be moving back and forth between Abbottsford in Chilliwack. So for us, that information about, you know, being prepared for three days was virtually useless"

Participant NB2 also had a concern regarding timing of risk information in the context of flood-preparedness.

NB2 "I would like to get the time frame I have. For maybe future floods they should give it to us on time so that we can have adequate time to prepare"

Accessing relevant information posed a significant hurdle for specific households, highlighting a potential breakdown in communication when it comes to making information relevant. This also emphasizes a deficiency in addressing the information requirements of affected residents. Specifically, participants ON1 and BC2 expressed concerns that the flood risk information available to them was not sufficiently localized, thereby diminishing its relevance and practicality in their specific areas.

ON1 "maybe if you have a little bit more focused communication to the impacted property owners would be more appropriate. A more targeted audience."

BC2 "So ours is a pretty broad area and so like when they send out my flood risk, it's four areas that, you know, it would take me about an hour to drive to from here. So it's not quite, you know, it's not specific enough"

A notable communication failure was described by a resident in rural Manitoba, where they described the popular use of landlines for rural residents that was in a constant state of widespread outages by Bell MTS due to failing and outdated infrastructure. Their landline lacked service for months after the flood event and they describe how even with a cellphone purchase, their family member faced significant impacts after recent flood events.

"MB3: Because she doesn't have cell service range, she is disabled She has to run out in the middle of her yard to try and get cell service. If anybody calls, she's got doctors, but so they basically removed her from the evacuation order, sent her home, not understanding there was no telephone service which to me these days is access to 911."*

Theme 3: Information Asymmetry.

The theme of information asymmetry emerged clearly during discussions meaning homebuyers may be unaware of their flood risk due to the lack of accurate and readily available flood-risk information, leading to a discrepancy in knowledge between buyers and sellers in the real estate market. Issues related to property investments, the responsibility of the real estate industry in sharing flood-risk information, and the lack of flood-risk awareness among new homeowners were highlighted. Participant MB3 expressed concerns that increased climate change information could impact financial investments, as it may lead to the devaluation of homes in the future. They believed that constant discussions about climate change and increased flood risk would deter potential buyers when they decide to sell their homes.

MB3 "I don't think people would want that spoken about. It might be helpful, but it wouldn't. I don't know that people would like to hear that because that would revaluate our homes. I don't think like even my husband and I, even though we're in a safe place, we wouldn't want people talking about that all the time, because then nobody will buy our home when we want to sell it 10 years from now, right?"

Access to flood-risk information, including flood maps, was found to be unavailable or outdated in some at-risk areas, potentially leading to unawareness among homebuyers. This situation raises concerns about the fairness and consistency of information, as some households and flood stakeholders may have unequal access to updated flood

maps. Participant BC2 highlighted the absence of up-to-date floodplain mapping in the Okanagan region, which could affect homeowners' knowledge of their flood risk.

BC2: "make mapping floodplain mapping more available. I know there is some that's not up to date, but there's definitely none currently, for any homeowner buying in the Okanagan doesn't show you that you're on a floodplain."

The interviews highlighted another aspect of information asymmetry related to flood-risk awareness, as mentioned by BC2. It was noted that the government expects households to be aware of their flood risk and the associated implications. BC2 specifically pointed out that insurance companies possess the necessary flood-plain information and can deny coverage, thereby impacting homeowners' ability to secure mortgages. The participant also emphasized that the circumstances have changed due to the effects of climate change. This reveals a disparity in knowledge and access to crucial flood-risk information, further emphasizing the presence of information asymmetry in the context of flood-risk awareness and its consequences for homeowners.

BC2 "They can't guarantee you that your home could be saved. Insurance companies again won't insure you because you're on a floodplain and without insurance you can't get a mortgage."

BC2 "Yeah it's happened in Saskatchewan, happened in Gatineau, QC where the government finally throws up their hands says you living on a floodplain should have never built there, but that was pre climate change. Now you're 100- and 200-year floods are every 5 or 20 years."

This participant also outlined possible information asymmetry among real-estate agents and other stakeholders and the responsibility of these various stakeholders to address the issue.

BC2: "if you go up to a realtor and say am I on a flood-plain? They wouldn't know. I think it's a huge issue that has to be on the Realtors, insurance agents, mortgage providers, town planners, building permit providers."

The participants stressed that the lack of flood-risk information poses a significant problem for those purchasing homes in their communities. They expressed concerns for new homeowners who may be unfamiliar with handling high-water events and the potential implications. The participants highlighted the need for flood-risk information to be included in real estate listings and made readily available to prospective buyers.

MB3 "we have new people buying homes. You know who just can't afford homes in the city and they're moving to the country, but they have no clue how to handle high water events and what that's going to mean for them"

ON4 "Knowing about the flood risk is the biggest problem that we have. People go in and buy a house and they have no clue that there's they're on a flood-plain"

ON4 "Yeah, that's that should be part of the merge listings for real estate that should be out there. There's people that they get tremendously hurt financially when they're, you know, they buy a new house or a used house and they had no idea about the risk of flood"

Theme 4: Information Accessibility Contributing To A Knowledge Gap

The interviews shed light on information accessibility issues which may contribute to a knowledge gap of flood-risk information between households within their communities. This theme encompasses cases of communication failures which can be applicable to Theme 2, but further relates to how the inaccessibility of risk information can contribute to a knowledge gap between households within their communities. Limited access to experts and trustworthy sources, inaccurate or misleading information, unequal messaging, and inaccessible information were some of the key issues identified by the participants. For instance, participant NB2 highlighted the confusion caused by the

absence of a reliable expert during community meetings after a flood, leading to a lack of trust among attendees based on this limited access to experts.

NB2: "We had community meetings after the flood. We didn't like really have an expert. It was just people gathering so you didn't even know who to trust. So it was confusing a lot."

Similarly, participant AB3 found that the provincial website lacked comprehensive information and wished it would provide references to additional sources of risk information.

AB3 "sometimes the website might not have all the details, they could have added if you needed more go here, this contact, or here's this place"

The accuracy of flood information disseminated through media channels was also a concern, with participant MB3 criticizing inexperienced reporters as often providing confusing and misleading or inaccurate portrayal of information through local news outlets. This potential knowledge and risk information divide based on this participant report of adequacy of news media communication of risk information, may disproportionately affect individuals (e.g. seniors) who heavily rely on local news as their primary source of flood-risk information as opposed to other sources such as government websites or information directly from flood-authorities.

MB3 "one of the most distracting things is the media outlets in Winnipeg. They're very not useful. They're looking for the story and the problem is they often have inexperienced news media reporters who say things that are very confusing to us and so of course particularly to our seniors in the area who watch the local news."

Moreover, participants emphasized that prior knowledge and understanding of floods and watershed protection played a crucial role in raising awareness, leaving community members without such knowledge vulnerable to confusion and misinformation.

BC2 “it's one of my hobbies, watershed protection. So I was up to speed, I would suggest Not a lot of my community members and neighbors absolutely would not know. There's a lot of confusion.”

ON1 “. From people with a more simplistic background, a nontechnical background, your average property owner along the water, maybe a senior, they don’t get it”

ON4 “we're probably at the leading edge of understanding the flood situation here in the community. Uh, I don't think that there's much that we would need to know. But you know other residents. Oh, absolutely they do”

ON3 “I think we're prepared now for it. So used that experience so when we get large rainfalls, we check the property and we check it regularly”

ON4 “I subscribed to 2 water levels forecasts, and they would send water levels forecast to my house. I would tell people when the flood risk was high and, you know, I could give them a forecast like get ready next month, better get all your stuff out of the basement or whatever. I would do that.”

Households such as ON1 were able to use flood-risk information available but admitted it was challenging to find implying an issue of information inaccessibility.

ON1 “Back when the 2 floods occurred, it took a while to figure out where all of that information was”

Participant NB1 expressed that many individuals in their community faced confusion and a lack of sufficient information regarding flood mitigation. However, NB1's ability to seek and access the necessary flood risk information enabled them to make informed decisions. They noted that while others in the area were able to raise their houses or cottages as a flood mitigation measure after the 2018 floods, NB1 found it financially impractical to do so. Instead, they took steps to install flood-mitigation measures in their basement based on recommendations found in their research which resulted in $136 in damages from the 2019 flood of similar intensity.

NB1 "people were still confused; it didn't provide enough information. A lot of people for example, everyone around here that could, raise their houses or cottages. I can only think of one person who did not raise their cottage, and it was a cottage because it would cost him $30000 to raise it and he had $6000 in flood damages so he could have 5 more of these floods and still come out ahead, rather than raise… so it was a financial decision. We couldn't raise our house, we did what we needed to do to the basement so its not feasible to raise it, it would have cost us 50 or 60k to raise it and next year we had $136 of damage"

A participant discussed the challenges with living in a rural area and the realities of differing municipal government priorities when more than one municipal government may occur along a floodplain. Public messaging of flood-risk information and management of a flood-issue may differ between municipalities possibility due to available resources to handle a flood-risk issue. This highlights an issue of unequal risk messaging, therefore a case of potential knowledge division of flood-risk information between communities along floodplains that are in different municipal jurisdictions.

MB3 "because we rely on municipal governments, municipal governments handle situations differently from municipality to municipality. So, and sometimes our municipalities are very close in proximity like we might have two municipalities in the same flood region, and so you'll be talking to somebody at work in there they have a very different story as to and there is a lot of verbal networking going on between people who are in flood zone. Because we work in more centralized towns and you're like Oh well, "my municipality just said this" while mine isn't talking at all.

MB3 "they count on their city councillors to manage it, in the rural areas is often where we're harder hit, probably in many ways, in the city you have Infrastructure people who are in place to monitor the different dams, dikes, diversions, and such but in the country, it's very local and local government can change very rapidly with inexperienced people"

For another participant that experienced the 2013 Alberta floods and was the last one on their street to evacuate, their search for online information such as their city website on whether they were in an evacuation order for their community was missing during a time where various neighbours have already evacuated.

AB2 "So when I access the city website it would have been nice if that information had been relayed on the website, like everybody who lives on Bow Crescent, Bow Village Crescent needs to evacuate, or you will not be able to go anywhere"

Additionally, participant AB2 highlighted that there was an issue with how evacuation information was unequally distributed, which may have led to their household being the last to evacuate.

AB2 "they had known earlier in the day, but did not inform the public, so there's like unequal messaging to different people"

Accessing information through social media channels was a common strategy among interview participants as a way to fill in the gaps of flood-risk information and to have access to frequent and recent updates. During the floods in Chilliwack BC, emergency support services such as the Red Cross and other organizations were described by participant BC1 to hold the responsibility of providing accurate information as people were confused of where to go or access help. As a result, communities members stepped in on social media to help others find emergency services.

BC1 "People filled the gap by offering information online or responding to tweets or posts on Facebook saying, Oh no, that's not where that is, you gotta go over here. So the fluidity of the social media, was helpful in the emergency"

BC1 "people would have gone more to them I think, but some people didn't know where to go or what to do"

Discussion

Communication Failures as an Impact on Aid Accessibility

In the interviews, some communication concerns include how information from flood-authorities such as governments neglects the needs of all households. This may be an indication of a failure of management or priorities when planning for risk

communication. First, there were reported issues from interview participants of the complexities of navigating aid supports such as online links or aid applications that had potential barriers due to strict eligibility. As this is challenging to verify how widespread this is and there is a lack of research in disaster aid access barriers, possibly this issue may be an unmet flood-risk information need in terms of communication for households. In addition, the responsibility of disaster aid support in Canada falls largely under the responsibility of provinces and territories unless the disaster exceeds the ability for a province/territory to bear the costs on its own (Public Safety Canada, 2022). As aid and communication practices associated with aid are associated individually per province/territory, further research on potential aid accessibility barriers is needed.

Furthermore, there is a need for discussion around equity and justice considerations in accessing support aids. Barriers stemming from strict eligibility requirements may be exacerbated by inadequate communication. An interview excerpt from MB3 highlighted that because aid requirement information was not adequately communicated to residents in potential evacuation zones, households unaware that an evacuation order had to be in place first, evacuated early, and became ineligible for aid support later. The reason to consider equity and justice in this potential communication failure, is it was likely that people evacuated early out of necessity, such as to be able to attend work in case of road route disruptions, or to be in a safer environment in unpredictable circumstances. For those with more limited coping capacities, choosing to leave earlier may have been vital for reasons of not being able to lose mobility, to not risk missing a paycheck, or to ensure access to other basic needs. People with lower capacities to cope with disasters tend to be lower income, disabled, seniors,

Indigenous, racialized, and other marginalized groups (Sanders et al., 2022). Placing aid eligibility requirements that discriminate against households with additional vulnerabilities may present a significant equity and justice issue, warranting further investigation in Canadian contexts. Since communication of aid requirements are not reaching all affected households, the negative effects of this communication failure may disproportionately impact households with existing vulnerabilities and lower coping capacities.

The need for Tailored Communication Approaches to Address Issues of Equity

The issue of blanket rules or one-size-fits-all approaches are a well-studied FRM and communication gap, but considerations for equity and vulnerabilities are not as well studied and may be a potential household need missed that could be addressed through tailored FRM and communication approaches (Attems, Thaler, et al., 2020; Snel et al., 2019). Interviews such as from participant BC1 additionally provided some household concerns regarding the communication of information that does not consider the needs of households such as household limitations on affordability or mobility, all of which are limitations experienced by more vulnerable groups. The communication of information not only needs to be effective through its ability to initiate risk-reducing action but should also provide information backed by FRM approaches that include information that households also need to initiate action. For example, transportation services for seniors and disabled persons or financial aid support contacts that reduce the information accessibility barriers and therefore better address household flood-risk information needs.

The issue with the 72-Hour Preparedness Recommendation

Emergency warnings for participant BC1 were found to be ineffective and did not reflect the possibility of an extended preparedness period beyond 3 days in Chilliwack, as for 5 weeks the city was isolated because of flood impacts on road infrastructure. What is known, is there is a standard 72 hour preparedness recommendation for emergencies by Public Safety Canada that provides recommendations to provinces and municipal governments, which may not meet the needs of households when this standard recommendation is implemented for any emergency context (Public Safety Canada, 2012). As Chilliwack followed the standard 72 hour recommendation, it remains uncertain whether the city was aware of transportation route vulnerabilities and potential of losing access to the rest of the province at that time. However, based on household experiences that revealed the negative impacts of the 3-day recommendation, it becomes evident that using a preparation recommendation standard may have limitations. The effectiveness of risk communication to households could be enhanced by adopting a more precautionary approach. A study that looked at generic emergency messaging such as the 72-hour recommendation in northern Ontario communities found it to be not very useful in contexts faced by rural communities, which may add further considerations that flood-contexts matter and the 72-hour preparedness recommendations may not work for all floods (Cole & Murphy, 2014).

Disparities in Flood-Risk Communication: Inequities Among Canadian Communities

When multiple communities are simultaneously impacted by a flood, interviewing respondents can offer valuable insights into the varying accessibility of flood-risk information across these different communities. Municipal governments play a significant role in flood-risk information, offering assistance and resources. However, in cases where flood impacts extend beyond jurisdictional boundaries, households may experience varying levels of support based on their respective municipal government's availability of flood-related resources (Golnaraghi et al., 2020).

Insights from the interviews further highlights the unequal distribution of flood-risk messaging and resources between municipalities, particularly disadvantaging rural areas in terms of adequate flood-risk information availability and accessibility (Cole & Murphy, 2014b; Stewart & Rashid, 2011; Zaman et al., 2022). Participant MB3 expressed concerns about inconsistent flood-risk messaging and perceived disparities in resources between rural areas and cities. Unfortunately, literature addressing flood-risk communication in rural communities and comparing it to urban approaches is lacking (Cole & Murphy, 2014). Studies on the 1997 Manitoba floods also revealed failures in communication within rural communities, with respondents attributing this to the lack of necessary skills and resources in rural municipalities (Stewart & Rashid, 2011). The concerns raised by participant MB3 align with these findings, indicating that rural household communication needs are still unmet in the present day.

Furthermore, interviews with participants ON1 and ON2, situated in different communities along a flood-impacted watershed, demonstrated differences in available resources. ON2 faced challenges in accessing flood support information due to the limited impact in their area, with only a few houses affected by rising lake levels. Consequently, these households struggle to obtain resources and support information as their local government may not respond adequately to the limited number of affected households. Despite the relatively small scale of impact, it is crucial to address this issue, given that floods are the most frequent disasters in Canada, affecting both populated and rural areas (Golnaraghi et al., 2020; Stewart & Rashid, 2011). The interviews emphasize the significance of this household need, which is brought to light by the observed disparities in flood-risk communication.

To gain a deeper understanding of this issue, further research should explore the potential discrepancies in flood-risk communication between rural communities and urban cities. This will help identify strategies to bridge the communication gap and ensure equitable access to flood-risk information for all communities.

Disparities in Flood-Risk Communication: Inequities Among Households

Participant concerns shed light on the existence of unequal messaging between households, emphasizing the need to address inequities in flood-risk communication. Participant AB2 acknowledged that their household was the last to evacuate on their street due to uneven distribution of evacuation information. Similarly, interview participants ON1 and BC2 expressed concerns about the lack of localized flood-risk information and called for a more targeted approach for affected households. These

interviews provide crucial insights into the equity and inequality concerns surrounding flood-risk messaging.

One key insight from the interviews is the importance of focusing communication efforts on households most affected by flood impacts. ON1 highlighted the need to prioritize communication towards these households, addressing an equity need in flood-risk communication. Additionally, participant BC2 emphasized the necessity for risk communication to be equally distributed in evacuated communities. Both needs contribute to understanding the potential information divide between households and offer pathways to address household communication needs effectively.

Exploring Information Asymmetry and Inequities in Flood-Risk Communication

The discussion on information asymmetry regarding flood-risk information is primarily found in the literature concerning insurance, while other forms of information exchange, such as property purchases, have received less attention. In the context of flood-risk information, one party can gain a financial advantage by withholding this information from another party. Reasons for non-disclosure may include ignorance or the unavailability of accurate flood-risk information, as reliable and up-to-date flood maps are limited and sometimes inaccessible (Henstra et al., 2019; Minucci et al., 2020). Although the interview questions did not specifically focus on information asymmetry, the participants themselves expressed concerns about the lack of flood-risk disclosure. These concerns shed light on a broader systemic issue of limited accessibility and disclosure of flood-risk information, and its consequential impact on multiple areas.

The discussion on information asymmetry regarding flood-risk information often centers around its impact on real estate transactions, with less attention given to other forms of information exchange. Participants in the interviews provided interesting insights into this issue. For instance, participant MB3 expressed reluctance towards increased flood-risk information disclosure related to future climate change impacts in real estate, as it could negatively affect their financial investments. This perspective may reflect a larger motivation for asymmetric information in real estate, particularly considering that a significant portion of Canadians rely on their homes as investments for retirement (*Designed for Savings 2021 Report*, 2021).

This dilemma raises the trade-off some households might face between preserving their investments and their support for sharing flood-risk information. In other interviews, information asymmetry was also identified as a concern for homeowners who are unaware of potential risks, particularly in terms of fairness for new homeowners. Asymmetric information is inherent in the real estate market, as sellers typically possess more knowledge than buyers, and there is a natural inclination for sellers to capitalize on the information they possess (Broxterman & Zhou, 2023).

This challenge of information asymmetry contributes to the continued reproduction of risk, which may be attributed by the ongoing deregulation of planning development in Canada (Oulahen & Ventura, 2022). This deregulation may enable the expansion of development in flood-prone regions, driven by profit motives among key interested persons in the housing market such as developers, real estate agents, and banking institutions (Bill 23, More Homes Built Faster Act, 2022, 2022). Further research

should be conducted to explore the connection between asymmetrical information and deregulated privatized markets, particularly in the context of flood-risk. This investigation is important because the deregulation of insurance and real estate markets may create incentives for the perpetuation of information asymmetry.

Conclusion

The research findings shed light on the significance of flood-risk information for households and reveal specific areas where their information needs are not being met. The prioritization of certain aspects of flood-risk information emerged as a common theme among the interview participants.

One key aspect highlighted by households is the content of flood-risk information. They expressed a need for additional details that are tailored to their specific requirements. This includes information that addresses the unique needs and circumstances of their households. They also emphasized the importance of links to support services such as transportation and emergency shelters, as well as access to reliable localized flood-risk information. Additionally, there was a need for provincial websites to enhance the informativeness and provide additional information resources. It may be feasible for flood-risk communicators within governments to work with internal or external agencies that specialize in evaluating social risk factors such as housing, seniors and accessibility, health, and social services to help determine what information to include for specific audiences.

Timing of information was another important factor mentioned by some interview participants. They emphasized the need for timely warnings and accurate flood

preparation information. The timing of when this information is provided was deemed crucial for effective flood-risk communication.

The comprehensibility of flood-risk information was also identified as an important consideration. The experiences shared in the interviews revealed mixed perceptions regarding information availability, which often depended on participants' comprehension of the available flood-risk information. Therefore, ensuring that the information is easily understandable is key for households.

Accessibility of information was highlighted by some interviewees as a significant concern. They stressed the importance of having access to detailed information, especially for households at greater risk. Additionally, they expressed the need for resources that provide further information to households in need.

Fairness emerged as an important principle in flood-risk communication. Interview participants emphasized the importance of equitable communication practices, fairness in flood-risk information disclosure, and avoiding situations where households feel compelled to disagree with flood-risk disclosures due to their investments in housing and retirement planning. They also pointed out the need to address underlying vulnerabilities that lead to disproportionate negative flood impacts on certain households.

From these experiences and discussed areas of importance, interview participants highlighted 6 major flood-risk information needs that are currently understudied or less well-known in the context of Canadian households.

Unknown/Understudied Household Needs Derived from Interviews:

- The need for telecommunication infrastructure to be valued as vital for flood-recovery.
- Aid Information needs to be effectively communicated to all flood-affected households, when not receiving information in a timely manner may impact aid support for households most in need.
- The need for tailored information from flood-authorities such as governments to apply to the needs of all households, including households with limited mobility and financial ability.
- The need for locally tailored and comprehensive flood-risk support information that caters not only to municipalities with a higher concentration of flood-impacted households but also to those with a smaller number of affected households, including rural areas.
- Need for equal messaging between households during evacuations and/or flood warnings.
- Need for targeted messaging of flood-risk information to households most at risk.

Some households included needs that have been studied previously and is already known in flood-risk communication literature, and these interview findings can therefore contribute to this body of knowledge from the diverse flood-contexts of the interviews. When it comes to flood warnings and preparedness recommendations, the generic 72 hour-preparedness recommendations were ineffective; communication approaches must address varied household contexts that may be more resilient from a more precautionary preparedness recommendation. The 72-hour recommendation has

been studied before in another Canadian context in northern Ontario communities with a similar concern from households (Cole & Murphy, 2014). The 2021 Chilliwack floods provide a valuable context for reevaluating the effectiveness of generic 72-hour top-down flood risk management (FRM) recommendations and considering more detailed information requirements.

The concerns surrounding asymmetrical information in real estate, the necessity of flood-risk disclosures, and the limited knowledge of flood-risk information among real estate professionals highlight the importance of fairness and power dynamics among private actors involved in flood-risk. To gain a deeper understanding of the factors contributing to information asymmetry and information inaccessibility, it is essential to examine the drivers of flood-risk production, including flood-plain development, as well as the interplay between different systems such as the insurance industry, housing as an investment, and housing supply issues in Canada. By comprehending these dynamics, we can explore alternative approaches that move beyond placing the burden solely on households and relying on private participant collaboration to manage flood-risk. Addressing the gaps in flood-risk communication requires a comprehensive understanding of diverse household contexts, and this study offers insights into some of the household needs that can enhance flood-risk resilience.

Appendices

Appendix A

Table 1: Operationalization of Concepts

Concepts	Operationalization
Flood-risk information	Any information pertaining to resources of flood-risk information through forms of media, online sources, word-of mouth, prior knowledge, emergency and governing bodies and information relayed from experts. This can include flood maps, financial resources or advice pertaining to floods, resource tools and recommendation pertaining to flood-risk, information regarding emergency procedures, current or future statuses of flood-risk, measurable indicators such as water gauges or water levels, 1 in 100-year flood indicators, property level flood-risk assessments, flood awareness campaigns etc.
Resilience	"The ability of an individual, community, city or nation to resist, absorb or recover from a shock and/or successfully adapt to adversity or a change in conditions in a timely and efficient manner." (Sayers et al., 2013)
Major-flood event	Extensive flooding to areas normally above the ordinary high-water mark from a nearby waterbody that are partially or completely inundated (National Weather Service, n.d.)
Flood-risk areas	Areas that have a potential for a flood event that risk health, life, property and the functions of a natural flood-plain (FEMA, n.d)

Table 2: Community Targets and Geographic Contexts of Interviews

Province	Communities Targeted	Number of Interviews	Geographic Contexts
British Columbia	Chilliwack, Abbotsford, Merritt, Grand Forks, Hope	2	Chilliwack, Okanagan valley
Alberta	Calgary, Chateh	3	Calgary
Manitoba	Winnipeg	3	Winnipeg
Ontario	Hamilton, Toronto, Niagara region, Kenora, Brantford, Ottawa, Upper Ottawa River	4	Upper Ottawa River, Hamilton, Niagara Region
New Brunswick	Grand-Lake, Fredericton, Moncton	2	Moncton, Fredericton
Nova Scotia	Halifax	0	
Northwest Territories	Hay River	0	

Table 3: Thematic Analysis Themes

Theme 1: Resource and Support Information	***Theme 2: Communication Failures***	***Theme 3: Information Asymmetry.***	***Theme 4: Information Accessibility***

			Contributing To A Knowledge Gap
Codes: support, funds, compensation, aid, resources, accessibility	Codes: preparedness, disability, timing, area, sources, messaging, communication,	Codes: knowledge, floodplain, Real estate/realtors, homes, investment, insurance, awareness, flood-risk	Codes: confusion, knowledge/know, media, unequal, inform/information, experience
ON2 “in 2017 when the new high-water level was hit, and we had a lot of erosion. We were looking for resources to do sandbagging. We couldn't find anything. No one would fund it, so at the same time there was flooding all along Saint Lawrence and the government was supporting them with sandbagging, efforts and stuff. But we couldn't even get sandbags. We had to find our own source to purchase them and get our own sand and do it all ourselves. There were no resources whatsoever to help us with that.” ON1 “here was basically monies available that we discovered both near term like things like sandbags, infrastructure assistance, the Canadian military got involved, they were locally available.” ON1: “No. It was complex paperwork, logistics rules, obviously I understand that the government would have to have some kind of level of control over the disbursement of funds, but you know if you had insurance, you were not eligible. There was a lot of complications.” AB3: “hard to find, links wouldn't work for supports that were financial assistance in Alberta” MB3 “The irony was they hadn't called an evacuation order and most of us were moved out already because we didn't want to drive through floodwaters and damaged our vehicles. There were already floodwaters on our roads. And we were driving through them for a little bit and then we just	BC1: “And so government needs to make certain that when they communicate information, or even when they are, you know, planning for their communities. People have to have somewhere to go, but they have to be able to afford to do it” BC1: “People on disability don't have cars and can't get out of their BC1: “I needed to be moving back and forth between Abbottsford in Chilliwack. So for us, that information about, you know, being prepared for three days was virtually useless” NB2 “I would like to get the time frame I have. For maybe future floods they should give it to us on time so that we can have adequate time to prepare” ON1 ”maybe if you have a little bit more focused communication to the impacted property owners would be more appropriate. A more targeted audience.” BC2 “So ours is a pretty broad area and so like when they send out my flood risk, it's four areas that, you know, it would take me about an hour to drive to from here. So it's not quite, you know, it's not specific enough” MB3 “Because she doesn't have cell service range, she is disabled* She has to run out in the middle of her yard to try and get cell service. If anybody calls, she's got doctors, but so they basically removed her from the evacuation order, sent her home, not understanding there was no telephone	MB3 “I don't think people would want that spoken about. It might be helpful, but it wouldn't. I don't know that people would like to hear that because that would revaluate our homes. I don't think like even my husband and I, even though we're in a safe place, we wouldn't want people talking about that all the time, because then nobody will buy our home when we want to sell it 10 years from now, right?” BC2: “make mapping floodplain mapping more available. I know there is some that's not up to date, but there's definitely none currently, for any homeowner buying in the Okanagan doesn't show you that you're on a floodplain.” BC2 “They can't guarantee that you will be your home could be saved. Insurance companies again won't insure you because you're on a floodplain and if it without insurance you can't get a mortgage.” BC2 “Yeah it's happened in Saskatchewan, happened in Gatineau, QC where the government finally throws up their hands says you living on a floodplain should have never built there, but that was pre climate change. Now you're 100- and 200-year floods are every 5 or 20 years.” BC2: “if you go up to a realtor and say am I on a flood-plain? They wouldn't know. I think it's a huge issue that has to be on the Realtors, insurance agents, mortgage providers, town planners, building permit providers.”	NB2: “We had community meetings after the flood. We didn't like really have an expert. It was just people gathering so you didn't even know who to trust. So it was confusing a lot.” AB3 “sometimes the website might not have all the details, they could have added if you needed more go here, this contact, or here’s this place” MB3 “one of the most distracting things is the media outlets in Winnipeg. They're very not useful. They're looking for the story and the problem is they often have inexperienced news media reporters who say things that are very confusing to us and so of course particularly to our seniors in the area who watch the local news.” BC2 “it's one of my hobbies, watershed protection. So I was up to speed, I would suggest Not a lot of my community members and neighbors absolutely would not know. There's a lot of confusion.” ON1 “From people with a more simplistic background, a nontechnical background, your average property owner along the water, maybe a senior, they don’t get it” ON3 “I think we're prepared now for it. So used that experience so when we get large rainfalls, we check the property and we check it regularly” ON4 “we're probably at the leading edge of understanding the flood situation here in the community. Uh, I don't think that there's much that we would need to know. But you

evacuated ourselves. So until they call the evacuation orders, we are not able to get compensation for anything” MB3 “ What we found is the after communication is really horrible, so once you're not evacuated once, you're basically no sorry you're off social assistance or any help”	service which to me these days is access to 911.”	MB3 “we have new people buying homes. You know who just can't afford homes in the city and they're moving to the country, but they have no clue how to handle high water events and what that's going to mean for them” ON4 “Knowing about the flood risk is the biggest problem that we have. People go in and buy a house and they have no clue that there's they're on a flood-plain” ON4 ”Yeah, that's that should be part of the merge listings for real estate that should be out there. There's people that they get tremendously hurt financially when they're, you know, they buy a new house or a used house and they had no idea about the risk of flood”	know other residents. Oh, absolutely they do” ON4 “I subscribed to 2 water levels forecasts, and they would send water levels forecast to my house. I would tell people when the flood risk was high and, you know, I could give them a forecast like get ready next month, better get all your stuff out of the basement or whatever. I would do that.” ON1 “Back when the 2 floods occurred, it took a while to figure out where all of that information was” NB1 “people were still confused; it didn’t provide enough information. A lot of people for example, everyone around here that could, raise their houses or cottages. I can only think of one person who did not raise their cottage, and it was a cottage because it would cost him $30000 to raise it and he had $6000 in flood damages so he could have 5 more of these floods and still come out ahead, rather than raise… so it was a financial decision. We couldn’t raise our house, we did what we needed to do to the basement so its not feasible to raise it, it would have cost us 50 or 60k to raise it and next year we had $136 of damage” MB3 “because we rely on municipal governments, municipal governments handle situations differently from municipality to municipality. So, and sometimes our municipalities are very close in proximity like we might have two municipalities in the same flood region, and so you'll be talking to somebody at work in there they have a very different story as to and there is a lot of verbal networking going on between people who are in flood zone. Because we work in more centralized towns and you're like Oh well, “my municipality just said this” while mine isn't talking at all. MB3 “they count on their city councillors to manage it, in

			the rural areas is often where we're harder hit, probably in many ways, in the city you have Infrastructure people who are in place to monitor the different dams, dikes, diversions, and such but in the country, it's very local and local government can change very rapidly with inexperienced people" AB2 "So when I access the city website it would have been nice if that information had been relayed on the website, like everybody who lives on Bow Crescent, Bow Village Crescent needs to evacuate, or you will not be able to go anywhere" AB2 "they had known earlier in the day, but did not inform the public, so there's like unequal messaging to different people" BC1 "People filled the gap by offering information online or responding to tweets or posts on Facebook saying, Oh no, that's not where that is, you gotta go over here. So the fluidity of the social media, was helpful in the emergency" BC1 "people would have gone more to them I think, but some people didn't know where to go or what to do"

Appendix B

Semi-Structured Interview Questions

1. **During your experience with a flood, if you can remember, where did you look for information about your potential risk for flood or any information during the flood? (**Examples: neighbours, the news? family? social media? Online)
    - Did you find that information adequate? Was it helpful? Unhelpful?
    - Did you experience confusion on where to find flood information resources or did you know where to look?
2. **Were you aware of any financial support information available to you? If you did, was it easy/hard to find?** (this can be government supports, grants, insurance)

3. **Would you prefer getting flood risk information on your own time (like using a website) or would you prefer an information session or consultation with an expert to relay flood risk information to you? (Virtual consultation with an expert).** Flood risk information would include details about your homes potential risk, how to prepare for a flood, how to reduce flood impacts on your property, flood maps, water levels of a creek/river).

4. **With climate change impacting frequency and intensity of flood events, would you find that detailed information that describes that increased risk useful for making flood-risk decisions? Why or why not?**
    - What would you like this information to give you?
    - Where you like to access this information?

5. **Is there information about your homes risk of floods in general you want to know of and why?**
    - Do you know where to look for that information?
    - are there sources you prefer to get that information from? (general website, government, city, conservation authority, social media)

6. **How would you prefer to be informed about a risk of flood?**

7. **How would you prefer to be informed about how to prepare for a flood?**

8. **How important/unimportant is it to you to have flood-risk information of any neighbourhood, or property searchable online?**

9. **Do you know what your current local flood-warning system looks like and what it means?**

10. **Is there something important we forgot? Is there anything else you think I need to know about your experiences with flood-risk information?**

CHAPTER 3 BRIDGING THE GAP IN RISK AWARENESS: EXAMINING HOUSEHOLD VALUES AND PREFERENCES OF FLOOD-RISK INFORMATION IN CANADA

Abstract

This chapter examines household values and preferences on flood-risk information. Four hypotheses related to accessing flood-risk information, language style preferences, information gaps, and personal responsibility are investigated using survey data from at-risk households in Canada. Findings reveal diverse preferences for accessing information, with interpersonal relationships comparatively less valued as a source for information while language style preferences favor more direct messaging with detail of risk information tailored to the needs of the user. Variations in accessibility, transparency, and knowledge gaps exist based on flood-risk perception. Individual versus collective values as it pertains to support for flood-risk reduction strategies reflect a complex relationship between household support for equitable flood-risk management, and voluntary-only evacuations. Differences in flood-risk status groups were observed regarding personal responsibility of risk and restricting property sales in flood-risk areas, highlighting the influence of flood-risk perceptions. This analysis highlights the need for tailored and accessible risk communication strategies, with considerations for the variability of flood-risk information values and preferences among households. By understanding these differences and accounting for perceived flood-risk status, flood-risk managers and communicators can develop targeted approaches to enhance flood-risk communication, risk awareness and community resilience.

Background

Introduction

Floods are increasing in frequency and severity globally due to urbanization and climate change, posing a significant challenge to household flood-risk resilience in Canada. While research has explored factors contributing to improved flood-risk resilience, the complex interplay of social, structural, and contextual mechanisms makes it challenging to fully understand how households can become more resilient (Attems, Thaler, et al., 2020; Snel et al., 2019). Current literature lacks sufficient research on the association between risk perception and flood-risk information preferences among diverse flood-contexts in risk communication (Cole & Murphy, 2014c). While previous research has examined various factors related to flood-risk resilience, there remains a gap in understanding how households perceive and prefer flood-risk information within diverse flood contexts (Honegger & Oehy, 2016; O'Sullivan et al., 2012).

This chapter explores flood-risk information and how it is perceived, framed, and preferred to further understand information preferences. Furthermore, it will compare these preferences, perceptions, and values among households based on their perception of risk. This research seeks to explore the relationship between risk perception and information preferences, considering the unique characteristics of different flood contexts (Cole & Murphy, 2014c). By assessing the context of perceived

risk awareness and information preferences, we may be able to identify gaps in risk communication between flood-risk management authorities and households in Canada.

Risk Perception and Awareness

Risk communication faces a challenge due to the potential discrepancy between perceived risk, which can be influenced by individuals' beliefs and cognitive abilities, and actual risk levels (Botzen et al., 2009). This gap between perception and reality can sometimes lead to unhelpful decision-making. Risk perception involves evaluating the likelihood of a hazard and the expected outcomes, especially negative consequences, as perceived by society where perception is subjected to various influences and contextual factors such as beliefs, thoughts, and constructs (Botzen et al., 2009; Bubeck et al., 2012; Knuth et al., 2014; Oubennaceur et al., 2022). Perceived risk often differs from objective risk, where objective risk comes from the measurable and quantifiable level of risk associated with a particular event, activity, or situation. It is based on factual and verifiable data, such as statistical analysis, and scientific evidence (Botzen et al., 2009; Knuth et al., 2014). Objective risk is independent of an individual's subjective perceptions or opinions and is typically assessed using objective criteria and methods.

A survey conducted by Ziolecki et al. (2020) revealed that only 6% of Canadians were aware of their flood risk. This lack of awareness remains a significant issue in Canada, particularly at the local level where resources for effective risk communication are insufficient (Ziolecki et al., 2020). As a consequence of this limited awareness, a small percentage of individuals have taken proactive steps to minimize flood risks to

their personal safety and property. Specifically, less than 30% of Canadian homeowners have implemented property-level flood protection measures, such as installing sump pumps, back-water valves, rain barrels, or water-resistant materials in their basements (Thistlethwaite, Henstra, Peddle, et al., 2017). Efforts to increase awareness such as providing more flood-risk information to households is essential, but insufficient to drive behavioral change alone without also including public engagement initiatives (Thistlethwaite, Henstra, Minano, et al., 2017). The success of public engagement initiatives relies on several shared elements, such as trust in the authorities leading the efforts, integrating community feedback, coordinating across different levels of governance, and encouraging a sense of personal responsibility in flood risk management (Thistlethwaite, Henstra, Minano, et al., 2017).

Households that are aware of their objective level of risk are in the best position to manage and adapt to existing risk, whether these risks are high or low. Meanwhile, underestimating risk, possibly due to the absence, misunderstanding, or rejection of knowledge and information, leaves people unprepared for future harm. The conceptual framework in *Figure 1* illustrates how improving the alignment between perceived and objective risk, has the potential to guide households towards greater resilience and sustainable forms of risk management. This framework was created by the researcher to support the idea that communicating flood-risk information (FRI) effectively may improve flood-risk awareness and guide individuals towards more situationally aware risk perception (Kammerbauer & Minnery, 2019).

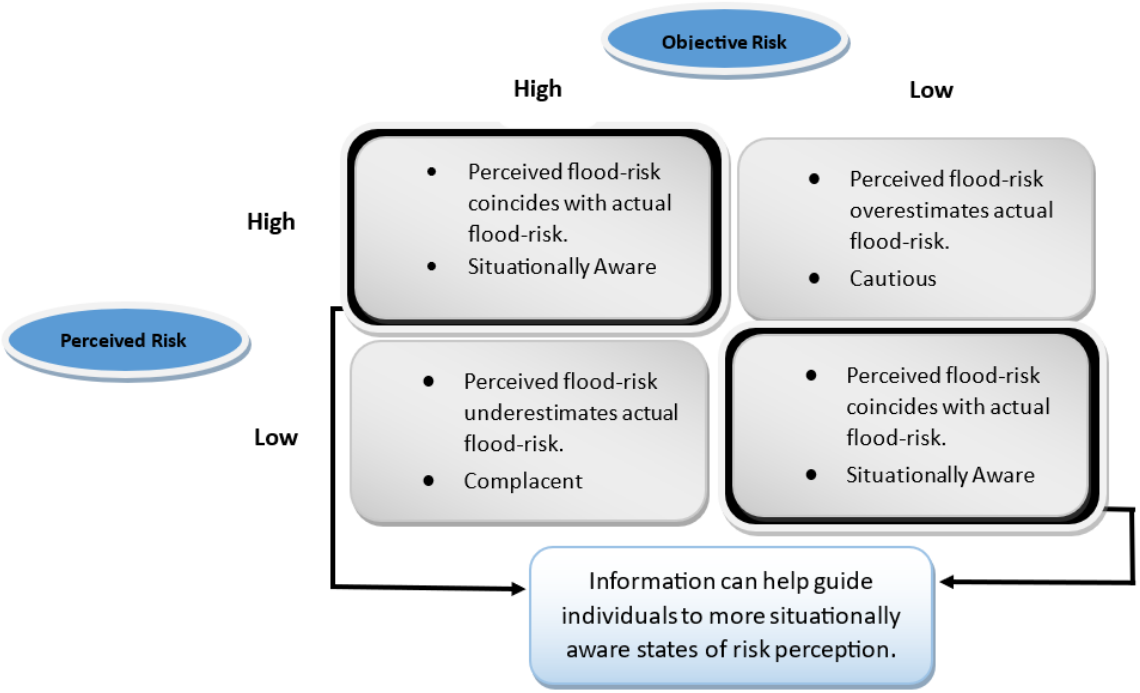

Figure I Conceptual Framework of Objective and Perceived Risk of Flood Area Status, with considerations of risk information Interpretation and Awareness

The Issue of Capacity for Local Level Risk Communication

Local governments play a critical role in flood-risk communication as they are in direct contact with households and entrusted with implementing FRM standards set by provincial governments. However, these municipalities often face resource constraints, limiting their ability to dedicate resources to this role (Golnaraghi et al., 2020; Thistlethwaite & Henstra, 2017; Ziolecki et al., 2020). A paper by Zaman et al., (2022), it highlights how there are resource limitations faced by local level governments when engaging with communities, which consequently hampers their ability to effectively communicate risks to households. The paper by Zaman et al., (2022) argues that in

order to address this engagement challenge, it is essential to foster better cooperation and collaboration between local and provincial governments. The current disaster management governance structures often follow a "top-down" approach, where central government agencies set goals and direct implementation, but these approaches tend to neglect community engagement and fail to address underlying vulnerabilities and systemic issues. Consequently, there are numerous local disputes and demands for more transparency and involvement of the community in decision-making. In response, some regions have shifted towards a participatory "bottom-up" structure, where various governmental and non-governmental entities work collaboratively to achieve a consensus on common goals and strategies for risk management (Zaman et al., 2022).

Previous studies have used household surveys and interviews to shed light on this issue and highlight the insufficient resources of local governments to enhance flood-risk communication. For instance, a study conducted in the Manitoba Red River region revealed that interviewees, when asked about the progress made in addressing communication challenges since the 1997 flood, identified their municipalities' limited resource capacities and skills to develop programs to improve public knowledge and emergency planning was a hindrance to improved risk communication (Stewart & Rashid, 2011). The study also emphasized the significant disparities in risk perception among households in different municipalities, pointing to inconsistencies in their risk communication approaches (Stewart & Rashid, 2011). Another study focused on the flood-prone Delta region in British Columbia found that municipal practitioners identified limitations in capacity, including financial capital and climate change expertise. The lack

of technical and human capacity at the local level posed a challenge to effective risk communication in Delta (Burch et al., 2010).

Flood maps, an important tool for local risk communication, can provide households with a localized understanding of flood risks. However, a study assessing the quality of municipal flood maps across Canadian communities revealed that 62% of the maps were of low quality which means meeting less than half of the criteria for evaluation, with only 16% meeting five or more out of nine criteria (Henstra et al., 2019). The criteria included a legible legend, a legible flood zone, local contextual features, personalized experience, map limitations, technical term explanations, historical context, advise for local residence and depiction of multiple hazards. Most municipalities in the study did not provide property-level flood risk information, issues of comprehensibility for a lay audience and lack of guidance on risk reduction, raises equity concerns regarding FRM policies that increasingly place responsibilities on households (Henstra et al., 2019).

The limited resource capacities of municipalities across Canada create a challenge in providing comprehensive flood-risk maps to households, which hinders their ability to enhance flood-risk awareness. Additionally, the lack of capacity to effectively communicate flood-risk information due to limited financial resources and expertise exacerbates the issue. The inconsistencies in communication approaches and the availability of flood risk information from one municipality to another emphasize the need for a provincial or federal strategy that can bridge the information gaps at the municipal level through a more collaborative and assistive approach.

To address these challenges, it is crucial to gain a comprehensive understanding of the information and communication gaps among households. Given the challenges faced by municipal governments in enhancing household awareness through risk communication, provincial and federal governments might have extra resources and capabilities that can be leveraged to support municipalities in addressing these gaps at the local level. This research approach aims to shed light on the information gaps and communication challenges faced by households who reside in various municipalities across Canada.

Research Objectives

The findings from this research may contribute to the development of a more effective provincial or Canada-wide approaches to flood-risk communication that considers the diverse needs and preferences of households at the local level. This is for the purpose of addressing the under-resources issues at the local level where federal and provincial governments may possess more adequate resources to close risk information gaps and improve risk awareness among Canadian households (Thistlethwaite & Henstra, 2017). This study considers several factors such as access to information, risk knowledge, public trust, individual values, and impact of local risk management frameworks may influence an individual's journey towards situationally aware risk perception. Moreover, this research aims to fill the gaps in the current literature by exploring the association between risk perception and flood-risk information preferences, thereby providing valuable insights into risk communication challenges and opportunities for improvement.

This research explores two general questions:

A. Is there varied flood-risk information values and preferences among households?

B. Do those values and preferences change, depending on perceived flood-risk status?

I have four specific hypotheses, first, households have no differences in preferences of where they access flood-risk information, second, households have no differences in preferences of language, and style of how flood-risk information is communicated, third, there is a flood-risk information gap between households, and fourth, households who value more personal responsibility to flood risk oppose strategies that reduce flood-risk.

Methods

Research Design

The study population consists of 285 adult respondents of an online survey of respondents from 9 provinces and 1 territory in Canada collected between June 10th 2022 and December 31st 2022. Respondents were recruited online through social media community groups and threads of the targeted communities in *Table 10 in Appendix C* on Facebook and Reddit. The target population for this study consisted of adults residing in flood-risk areas of Canada. Specific Facebook and Reddit community groups associated with flood-prone areas or those that had experienced previous floods were selected for recruitment purposes. The groups were community discussions pages or

threads that were either general such as just a space where people can share any information regarding a community or had a specific focus on a flood-event from the past (which was only present on Facebook community groups). Therefore, general community groups such as ones more commonly identified in Reddit flood-risk communities that had major past flood-events were selected for recruitment to ensure a higher probability of obtaining survey participants who possess flood-risk awareness. The reason for targeting flood at risk community groups, was for the reason of exploring perceived risk in the sample, as well as furthering the chances of obtaining data that were from households who have been impacted by floods to some capacity, including living in proximity to past flood events. Recent floods and historical flood-events in specific communities in Canada were the targeted areas of recruitment, ranging from smaller scale localised flooding to larger scale floods that reach a state of emergency status. This was to ensure there was a diverse range of flood-contexts.

The survey in total contained 8 multiple choice questions, 1 short-answer, 1 rank-order question, 11 Likert Scale questions and 1 open question. In the initial design of the survey, the questions and sections were selected based on if they could contribute to understanding what households value regarding flood-risk information, informed by the interviews in Chapter 2. The question design included Chapter 2 themes of flood-risk information accessibility, transparency and comprehensibility, trust, awareness, positioning on highly polarised topics such as evacuations, property sales in flood-risk areas, and the individualization of responsibility for flood-risk on households. This was to ensure that the survey design was informed by household needs and concerns to further address potential gaps in flood-risk communication.

A screening survey tool was used to ensure participants were over the age of 18 and to prevent participants who do not reside in Canada by asking participants to provide their first 3 postal code digits. Since this study had a draw prize of $100, e transferred as compensation, additional measures to protect survey data accuracy was applied in addition to CAPTCHA tools. An open-ended question in the survey asked participants if there was anything they would like to share regarding their experiences with flood-risk information which provided a way to detect fraudulent responses to ensure data validity. Fraudulent responses would answer the open-ended question with an irrelevant and repeated script that was easily detectable. Open-ended questions can be considered one of the most effective strategies in survey bot detection (Storozuk et al., 2020).

Analytical Tools for Survey Analysis

In this study, a significance level of 0.05 was chosen as the decision threshold to assess whether the data align with the null hypothesis. This significance level indicates a confidence level of 95%, allowing for the determination of statistical significance and guiding decision-making during the analysis process. Participants were based on their perceived flood-risk. Group A, comprising 130 participants, represents the perceived flood-at-risk group, while Group B consists of 155 participants categorized as the perceived not at risk of flood group. The classification of participants into these groups was based on a survey question that obtained the household's perceived flood risk status.

To analyze the data obtained from Likert scale questions in this study, various statistical tests were employed based on the nature of the research objectives and the characteristics of the data.

The purpose of the analysis is to identify the occurrence of diverse preferences among households for various types of flood-risk information, and to identify potential gaps in flood-risk information that targets hypothesis 1 and 2. This will be presented by descriptive data analysis in addition to box and whisker plots to present the distribution of survey question responses.

Ranking question H1.R6 involved ordering communication options from top (mostly preferred) to bottom (least preferred) for where participants might access flood-risk information the most. A comparison of weighted means among each option that is ranked in order of preference was used to compare the responses for the same purpose of identifying if there is an occurrence of diverse preferences by households *(Table 2).* To compare weighted means of ranking questions, a method that involves assigning weights to the variable responses was employed to calculate weighted mean scores that could be compared. This approach allowed the capture of relative importance of each response and identify any significant differences in the weighted mean scores. This was done by assigning different weights to each rank, ranging from the highest weight of 6 for Rank 1 to the lowest weight of 1 for Rank 6. The rank value was then multiplied by the assigned weight, and these resulting products were summed up for each variable. This was to ensure that higher weights were given to responses ranked 1st, indicating their greater significance, while lower weights were assigned to

responses ranked 6th. To obtain the weighted means, the sum of the weighted products was divided by the sum of the counts for each rank. This calculation accounted for the variations in rank positioning and provided a more accurate representation of the overall weighted average for each variable. Additionally, Kruskal-Wallis rank sum test was used to compare if rankings of risk communicators significantly differ among all respondents using the weighted mean scores *(Table 3).*

Secondly, the purpose of this analysis is to identify potential gaps in flood-risk information that targets hypothesis 3, by also employing the use of box and whisker plots and descriptive analysis which focuses on metrics of household's accessibility, transparency of flood-risk information, and familiarity of flood-risk information.

Thirdly, the purpose of the analysis is to compare survey responses by flood-risk status in order to explore potential factors that may lead to differing values, preferences or awareness through the use of the Wilcoxon rank sum test that targets all hypotheses. This non-parametric test is suitable for ordinal data, does not assume normality and allowed for the ability assess whether there were significant differences in the responses between the two groups. To compare survey responses by flood-risk status for ranking question H1.R6, Kruskal-Wallis rank sum test was used to compare weighted means of flood-risk status groups A and B.

Lastly, for exploring the correlation between Likert scale questions in hypothesis 4, the Kendall's rank correlation tau was selected. This non-parametric measure assesses the strength and direction of the monotonic association between two variables

and enabled the ability to examine the relationship between different Likert scale questions.

Results

Hypothesis 1: Households have no differences in preferences of where they access flood-risk information.

To support hypothesis 1, questions selected included what information sources that households prefer to rely on, and household trust in the communicators of risk information. By analyzing these questions, an understanding of household preferences within different dimensions of information sharing can be obtained. Refer to results in *Table 1*, *2, and 3 in* Appendix A.

Question H1.1, asks whether participants agree with the statement "I get the best flood-risk information from my neighbours, friends, and family." The positioning of the box and whisker plot in *Figure 2* demonstrates that a substantial proportion of participants leaned towards ratings of disagreement. When comparing flood-risk status groups A and B, no statistically significant differences in Likert scale ratings were found between the groups based on a (p-value = 0.3196).

Question H1.2 asks participants about their agreement with the statement “Face to face flood-risk consulting with an expert would be my most-preferred way of receiving flood-risk information”. The positioning of the box and whisker plot in *Figure 2* around the neutral midpoint reflects a lack of strong consensus among respondents, indicating a diversity of perspectives on face to face with an expert is a preferred way of obtaining flood-risk information. When comparing flood-risk status groups A and B, the distribution

of each groups data appears similar to the overall sample, and no statistically significant differences in Likert scale ratings were found between the groups based on a (p-value = 0.6998).

H1.3 is a question about the usefulness of a community-based flood group, which community-based flood-groups that would be available to ask questions about flood-risk, host information meetings, and emergency planning resources were rated by participants. The box and whisker plot in *Figure 2*, the interquartile range, represented by the box, extended from 'moderately useful' to 'very useful,' demonstrating that most respondents perceived the flood group as valuable within this range. Overall, the positioning of the box and whisker plot between 'moderately useful' and 'very useful' suggests a generally positive reception of the potential usefulness of flood-groups in risk communications, with some variations in perceived usefulness among the participants. The flood risk status group comparisons of A and B show no observable differences in statistical testing based on a (p-value of 0.2329).

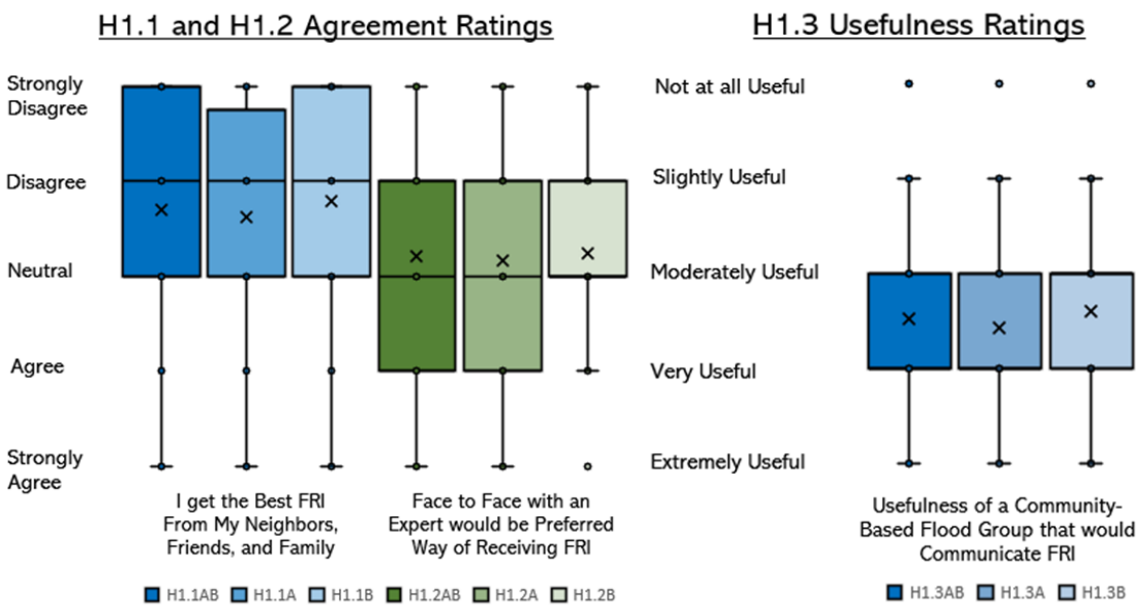

Figure 2 H1.1 & H1.2 Agreement Ratings, H1.3 Usefulness Ratings

The trustworthiness ratings of various flood-risk communicators were obtained through H1.T1-6, where participants were asked to rate their trust in each communicator. *Figure 3* presents the box and whisker plots depicting these trustworthiness ratings. Notably, the police and emergency services (H1.T3) and field and academic flood risk experts (H1.T5) received significantly higher trustworthiness ratings. The field and academic experts had 69% of participants rating 'Strongly trustworthy,' indicating a substantial level of trust among the sampled population.

Similarly, the Newscaster and familiar media personnel (H1.T1) and local government representatives (H1.T2) such as mayors, city council and local politicians received relatively high trustworthiness ratings. However, their means and medians

were lower compared to the experts and emergency services. *Figure 3* visually demonstrates this observation.

The provincial government representatives (H1.T4) displayed more mixed ratings of trustworthiness, indicating that this source may be perceived as less trustworthy compared to other communicators in the sample. The box and whisker plot for this group shows a wider range of responses, suggesting a greater variability in trustworthiness ratings.

The trustworthiness ratings of community members, neighbors, and online communities with information sourced by local citizens (H1.T6) were comparatively lower than all other communicators. The ratings for this source indicated mixed trust among the households in the sample. The box and whisker plot reveals a lower median and mean, suggesting a lower level of trustworthiness.

When comparing flood-risk status groups A and B, the distribution of the data for groups A and B appears similar to the distribution of data of the overall sample, and no statistically significant differences in Likert scale ratings of trustworthiness were found between the groups based on the p-values listed in *Table 1* in Appendix B.

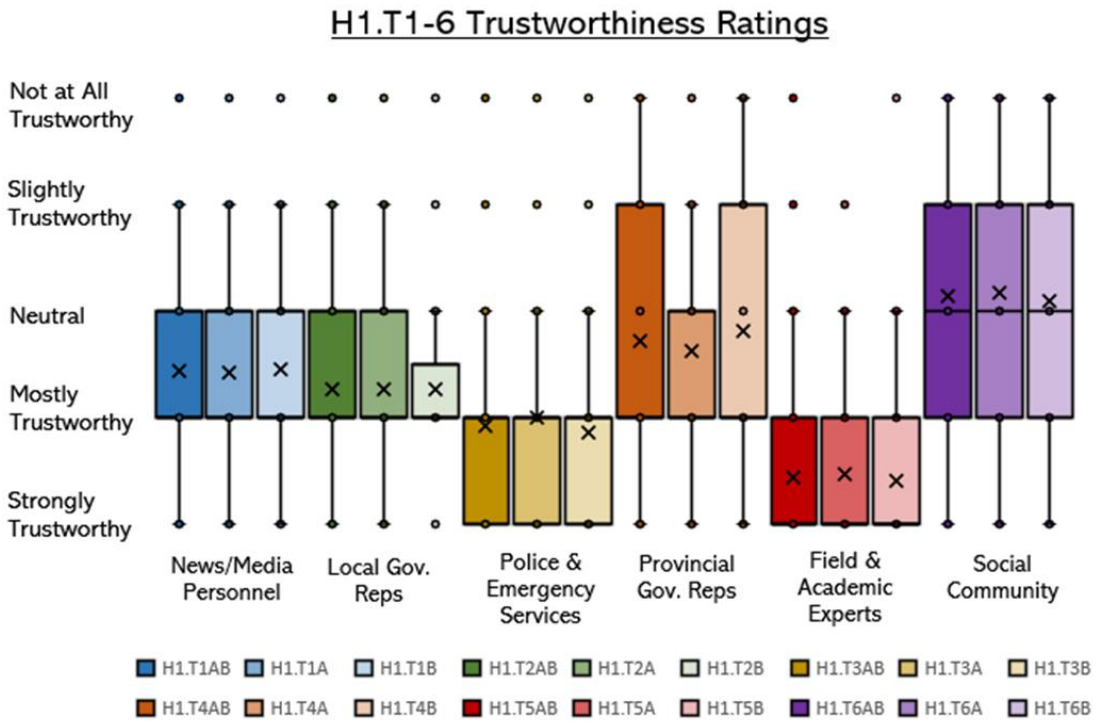

Figure 3 H1.T1-6 Trustworthiness Ratings

Rank order question H1.R6 is the rankings of communication options from most preferred (rank 1) to least preferred (rank 7). Weighted mean scores were used to compare the ranking position of each communication option, which would be used to compare between the overall sample AB and Groups A and B to determine if there is difference between the weighted means. Observing the overall sample AB comparison of weighed means appear similar across information sources in *Table 2*. News was ranked as 1st for 34% of the sample, followed by social media and local city/town website at 22% each, google searches at 9%, radio at 7% and other at 5%. Since this analysis uses weighed means among rankings which were calculated by assigned weights to each ranking that coincide inversely with their ordinal position, its apparent that there is not a source that is considerably highly favored, even though preferences

do seem to differ slightly. Using the Kruskal-Wallis Rank Sum Test in *Table 3*, no significant differences between the means were found between the variables for the overall sample AB with a (p-value = 0.4159). When comparing the weighted means among Groups A and B, no significant differences were found between these groups with a (p-value = 0.8728).

Rank Question H1.R6 Comparison of Weighted Mean Scores Order these communication options from top (mostly preferred) to bottom (least preferred) for where you might access flood-risk information the most?									
Code	**Source**	**Sample**	**Rank 1**	**Rank 2**	**Rank 3**	**Rank 4**	**Rank 5**	**Rank 6**	**Weighted mean score**
1	Social Media (Twitter, Facebook etc)	AB	64	46	52	43	44	36	3.77
		A	32	23	16	19	24	16	3.78
		B	32	23	36	24	20	20	3.76
2	News	AB	98	64	63	31	23	6	4.58
		A	46	34	27	12	8	3	4.68
		B	52	30	36	19	15	3	4.49
3	Radio	AB	19	50	39	75	68	34	3.21
		A	11	22	17	33	33	14	3.25
		B	8	28	22	42	35	20	3.17
4	Google Searches	AB	27	50	61	69	65	13	3.53
		A	8	16	33	33	35	5	3.34
		B	19	34	28	36	30	8	3.69
5	Local city/town website	AB	64	62	58	51	33	17	4.08
		A	28	30	34	22	11	5	4.21
		B	36	32	24	29	22	12	3.97
6	Other	AB	13	13	12	16	52	179	1.83
		A	5	5	3	11	19	87	1.73
		B	8	6	9	5	33	92	1.92

Table 2 Rank Question H1.R6 Weighted Mean Scores of various Communication Options

Rank Question	Kruskal-Wallis Rank Sum Test	Chi-Squared	DF	P-Value
H1.R6	Testing Comparing Weighted Means of AB	5	5	0.4159
	Test Comparing Weighted Means of A and B	0.025641	1	0.8728

Table 3 Rank Question H1.R6 Weighted Mean Comparisons of all Communication Options of all Responses AB, and by Flood Risk Status Groups A and B.

Hypothesis 2: Households have no differences in preferences of language, and style of how flood-risk information is communicated.

The homogeneity of preferences in communication style was analysed using 2 Likert scale questions that ask about language style preferences and the level of detail that is preferred within flood-risk information. Level of detail in Likert scale ratings included a description of different levels of language difficulty, and levels of data complexity such as the use of charts, maps, and diagrams with varying degrees of detail. The hypothesis assumes that participants will prefer similar preferences of detail and language, rather than a mixed distribution of responses across various levels of detail and language preferences. These responses are compared further between perceived flood-risk status groups A and B to assess any potential differences in responses. Results can be found in *Table 4* in Appendix B.

When it comes to the agreement of the statement H2.1 “When communicating a flood emergency to the public, would you prefer they use more alarming language and encourage more rapid preparedness than to be calm and possibly underestimate the

threat (example: prepare for 7 days instead of 3 days without power/access to necessities"). In the sample, 20% of participants strongly agree, 47% agree, 18% neither agree or disagree, 12% disagree and 4% strongly disagree with the statement. These results indicate higher preference for language and risk framing that takes on a more direct approach among sampled participants. Upon comparing Groups, A and B regarding perceived flood-risk status, agreement on language preferences does not differ among groups based on a (p-value = 0.5114).

Question H2.2 asks about the level of detail in flood-risk information households prefer. In the overall sample, 11% of respondents preferred extremely detailed flood risk information (hard data for interpretation, academic resources etc, 44% preferred very detailed (some data to interpret, charts, maps, highly descriptive language) and 43% preferred moderately detailed (maps, diagrams, descriptive but easy to understand language). Less than 2% of respondents preferred slightly detailed (general and simple to interpret information and not detailed (basic information). It seems that there is varied preference among various degrees of detailed information, but very few respondents preferred simple or basic flood-risk information. Upon comparing Groups, A and B regarding perceived flood-risk status, the preferences of detail do not differ among groups based on a (p-value = 0.3987).

Hypothesis 3: There is a flood-risk information gap between households.

Hypothesis three asks if there is an information gap between different households in the sample. This means for there to be a gap in information which is when households may have varied levels of comprehension, accessibility, perceived

relevancy and transparency and awareness of risk information, that households would rate these variables differently, rather than similarly. If households rate similarly on a survey question, there may not be a major difference between household experiences on that variable, but if households are split on a survey question, such as differed rates of agreement as an example, that may be an indication of an information gap in terms of comprehension, accessibility, perceived relevancy, transparency, or awareness. These questions will also be compared based on flood-risk status to see whether there may be an occurrence of an information gap between perceived flood-risk status groups.

Question H3.1 asks participants to rate the level of accessibility of flood-risk information that includes flood history, and the current and future flood risk of any property. The positioning of the box and whisker plot in *Figure 4* around the neutral midpoint reflects a lack of strong consensus among respondents, indicating a diversity of perspectives on the accessibility of flood-risk information.

Question H3.2 is regarding transparency of flood-authorities such as governments, dam managers, and other water management authorities on providing useful and detailed information to the public. The box and whisker plot in *Figure 4*, the interquartile range, represented by the box, extended from 'sometimes transparent' to 'mostly transparent,' demonstrating that most respondents rate the transparency of flood-authorities providing useful and detailed information to the public within this range. Overall, the positioning of the box and whisker plot between 'sometimes transparent' and 'mostly transparent' suggests a generally stronger transparency ratings, there is some variations in transparency ratings among the participants.

Question H3.3 is regarding FRI relevancy based on whether households find that available FRI they currently access through their preferred information sources is relevant based on levels of agreement. The box and whisker plot in *Figure 4*, the interquartile range, represented by the box, extended from 'neutral' to 'agree,' demonstrating that respondents lean towards agreement that FRI is relevant to them based on the flood-risk information they currently access.

Question H3.4 asks participants how familiar are you to knowing where to access important FRI. The positioning of the box and whisker plot in *Figure 4* around the neutral midpoint reflects a lack of strong consensus among respondents, indicating a diversity of perspectives on the familiarity of where (e.g. local town website, conservation authority, provincial website) to access important FRI. When comparing flood-risk status groups A and B, the distribution of each groups data appears different to the overall sample based on Figure 4, with group B showing ratings of lesser familiarity.

Question H3.5 asks participants on how aware they are of what to do during a flood emergency warning based on ratings of familiarity. A description was also added in the question for further clarity that includes “you receive warning that a flood is likely to happen in your neighbourhood, from what you already know, would you know what to do?”. The positioning of the box and whisker plot in *Figure 4* around the neutral midpoint reflects a lack of strong consensus among respondents, indicating a diversity of perspectives on the familiarity of what to do during a flood emergency.

Question H3.6 asks participants whether they agree that their knowledge of their flood-risk is adequate and whether they think they need any further information. The box

and whisker plot in *Figure 4*, the interquartile range, represented by the box, extended from 'neutral' to 'disagree,' demonstrating that respondents lean towards ratings of disagreement that their knowledge of flood-risk information is adequate.

When comparing flood-risk status groups A and B across all Hypothesis 3 questions, it is evident that group B, the perceived 'not at risk' group, generally exhibited lower ratings in terms of accessibility of flood-risk information, transparency of Flood Risk Information (FRI), familiarity with accessing FRI, and knowing what to do during a flood emergency. Additionally, group B expressed greater disagreement regarding the relevance of the FRI they currently access and that their flood-risk knowledge is adequate. These differences were confirmed through a Wilcoxon Rank Sum test, which demonstrated statistically significant distinctions between the means of the two groups (refer to *Table 5* in Appendix B for p-values < 0.05). These findings indicate there may be a gap in knowledge of flood-risk information between the two flood-risk status groups.

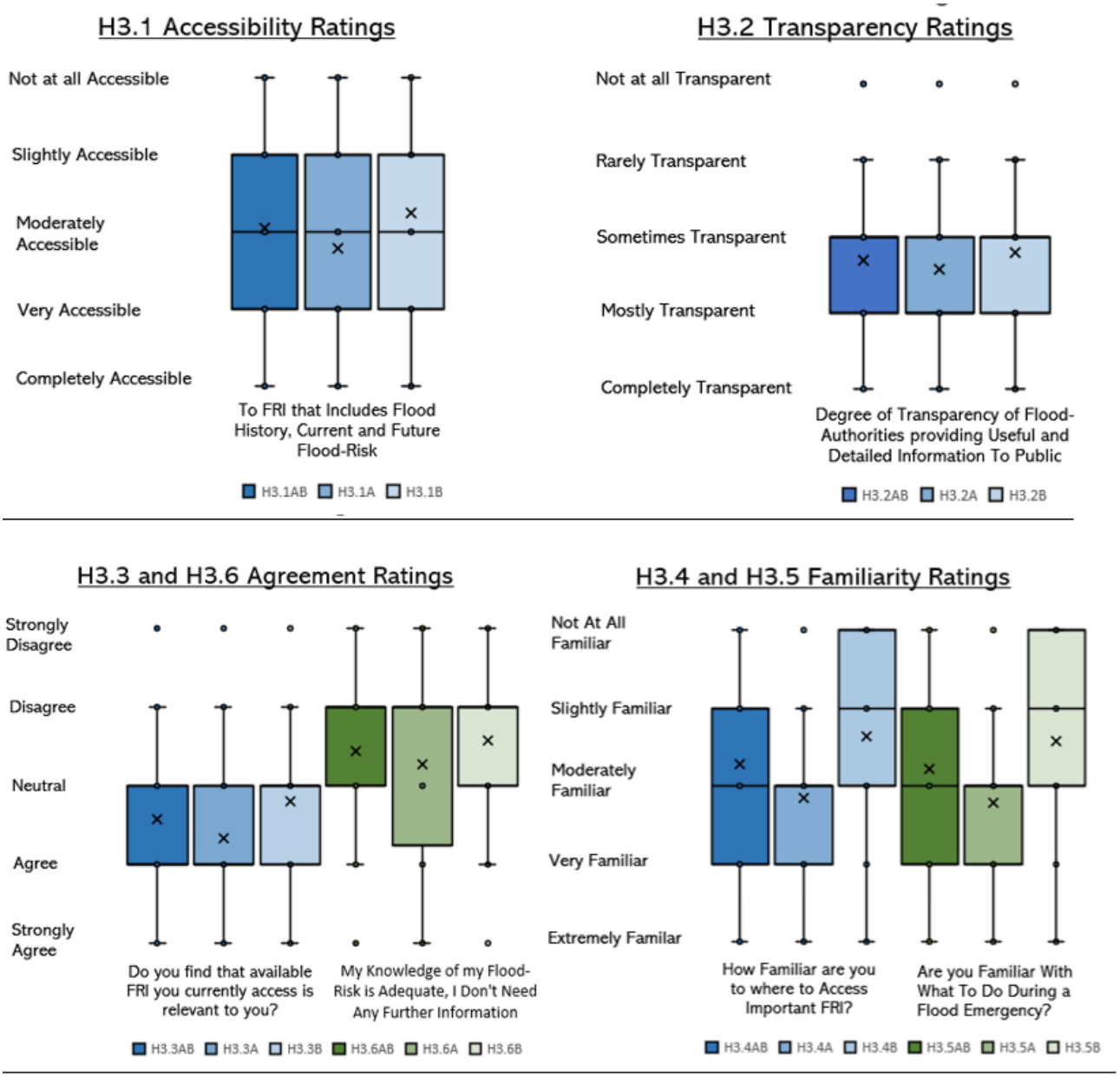

Figure 4 Hypothesis 3 Ratings

Hypothesis 4: Households who value more personal responsibility to flood risk oppose strategies that reduce flood-risk.

Hypothesis 4 explores the potential conflict between households that place a high value on personal responsibility in flood risk and their attitudes towards strategies aimed at reducing flood risk. This hypothesis investigates the interplay between individualistic values and the adoption of flood risk reduction measures. Some flood-risk reduction measures may be perceived as more collectivist in nature, such as focusing on community and societal-level risk mitigation efforts through mandatory evacuations, banning property sales in high-risk areas, equitable distribution of resources and greater flood-risk responsibility put on government. To analyze possible correlations between 4 statements that are half collectivist aligned and half individualist aligned, Kendall's rank correlation tau was employed. Then these statements were also compared based on flood-risk status. By evaluating these factors, this research aims to gain insights into the relationship between individualism, attitudes towards flood risk reduction, and the broader context of community and societal risk mitigation efforts.

A statistically significant negative correlation was observed between statements H4.1SR and H4.2PR, which assessed participant agreement on statements: FRM should protect the most vulnerable and equitably distribute resources and flood evacuations should always be voluntary, using Kendall's rank correlation tau coefficient. The correlation was significant with a (p-value = 0.003666) and a tau coefficient of -0.1482556, indicating a moderate negative correlation between the variables. This suggests that participants who express higher agreement with the more socially aligned statement of FRM protecting most vulnerable and equitable distribution of resources

tend not to agree that evacuations should always be voluntary. However, no evidence of correlation was found between any other statements in *Table 6* because of p-values > 0.05.

The Wilcoxon rank sum test was employed to compare Groups A and B for each question statement, to determine if there are differences in agreement between the two groups. Statistical analysis revealed that for H4.1PR, which states “flood preparedness is on the responsibility of the household, not the government”, there was a statistically significant difference between the groups (p-value = 0.03187). Group B, households perceived to be not in a flood risk area, exhibited greater agreement with statement compared to Group A.

Similarly, for H4.2SR, which pertains to banning property sales in flood-risk areas, there was a statistically significant difference in agreement between Groups A and B (p-value = 0.03891). Group B, the perceived not at-risk group demonstrated greater agreement with the statement, while the flood at risk group A seemed to agree less with the idea of banning property sales in flood-risk areas.

Discussion

Hypothesis 1

The analysis of participant preferences for accessing FRI yielded mixed results, where some question statements possessed limited differences in participant preferences of where they access flood-risk information while some question statements possessed diverse preferences among participants. Participants generally did not prefer FRI from neighbors, friends, and family, while community-based flood

groups were considered useful. Preferences for face-to-face interactions with experts had more diverse ratings of agreement, indicating participants were largely divided on this preference. Trustworthiness ratings varied widely among participants, with provincial government representatives and social community (in-person and online) receiving diverse ratings of trustworthiness. News/media personnel and local government representatives were perceived as neutral to mostly trustworthy, while police and emergency services and field and academic experts were considered the most trustworthy sources.

When it comes to preferred sources of information, households were asked about obtaining information from various options, such as within their social circles (friends, neighbors, family members), through one-on-one interactions with experts, or via participation in community-based groups. Among these options, it was observed that information from within social circles resulted in the most similar household responses in terms of ratings. One-on-one interactions with experts and community-based groups displayed greater diversity in preferences, as indicated by varying agreement and usefulness ratings. This suggests that, overall, the sample does not largely consider their social circles as their preferred source of flood-risk information, irrespective of their perceived flood risk status as no statistically significant differences were found between groups A and B.

In contrast, field and academic experts and police and emergency services have the greatest similarities in trustworthiness ratings among households, with news media with local leaders rated slightly less in trustworthiness in comparison. Provincial Leaders

and community members had the most mixed ratings of trustworthiness indicating households of this sample may trust these communicators differently**.** This observation is noteworthy when comparing it to the findings of H1.1, which explored the preference for sourcing flood-risk information from social circles such as friends, family, and neighbors. The comparison suggests that local sources, both online and within in-person social networks, are relatively less valued and trusted compared to other information sources according to this study sample.

Existing literature has examined the varying levels of trust that households place in different risk communicating actors, highlighting differences in trust across information sources. For instance, one study asserts the presence of three key trustees with a central role in risk communication, local government, neighbours, and emergency/relief volunteers, with neighbours rated with the lowest mean level of trust, and emergency/relief volunteers had the highest mean level of trust (Seebauer & Babcicky, 2018). This is consistent with the results of this study, as sourcing FRI from social circles including neighbours was less preferred and in terms of trustworthiness, an individuals social network was deemed less trustworthy compared to all other risk communicating actors. Some flood-risk communication literature has suggested that approaches that include the use of an individual's social network is more effective than top-down government communication (Haer et al., 2016), and it has been suggested that strengthening social networks and social capital supports through information sharing will lead to strengthened risk resilience (Belblidia, 2010). In contrast, we found that individual social networks may be a weak area in the households surveyed based on disagreement on sourcing information and lower trust in social network actors such

as friends, family, neighbours, and in-person and online communities. This suggests that disseminating information through social networks may have limited success compared to other sources. It also suggests a need to strengthen social networks to more effectively engage in flood-risk communication processes, as research indicates this is a valuable piece of building resilience (Belblidia, 2010; Haer et al., 2016).

Hypothesis 2

Similar to hypothesis 1, hypothesis 2 investigates differences in household flood-risk information preferences, specifically focusing on language style and level of detail. Regarding the language style of emergency messages (H2.1), it is apparent that households exhibit a shared preference for the use of alarming language and the promotion of rapid preparedness rather than using calm approaches in emergency messaging (language that is carefully selected to not incite fear and anxiety). Similarly, in H2.2, which examines the level of detail, households demonstrate a preference for higher levels of detail. However, the preferences for detail range from extremely detailed and academic to highly descriptive and moderately detailed with simplified language. This variability within the realm of detailed preferences suggests that households may prefer flood-risk information that is tailored to their specific needs, encompassing various formatting options, language choices, and visual representations of flood-risk data. This emphasizes the importance of providing customized risk information that aligns with households' comprehension levels and requirements (Attems, Thaler, et al., 2020; Martens et al., 2009).

The need for tailored flood-risk information is a major gap often identified in flood-risk communication literature (Attems et al., 2020; Haer et al., 2016; Snel et al., 2019). The issue can further be emphasized by the findings in this study. A more specific example of this gap in Canada, would be with the need for tailored flood maps representative of a local context, which would be comprised of information that could provide more details representative of households needs, such as community level flood-risk information (Henstra et al., 2019). An example of community level flood-risk information would be what properties are at risk of inundation, what the emergency routes are and what routes could be blocked by flooding. However, barriers to providing tailored flood-risk information such as through the use of flood maps can be affected by the limited financial, resource and expertise capacities of local municipalities and local level flood-management bodies to produce flood-maps more appropriate for public needs and comprehension (Burch et al., 2010; Henstra et al., 2019).

To address this information gap and raise community awareness, certain provincial governments, like Alberta, have taken action by implementing a flood hazard identification program. Following the devastating 2013 southern Alberta floods, the need for community-level flood maps became apparent, leading to the development of a comprehensive and user-friendly flood map tool. This tool allows households to input their address and receive information on the potential extent of flooding in their community, including varying levels of flood severity. The objective is to provide households with valuable information that enhances their awareness and preparedness regarding flood risks (Government of Alberta, 2023).

In contrast, provinces like Ontario currently lack a provincial map tool specifically designed for public use. Instead, flood maps are provided by some conservation authorities at the local level, but with limited usability for households such as limited use of labels and terminology understandable to lay audiences (Henstra et al., 2019). Both conservation authorities and municipalities face significant financial constraints, particularly smaller conservation authorities that have limited access to tax revenue, which hinders their ability to develop comprehensive flood-management programs, including the creation of up-to-date flood maps, let alone adequately designed for public needs (McNeil, 2019). Additionally, a BC study identified that a provincial or national floodplain mapping strategy is needed to address the limited capacities at the local level (Oulahen et al., 2018).

While existing research has predominantly focused on the expert-lay gap and household comprehension of risk information, limited attention has been given to understanding the effectiveness of current flood-risk resources, particularly in diverse Canadian contexts, and their ability to inform households (Attems, Thaler, et al., 2020). Therefore, further investigation into the diversity of household preferences for detailed risk information is warranted to gain a deeper understanding of how to effectively address household needs when communicating information from top-down flood-risk communicators such as various levels of government.

Hypothesis 3

Hypothesis 3 focuses on whether there is a gap in flood-risk information between households based on ratings in accessibility, transparency, knowing where to access

flood-risk information, knowing what to do during an emergency and whether their flood-risk knowledge is adequate. The results unsurprisingly have found significant differences in these factors between perceived flood-risk status groups, where the perception of flood risk is influenced by these variables related to flood-risk knowledge and access to information, suggesting a relationship between how well-informed households are and how they perceive and respond to flood risks. Households who perceive they are at-risk of floods report better access to information, rate higher transparency among flood-risk communicators, have more knowledge of where to find information, and report greater awareness of flood emergency response procedures than households who perceive they are not at risk.

In terms of accessibility ratings, households in the overall sample ‘AB’ exhibited varied perceived levels of accessibility, with a division between very accessible and slightly accessible ratings. When comparing different flood-risk status groups, group ‘A’ reported higher accessibility ratings compared to group ‘B’. This suggests that individuals who perceive themselves at risk of floods may have better knowledge and awareness of how to access flood-risk information compared to those who perceive themselves as not at risk. It implies that the perception of personal risk may play a role in motivating individuals to seek out and utilize available resources for accessing flood-risk information, therefore this may not be an issue of accessibility but instead an issue of participants seeing a need based on their perception of flood-risks. This explanation may also apply to the similar observation of all hypotheses 3 questions where the perceived flood-at-risk group possessed greater ratings of transparency of FRI,

relevancy of FRI, familiarity of what to do during an emergency and where to access FRI compared to the perceived not at-risk group.

One study revealed that in risk communication, people tend to seek more information when they feel they lack knowledge or perceive a greater level of risk. They do this because they believe they can handle the risk better by acquiring more information. Furthermore, their intention to seek information is influenced by the perception that the information they find will be useful (Kellens et al., 2012). Therefore, this suggests that individuals who perceive themselves at risk may find the available risk information to be more accessible, transparent, and relevant. This is because they view this information as useful in addressing their risk perceptions, creating a heightened need for it. The information seeking behaviour of participants identified by this study comparing risk perceptions and experiences seeking flood-risk information may contribute to the gap identified in Kellens et al., (2012) where it's stated that effects of residing in a hazard-prone location on information-seeking behavior have not been extensively studied.

Question H3.6 explores participants' confidence in their knowledge and whether they feel the need for additional flood-risk information. This question aims to uncover potential differences in attitudes towards obtaining new FRI among different flood-risk groups and identify any gaps in FRI if there is reluctance to seek new information. In the overall sample, there was a higher level of disagreement with the statement regarding the need for additional information. However, when comparing by flood-risk status, group 'A' slightly agreed more with this statement compared to group 'B'. This suggests

that households who perceive themselves at risk have slightly higher confidence in their existing risk information knowledge and lack of need for additionally information compared to households who perceive themselves as not at risk. This suggests that a sense of risk might lead some households to believe they are already well-informed. These findings may be further informed by a previous study that have shown that feeling the need for information didn't directly lead to seeking information (Kellens et al., 2012). The Kellens et al., (2012) study observed a similar phenomenon, indicating that simply feeling the need for information doesn't necessarily translate into actively seeking that information. Therefore, recognizing the need for information doesn't automatically motivate people to actively look for it.

Based on the recruitment strategies of this study targeting flood-risk communities, the perceived not at-risk group is likely an example of a group who perceive they are not at risk while there may be objective flood risk present. Therefore flood-risk awareness may be highlighted as an issue contributing to differing ratings of accessibility, transparency, knowledge of FRI, and what to do during an emergency based on study results highlighting a significant difference of ratings between flood-risk status groups. Its evident that flood-risk awareness is low within Canada, and it should be considered that household perception of risk may significantly differ from objective risk when comparing to studies such as Ziolecki et al., (2020). where 6% of survey respondents were aware they were at risk.

The results of perceived risk in this study combined the perceived not-at-risk group and risk is unknown group to provide more simplistic data analysis as it was

assumed that those who are unaware of their risk would not differ from the not-at-risk group, based on the studies recruitment of only flood-risk areas. Of the perceived not-at-risk group, 57% of the 155 participants indicated their perceived risk was unknown. Therefore, risk awareness may play a significant role information seeking and preferences, especially if low risk perceptions such as unknown risk or perceived not at-risk participants are placed in the same group.

Hypothesis 4

Hypothesis 4 aimed to further investigate the values held by households regarding personal responsibility and flood-risk reduction strategies, specifically the banning of property sales in flood-risk areas and the voluntariness of flood evacuations. This was of interest both by the themes discussed in Chapter 2, as well as a way to help answer the research question of whether values between households in terms of flood-risk information vary.

The results revealed a statistically significant negative correlation between statements H4.1SR and H4.2PR. Participants who valued equitable distribution of resources tended to disagree with the idea that flood evacuations should always be voluntary. This suggests a moderate conflict between personal responsibility and the perception of social responsibility for flood risk management. This aligns with hypothesis four as the observed negative correlation between valuing equitable distribution of resources and agreement on voluntary evacuations suggests a potential conflict between individualistic values and collective efforts to reduce flood risk. Participants who prioritize personal responsibility may view mandatory evacuations as infringing

upon their autonomy and prefer a more individualistic approach to managing flood risk. No other correlations were found to be significant therefore it is unclear if households who value more personal responsibility to flood risk oppose strategies that reduce flood-risk.

These findings may be informed by the framework cultural theory of risk that has been utilised in flood-risk communication literature that explores how cultural biases influence risk perception. Cultural biases, such as individualism and collectivism, shape individuals' responses to risk and their interpretation of the world. Individualism refers to valuing of individual goals and rights over group obligations, while collectivism emphasizes group goals and responsibilities (Xu, 2018). In Xu, (2018) study which examined how the media frames information and the influence of individualistic or collectivistic cultural views on risk perception, it was noted that cultural perspectives can impact cognition and emotion. Emotions are important in risk perception, as the intensity of emotions can influence people's assessment of risks (Markus & Kitayama, 1991; Xu, 2018). Additionally, emotions can shape how the public responds to risks and their attribution of responsibility (Markus & Kitayama, 1991). Moreover, another study suggests that the challenge with mandatory evacuations lies in balancing individual liberties with the need to protect the common welfare, highlighting the contrast of these values further in the context of managing societal flood-risk (Fairchild et al., 2006).

Furthermore, a statistically significant difference was observed between the perceived flood-at-risk group and the perceived not at-risk group regarding H4.1PR (flood preparedness is the responsibility of the household, not the government). The

perceived flood-at-risk group exhibited a higher level of disagreement with the statement on responsibility (H4.1PR), suggesting a greater inclination toward government support compared to the perceived not at-risk group. This finding aligns with the expectation that individuals who perceive themselves as being susceptible to flood risks would be more supportive of resources that benefit them, unlike individuals who do not perceive such risks. This seems like an issue where households who may be at risk but are unaware of their risk agree slightly less for government help for flood-preparedness measures that are prior to a flood. This may indicate that risk awareness may play a role in how households consider their individual responsibility in flood-preparedness.

Insights from one study aimed to understand what factors influence people's sense of social responsibility (SR) towards flooding in their community (Begg, 2018). Their findings showed that higher SR perceptions can lead to better resilience, and to improve these perceptions, the study suggests using information strategies to raise awareness about flood risks and the importance of social responsibility (Begg, 2018).

Connecting these findings, we can infer that households with a higher level of flood-risk awareness may be more likely to perceive greater social responsibility in managing flood-risk as opposed to individual responsibility. When people are aware of the potential risks they face, they may be more inclined to act and seek help, including government assistance in preparing for floods (Begg, 2018). In contrast, households that are unaware of their flood risk may not prioritize flood-preparedness measures as much, leading to a lower perception of social responsibility in the context of this study.

Additionally, a statistically significant difference was found between the flood-risk status groups and agreement with the statement on banning property sales in flood-risk areas, with the perceived at-risk group ‘A’ demonstrating higher ratings of disagreement of banning property sales in flood-risk areas. While the existing literature has not specifically examined complete bans on property sales in high-risk areas, previous studies have explored related aspects, such as the disclosure of flood risk during property sales. For instance, one study found that 89% of participants agreed that sellers should inform potential buyers if the property is located in a designated flood risk area (Ziolecki et al., 2020). Additionally, the same study addressed property buyouts by the government for residences at risk of repeated flooding, with 49% of respondents supporting such buyouts, 20% opposing them, and 32% being unsure. These findings shed light on the differing perspectives of households regarding flood-risk property sales and buyouts.

Many factors may motivate the at-risk responses to disagree with bans on property sales in flood risk areas. The most obvious is that such a ban would immediately impact the value of an important asset in their possession—since they may no longer be able to sell their homes. The difference in households' agreement with the statement on banning property sales in flood-risk areas could be influenced by various factors. Possible factors could include the sense of security provided by flood insurance coverage, the cost-benefit analysis of living in a flood-prone area, individual values related to private property rights and autonomy, as well as investments in properties located in flood-risk areas, may also play a role. (Dachary-Bernard et al., 2019; *Designed for Savings 2021 Report*, 2021; Ericson et al., 2000; IBC, 2019). The

perceived not-at-risk group may be influenced less by these factors, leading to greater support for banning property sales in high-risk areas compared to those who perceive themselves as at risk.

Limitations Of Study

This study is subject to several limitations, which pertain to the sample characteristics, study design, and generalizability of the findings. Firstly, the sample was obtained from various flood-at-risk proximate communities, targeting households that were likely to be at risk. However, it should be acknowledged that not all participants in the survey can be objectively classified as at-risk, as the study primarily focused on perceived risk. Due to the nature of the research focus, it was considered less necessary to incorporate a concrete measure of objective risk. Determining the exact objective risk for each participant solely based on geographic data from the first 3 digits of their postal codes, as presented in *Figure 6* Appendix C, would not be feasible. Additionally, it is important to note that the limited availability of accurate and up-to-date flood-risk maps in Canadian municipalities further complicates the establishment of a comprehensive objective risk classification, particularly considering the diverse locations of the participants (Henstra et al., 2019).

Recruitment of participants from flood-risk areas, specifically dividing them into perceived flood-risk status groups, relied on a strategy that targeted Facebook community pages and Reddit threads of notable flood-risk communities, refer to *Table 9* in Appendix C. This was subject to a page or threads moderator approval. This approach was chosen to ensure an adequate number of participants, as it was

anticipated that including non-targeted communities would not yield sufficient data for the perceived at-risk group. This decision was informed by a report that indicated only 6% of its 2500 survey respondents across Canada perceived themselves as residing in a flood-risk area (Ziolecki et al., 2020).

Consequently, the participants who were more likely to use these social media channels had greater access to the survey, which may introduce selection bias and limit the representativeness of the perspectives obtained. In 2022, approximately 70% of adults in Canada had a Facebook account, with 70% of them using it daily. Additionally, 19% of adults had a Reddit account, with 40% using it daily. Notably, Reddit users demonstrated higher usage rates within the younger age groups of 18-34 (Mai & Gruzd, 2022). The study survey obtained a significant portion of participants from Reddit, as determined by the survey responses following recruitment posts, indicating that Reddit was the more responsive recruitment strategy. It is necessary to recognize that this reliance on online platforms may limit the diversity of perspectives and exclude individuals who do not use or have limited access to these platforms.

Another limitation to consider is the potential for varied interpretation of questions and statements in the survey. Due to the use of shortened and concise statements to reduce survey fatigue, there may be a lack of contextual information that could affect participants' understanding and interpretation of certain terms or concepts. For instance, a statement such as "flood preparedness is on the responsibility of the household, not the government" can be understood differently based on participants' knowledge of flood preparedness measures.

However, it is important to note that the impact of varied interpretation on the outcomes of the survey questions and statements is expected to be minimal. The selected questions and statements were designed to be clear and focused, aiming to minimize ambiguity and provide a common understanding among participants. Additionally, efforts were made to ensure that the key aspects of the questions and statements were communicated effectively to capture the intended information. While some degree of variation in interpretation is inevitable, the overall analysis and findings of the survey are expected to be reliable and informative.

Furthermore, the survey collected limited demographic data, such as income, age, gender, and other characteristics, which provided restricted insights into the influence of demographic factors on risk information preferences and values. This decision was made to mitigate survey fatigue and improve response rates. Future research endeavors could expand upon these findings by incorporating more detailed demographic data to enhance the understanding of the interplay between demographics (gender, race, income, disability, level of education) and the studied variables.

As this study obtained just a small sample of 285 responses from households across Canada, the generalizability of these findings is limited. The findings are meant to provide insights to potentially occurring flood-risk communication challenges based on a diverse set of flood-contexts. Recommendations are listed as means of possible improvements that addresses the issues identified in the data analysis.

Conclusion

This research explored the values and preferences of flood-risk information among households and how these preferences are influenced by perceived flood-risk status. Several key findings emerged from the study that shed light on various aspects of flood-risk communication.

Firstly, the study revealed that households do not heavily rely on their social circles as their primary source of flood-risk information. This suggests that risk information obtained from social networks may not be as trusted or reliable as other sources, which has significant implications for the effectiveness of bottom-up communication approaches. Moreover, the variation in trustworthiness ratings among different communicators emphasizes that households trust risk communication actors differently, highlighting the importance of tailoring communication strategies to suit different source preferences among households, and the need to improve levels of trust in sources such as provincial governments and wider social community.

Secondly, households generally prefer more alarming language and detailed flood-emergency communication. This emphasizes the necessity of providing tailored risk information that meets the specific needs and comprehension levels of households. Understanding household preferences for language and detail can significantly improve the effectiveness of flood-risk communication. Future studies should further assess the diversity in household preferences for detailed risk information such as incorporating the evaluation of current risk information on municipal and provincial websites to determine if level of detail is adequate for household needs.

Furthermore, the study brought to light significant differences in accessibility, transparency, and flood-risk knowledge between perceived flood-risk status groups. Households perceiving themselves at risk displayed higher ratings in these areas compared to the not at-risk group, indicating a relationship between flood-risk knowledge and risk perception. Addressing this gap in flood-risk knowledge and accessibility, especially among households who perceive themselves as not at risk, is essential to foster effective risk communication and preparedness.

The findings also provided insights into the complex interplay between flood-risk perceptions, values, and households' perspectives on flood-risk reduction strategies. The relationship between valuing personal responsibility and supporting risk reduction strategies was not straightforward, suggesting the need for further research to fully comprehend these dynamics. Additionally, significant differences were found between flood-risk status groups regarding more individual responsibility for flood preparedness and the banning of property sales in flood-risk areas being more agreeable to the perceived not-at-risk group.

Based on these findings, it is imperative that flood-risk communication strategies be tailored to individual needs and preferences. Governments should prioritize the development of flood-risk information resources that encourage community engagement and strengthen social capital. Rebuilding public trust in risk communication and incorporating the precautionary principle in messaging can further enhance the effectiveness of communication efforts.

It is recommended that provincial and federal governments could assist municipalities in addressing some of these issues raised by survey participants by:

1. Developing flood-risk information resources that encourage ways for individuals to strengthen their social capital such as government funded community engagement initiatives as a resilience strategy.

2. Rebuilding public trust in risk communication through improved transparency and accessibility of information

3. Prioritizing the precautionary principle in flood-risk messaging language when there is plausible risk by adjusting 72-hour preparedness guidelines that reflect more significant preparedness recommendations for more vulnerable households.

4. Providing more options of varying levels of detail of risk information resources that meets diverse needs of households.

5. Strategize an awareness campaign that provides and engages with at-risk households unaware of their flood risk with adequate and accessible flood-risk information resources.

By implementing these general recommendations, governments can take concrete steps to promote collective resilience, rebuild public trust, and ensure that flood-risk information reaches and resonates with individuals and communities across Canada. Given that this was a nation-wide survey encompassing participants from various

geographic contexts, the information obtained can be instrumental in informing communication strategies among government bodies while there are ongoing capacity constraints for municipal governments to engage in risk communication effectively (Thistlethwaite & Henstra, 2017). Ideally, improving municipal resources for providing adequate flood-risk communication and risk awareness strategies would likely be more effective because of their more direct roles in emergency management, as often recommended by risk communication literature. This study alternatively considers ways for top-level governments to adjust their flood risk communication strategies to address the communication, knowledge, and information gaps at the local level by providing additional financial supports, tools, and guidance.

Overall, the study emphasizes the importance of understanding diverse values and preferences within households related to flood-risk information. By strengthening risk communication strategies and addressing information gaps, we can guide individuals and communities towards more situationally aware risk perceptions, thus enhancing overall resilience in the face of flood events.

Appendices

Appendix A Figures

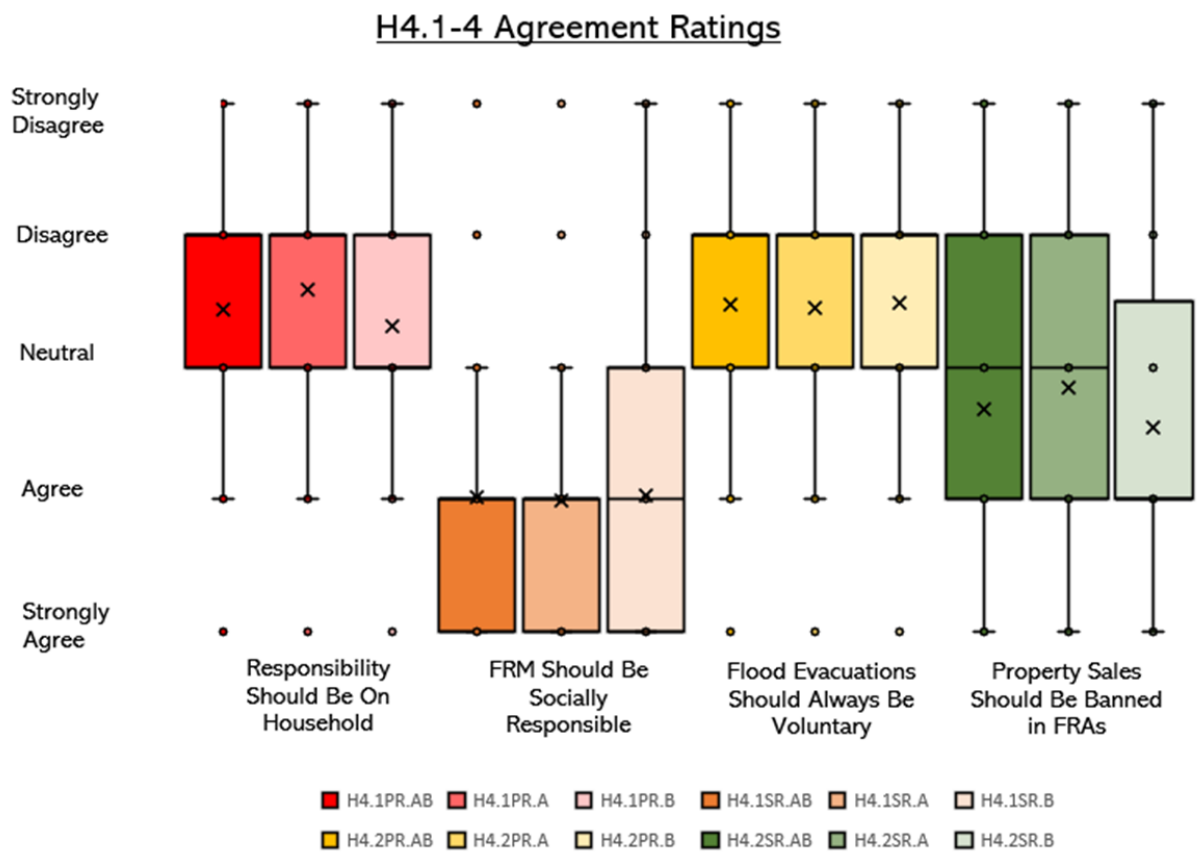

Figure 5 Hypothesis 4 Ratings

Appendix B Tables

Table 1 Likert Questions Hypothesis 1

Likert Questions - Hypothesis 1: Households have no differences in preferences of where they access flood-risk information.
Test Comparing A & B: Wilcoxon Rank Sum test with Continuity Correction

Question	Sample	Mean	Median	SD	AB Chi-Squared	Test Statistic	P-Value
H1.1 *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **I get the best flood-risk information from my neighbours, friends, and family**	AB	3.71	4	1.068774	X-squared = 95.614, df = 4, p-value < 2.2e-16	9412.5	0.3196
	A	3.62	4	1.142996			
	B	3.79	4	0.9999162			
H1.2 *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **Face to face flood-risk consulting with an expert would be my most-preferred way of receiving flood-risk information.**	AB	3.21	3	1.115462	X-squared = 59.193, df = 4, p-value = 4.286e-12	9816	0.6998
	A	3.17	3	1.182157			
	B	3.25	3	1.058926			
H1.3 *Usefulness (1 = Extremely Useful, 5 = Not at all Useful)* **On a scale of 1 to 5, rate the level of usefulness of a community-based flood group that would be available to ask questions about flood-risk, host information meetings, and emergency planning resources.**	AB	2.53	2	1.152055	X-squared = 58.667, df = 4, p-value = 5.529e-12	9274.5	0.2329
	A	2.44	2	1.120658			
	B	2.6	3	1.175436			
H1.T1 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Newscaster or media personnel you are familiar with**	AB	2.44	2	1.007324	X-squared = 156.07, df = 4, p-value < 2.2e-16	9899	0.7872
	A	2.42	2	1.017556			
	B	2.46	2	1.001549			
H1.T2 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Local government representative (Mayor, city counsel, local politician)**	AB	2.26	2	0.9836444	X-squared = 186.7, df = 4, p-value < 2.2e-16	10246	0.7914
	A	2.26	2	0.9926384			
	B	2.26	2	0.979257			
H1.T3 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Police or emergency services**	AB	1.92	2	0.9530879	X-squared = 219.47, df = 4, p-value < 2.2e-16	10628	0.3893
	A	1.99	2	1.038008			
	B	1.85	2	0.873815			
H1.T4 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Provincial government representative (Premier, department heads)**	AB	2.72	2	1.274205	X-squared = 44.316, df = 4, p-value = 5.516e-09	9285	0.2396
	A	2.62	2	1.277506			
	B	2.81	2	1.269506			
H1.T5 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Field and academic experts in flood-risk**	AB	1.43	1	0.7550669	X-squared = 430.76, df = 2, p-value < 2.2e-16	10624	0.3311
	A	1.47	1	0.7490403			
	B	1.4	1	0.7610656			
H1.T6 *Trustworthiness (1 = Strongly Trustworthy, 5 = Not at all Trustworthy)* **Community members, neighbours and online communities with information sourced by local citizens**	AB	3.13	3	1.024689	X-squared = 93.404, df = 4, p-value < 2.2e-16	10492	0.5308
	A	3.17	3	1.027818			
	B	3.10	3	1.024215			

Table 4 Likert Questions Hypothesis 2

Likert Questions - Hypothesis 2: Households have no differences in preferences of language, style and platforms of how flood-risk information is communicated. Test Comparing A & B: Wilcoxon Rank Sum test with Continuity Correction							
Question	**Sample**	**Mean**	**Median**	**SD**	**Chi-Squared**	**Test-Statistic**	**P-Value**
H2.1 ***Agreement (1 = Strongly Agree, 5 = Strongly Disagree)*** **When communicating a flood emergency to the public, would you prefer they use more alarming language and encourage more rapid preparedness than to be calm and possibly underestimate the threat (example: prepare for 7 days instead of 3 days without power/access to necessities)**	AB	2.31	2	1.033262	X-squared = 150.84, df = 4, p-value < 2.2e-16	9647	0.5114
	A	2.25	2	0.948776			
	B	2.37	2	1.09911			
H2.2 ***Level of Detail (1 = Extremely Detailed (hard data for me to interpret, academic language and resources), 2 = Very Detailed (some data for me to interpret e.g. charts, maps etc, highly descriptive language), 3 = Moderately Detailed (maps, diagrams, descriptive but easy to understand language), 4 = Slightly Detailed (mostly general and simple to interpret information), 5 = Not Detailed (basic information))*** **How detailed do you want your flood-risk resources to be?**	AB	2.37	2	0.7085381	X-squared = 130.8, df = 2, p-value < 2.2e-16	9541	0.3987
	A	2.34	2	0.6882609			
	B	2.4	2	0.7261355			

Table 5 Likert Questions Hypothesis 3

Likert Questions - Hypothesis 3: There is a flood-risk information gap between households. Test Comparing A & B: Wilcoxon Rank Sum test with Continuity Correction							
Question	**Sample**	**Mean**	**Median**	**SD**	**Chi-Squared**	**Test-Statistic**	**P-Value**
H3.1 ***Accessibility (1 = Completely Accessible, 5 = Not at all Accessible)*** **On a scale of 1 to 5, rate the level of accessibility you have to flood-risk information that includes flood history, and the current and future flood risk of any property**	AB	3.04	3	1.197848	X-squared = 34.281, df = 4, p-value = 6.527e-07	7846.5	0.0009456
	A	2.79	3	1.104579			
	B	3.25	3	1.235795			
H3.2 ***Transparency (1 = Completely Transparent, 5 = Not at all transparent)*** **How would you rate the degree of transparency by flood-authorities such as governments, dam managers, other water managements authorities on providing useful and detailed information to the public.**	AB	2.69	3	0.944232	X-squared = 159.02, df = 4, p-value < 2.2e-16	8628.5	0.02675
	A	2.57	2	0.9477715			
	B	2.79	3	0.9327177			
H3.3 ***Agreement (1 = Strongly Agree, 5 = Strongly Disagree)*** **Do you find that available flood-risk information you can currently access through (online, through media, news or other sources) is relevant to you?**	AB	2.59	2	0.8784266	X-squared = 198.46, df = 4, p-value < 2.2e-16	7122.5	4.631e-06
	A	2.33	2	0.761358			
	B	2.8	3	0.9145292			
H3.4 ***Familiarity (1 = Extremely Familiar, 5 = Not at all Familiar)*** **How familiar are you to where to access important flood risk information?**	AB	3.28	3	1.254712	X-squared = 28.386, df = 4, p-value = 1.042e-05	6450.5	7.875e-08
	A	2.85	3	1.162139			
	B	3.63	4	1.222194			
H3.5 ***Familiarity (1 = Extremely Familiar, 5 = Not at all Familiar)*** **From what you know about floods, how aware are you of what to do during a flood emergency warning? (you receive warning that a flood is likely to happen in your neighbourhood, from what you already know, would you know what to do?)**	AB	3.22	3	1.179451	X-squared = 42.408, df = 4, p-value = 1.373e-08	6271.5	1.579e-08
	A	2.79	3	1.076141			
	B	3.58	4	1.144558			
H3.6 ***Agreement (1 = Strongly Agree, 5 = Strongly Disagree)*** **My knowledge of my flood risk is adequate, I don't really need any further information**	AB	3.45	4	1.065475	X-squared = 117.93, df = 4, p-value < 2.2e-16	8447	0.0134
	A	3.28	4	1.063965			
	B	3.59	4	1.049348			

Table 6 Correlation Testing Hypothesis 4

Correlation Testing - Hypothesis 4: Households who value more personal responsibility to flood risk oppose strategies that reduce flood-risk. Test: Kendall's rank correlation tau				
Questions	Groups	Test Statistic	Tau	P-Value
H4.1PR/H4.1SR (Responsibility should be on household / FRM should be socially responsible)	AB	z = -1.2223	-0.06180733	0.2216
	A	Z= -1.4863	-0.1124223	0.1372
	B	Z = -0.25257	-0.01729997	0.8006
H4.1PR/H4.2PR (Responsibility should be on household / Flood evacuations should always be voluntary)	AB	z = 0.48001	0.02377233	0.6312
	A	z = 0.35814,	0.02624019	0.7202
	B	z = 0.36245	0.02452075	0.717
H4.1PR/H4.2SR (Responsibility should be on household / Property sales should be banned in FRAs)	AB	z = -0.68493	-0.03327989	0.4934
	A	z = -0.70021	-0.05081312	0.4838
	B	z = -0.79559	-0.05256351	0.4263
H4.1SR/H4.2PR (FRM should be socially responsible / Flood evacuations should always be voluntary)	AB	z = -2.9056	-0.1482556	0.003666
	A	z = -2.0197	-0.1526396	0.04341
	B	z = -2.127	-0.1481513	0.03342
H4.2SR/H4.2SR (FRM should be socially responsible / Property sales should be banned in FRAs)	AB	z = 0.52537	0.02629988	0.5993
	A	z = -0.6551	-0.04903566	0.5124
	B	z = 1.5649	0.1064424	0.1176

Table 7 Likert Questions Hypothesis 4

Likert Questions - Hypothesis 4: Households who value more personal responsibility to flood risk oppose strategies that reduce flood-risk. Test Comparing A & B: Wilcoxon Rank Sum test with Continuity Correction							
Question	**Sample**	**Mean**	**Median**	**SD**	**Chi-Squared**	**Test-Statistic**	**P-Value**
H4.1PR *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **Flood preparedness is on the responsibility of the household, not the government**	AB	3.438596	4	1.119883	X-squared = 75.684, df = 4, p-value = 1.428e-15	11507	0.03187
	A	3.59	4	1.097539			
	B	3.31	3	1.125661			
H4.1SR *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **Flood-risk management should be aimed at protecting the most vulnerable and maintain an equitable distribution of resources.**	AB	2.014035	2	0.8998119	X-squared = 212.67, df = 4, p-value < 2.2e-16	9734	0.5956
	A	1.99	2	0.8935367			
	B	2.03	2	0.9075395			
H4.2PR *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **Flood evacuations should always be voluntary.**	AB	3.470175	4	1.111712	X-squared = 154.14, df = 4, p-value < 2.2e-16	10044	0.9618
	A	3.45	4	1.175404			
	B	3.48	4	1.059005			
H4.2SR *Agreement (1 = Strongly Agree, 5 = Strongly Disagree)* **Property sales should be banned in high-flood-risk areas**	AB	2.684211	3	1.269328	X-squared = 25.509, df = 4, p-value = 3.974e-05	11471	0.03891
	A	2.85	3	1.266513			
	B	2.55	2	1.259734			

Table 8 Concepts and Operationalization

Concepts	**Operationalization**
Flood Risk	Flood-risk is a combination of likelihood, probability, or chance that a flood-event would occur depending on level of exposure and vulnerability of that property or community.
Flood-risk information	Any information pertaining to resources of flood-risk information through forms of media, online sources, word-of mouth, prior knowledge, emergency and governing bodies and information relayed from experts. This can include flood maps, financial resources or advice pertaining to floods, resource tools and recommendation pertaining to flood-risk, information regarding emergency procedures, current or future statuses of flood-risk, measurable indicators such as water gauges or water levels, 1 in 100-year flood indicators, property level flood-risk assessments, flood awareness campaigns etc.
Resilience	Resilience refers to the capacity of individuals, communities, cities, or nations to withstand, assimilate, or rebound from shocks, adversity, or changing circumstances in a prompt and effective manner.
Situational Aware	The capacity of individuals to accurately perceive and comprehend the objective risks associated with flooding, including their risk potential.
Values	Areas that are affected by flooding to some degree such as partial or full flooding, road networks and infrastructure enduring partial or full-flooding, basement flooding, property flooding, and power-outages due to flooding.
Flood-risk areas	Areas that have a potential for a flood event that risk health, life, property and the functions of a natural flood-plain.
Complacent	State of being unconcerned or unaware of the true extent or severity of a potential risk. It involves downplaying or disregarding the significance of a risk, often due to a false sense of security or a belief that the risk is unlikely to affect oneself or others.
Cautious	The tendency or approach of individuals to exercise carefulness, prudence, and deliberation when evaluating and responding to potential risks. It involves being vigilant with the assumption that risks may be greater than they initially appear.
Perceived risk	Influenced by risk beliefs or judgements based on the individual's perspective and cognitive abilities (Botzen et al., 2009).
Objective risk	Actual probability or likelihood of a specific event or outcome occurring, based on verifiable data, scientific evidence, or statistical analysis (Knuth et al., 2014).

Appendix C Maps and Location

Figure 6 Geography of Survey Participants

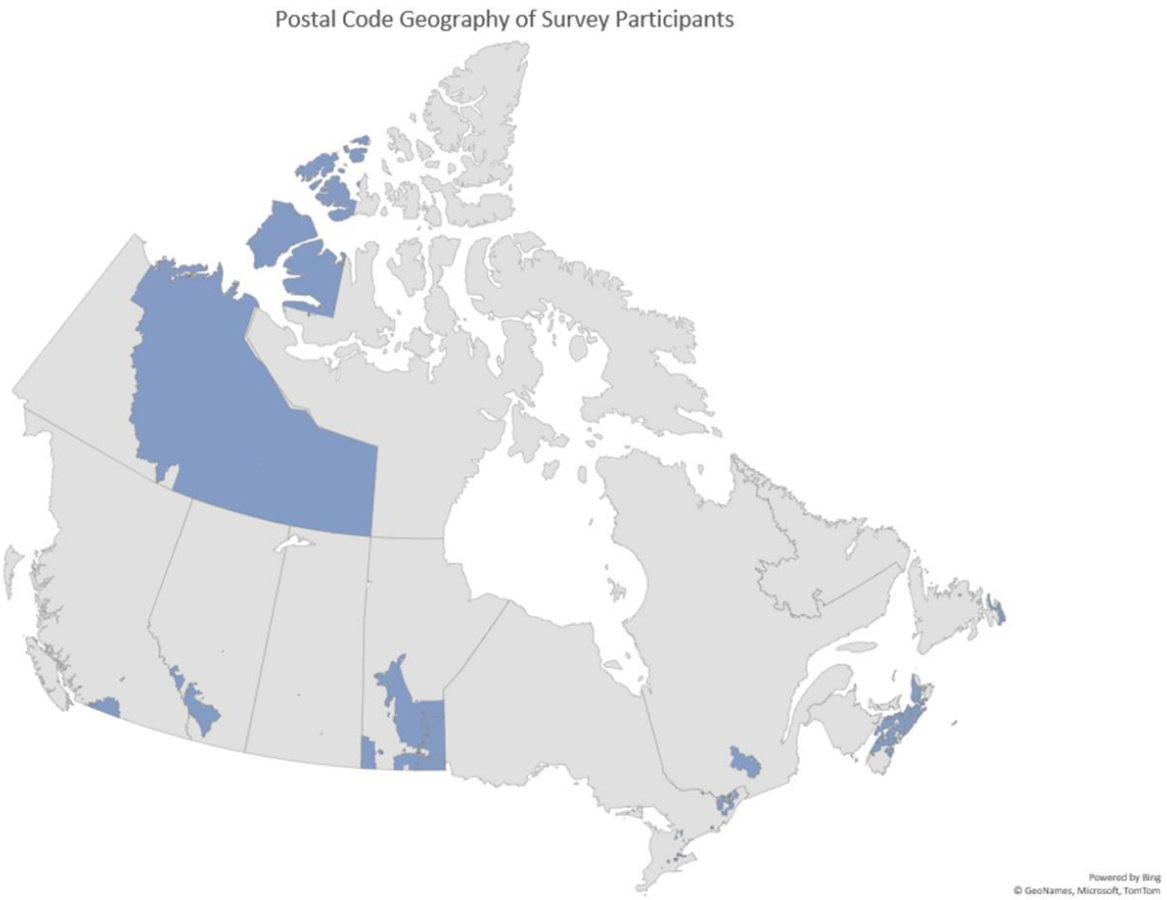

Table 9: Community Targets of Participant Recruitment

Province/Territory	**Communities**
British Columbia	Chilliwack, Abbotsford, Merritt, Grand Forks, Hope
Alberta	Calgary, Chateh
Northwest Territories	Hay River
Manitoba	Winnipeg
Saskatchewan	Swift Current, Regina
Ontario	Hamilton, Toronto, Niagara region, Kenora, Brantford, Ottawa, Upper Ottawa River
Quebec	Gatineau, Upper Ottawa River
New Brunswick	Grand-Lake, Fredericton, Moncton
Nova Scotia	Halifax, Antigonish, Lunenburg, Inverness, and Victoria Counties
Newfoundland	St. Johns

CHAPTER 4: CONCLUSION

In this research, we have explored the significant aspects of flood-risk communication and explored the values and preferences of households regarding flood-risk information in diverse flood contexts across Canada. The findings from both Chapter 2 and Chapter 3 provide valuable insights that can inform the development of more effective flood-risk communication strategies tailored to the needs of households at the local level.

Chapter 2 investigates household risk communication perspectives in the context of experiencing a flood-event to identify areas where their information needs are not adequately addressed. The interviews with households reveal six major flood-risk information needs that are currently being missed, drawing attention to the necessity of tailored communication approaches. From the content and timing of information to its comprehensibility and accessibility, households emphasized the significance of information that addresses their unique circumstances and requirements. Moreover, fairness emerged as a key principle in flood-risk communication, highlighting the importance of equitable communication practices and the need to address vulnerabilities that disproportionately impact certain households.

Chapter 3 further explores the preferences and values of flood-risk information among households and how these preferences are influenced by perceived flood-risk status. The study uncovers that households do not heavily rely on social circles as their primary source of flood-risk information, suggesting the importance of trustworthiness in communication actors and the need for tailored communication strategies. Additionally,

there was significant differences in flood-risk knowledge, accessibility, and transparency among perceived risk-status groups. Those who perceive themselves at risk have higher ratings in flood-risk knowledge, accessibility, and transparency compared to the "not-at-risk" group suggests that the ‘‘not-at-risk” group may not be fully aware of the potential risks they face. Closing this awareness gap, especially for households perceiving themselves as not-at-risk, becomes imperative for effective risk communication and preparedness. Furthermore, there are distinctions between risk-status groups in terms of individual responsibility for flood preparedness and the acceptability of banned property sales in high-risk areas are more agreeable to the “not-at-risk” group. These findings indicate that risk perception plays a role in shaping attitudes towards individual responsibilities for flood preparedness and the acceptability of specific flood-risk management measures, such as banning property sales in high-risk areas.

The themes and contributions of this research highlight the significance of understanding diverse values and preferences within households related to flood-risk information. By strengthening flood-risk communication strategies and addressing information gaps, we can guide individuals and communities towards more situationally aware risk perceptions, ultimately enhancing overall resilience in the face of flood events.

Based on the findings, we offer concrete recommendations for flood-risk communication. Provincial and federal governments can play an important role in assisting municipalities in addressing the identified challenges. This includes developing

flood-risk information resources that encourage community engagement and strengthen social capital. Rebuilding public trust in risk communication, prioritizing the precautionary principle in messaging, and providing more options of varying levels of detail for risk information are also necessary steps in enhancing communication efforts. Capacity restraints limit how a local government can produce more diverse risk communication approaches, therefore collaboration, information-sharing and additional financial supports are needed.

In conclusion, effective flood-risk communication necessitates a nuanced approach that addresses the diverse needs and preferences of households. Implementing the recommendations and strategies discussed in this research enables governments to take concrete steps towards promoting collective resilience, rebuilding public trust, and ensuring that flood-risk information reaches and resonates with individuals and communities across Canada. As flood-risk management evolves, exploring alternative approaches and fostering collaboration among various flood-risk involved agents remains imperative. This research contributes valuable insights to shape a more informed and inclusive flood-risk communication landscape in Canada, ultimately enhancing resilience in communities facing future flood events.

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