UNIVERSITY OF ALBERTA
DEPARTMENT OF RESOURCE ECONOMICS
AND ENVIRONMENTAL SOCIOLOGY

The Social Context of Flood Risk in Alberta: Perspectives from Municipal Planners, Insurance Agents, the General Public and Media Sources

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(Editors)

Project Report #21-01

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EXECUTIVE SUMMARY

This project report contains research conducted by senior undergraduate students in a university capstone course, from January to April, 2021. The course invites students to conduct original research as an integrative experience for a degree in the Faculty of Agricultural, Life & Environmental Sciences, University of Alberta. All student authors were completing their degrees in Environment and Conservation Sciences, with majors in Human Dimensions, Environmental Economics and Policy, or Environmental Studies. At the beginning of each chapter, the names of student authors are listed. The final report was modified by the editors for clarity and consistency.

This research is focused on the social context of flood risk in Alberta, with an emphasis on understanding the evolving challenges of urban residential flooding. This interest arose from interactions with faculty members at the University of Alberta, representatives from TD Insurance and researchers at the Institute for Catastrophic Loss Reduction, who were focused on understanding why homeowners in urban areas are not implementing measures on their properties to reduce the risk and impacts from stormwater flood events. Challenges homeowners face include the increasing frequency of surface flooding and how the media reports on these events over time. We also observe divergent perspectives on how to mitigate flood risk and who is responsible for these actions. These differences are noted in the information gathered from municipal planners and insurance brokers. The social context of flood risk also includes public perspectives of flooding and how these perspectives might be impacted by recent experiences with flooding and political ideology. Through a better understanding of these issues, we hope that key decision makers, such as municipal planners and insurance brokers, as well as homeowners, can better understand this social context and design programs or undertake activities to assist with flood risk reduction.

In chapter one, the authors review 37 media articles on flooding in Alberta. Analysis indicates that topics in the media were associated with three broad factors: lack of awareness, socioeconomic concerns and concern for ongoing flooding. The two most frequently proposed solutions to flood risk were homeowners improving their homes to mitigate against flood risks or damages, and major infrastructural improvements or developments to withstand flood

damages. Results showed that there were more articles that placed the onus on governments to do more in both fixing flooding problems and in accepting responsibility for allowing flooding to occur in the first place. Researchers also found that climate change is slowly starting to become part of the discussion surrounding urban flooding.

With a focus on municipal planners (i.e., Edmonton, Calgary and St. Albert), chapter 2 investigates how planners understand flood risk, and their perceptions of collaboration and community engagement in flood risk management decision-making processes. Based on 12 in-depth interviews, this research revealed that there is considerable contention around the roles and responsibilities of homeowners, municipalities, and the provincial government. For example, there are different perspectives on who should be responsible for overland flooding within municipalities, with evolving expectations for governments and homeowners. Emerging perspectives on these roles and responsibilities is precipitated by large disaster events such as the 2013 fluvial floods in southern Alberta. The chapter also identifies emerging approaches to flood mitigation in municipalities, with distinct approaches to new versus old neighbourhoods, and ongoing challenges of flood mitigation as it relates to municipal versus private land.

Chapter 3 involves in-depth interviews with 15 insurance brokers who work for TD Insurance. These individuals were identified for the students through prior contacts between university faculty members and the insurance company. Key questions in this study include the following: What do insurance adjusters see as the biggest barriers for customers to invest in flood prevention measures for their homes? With these barriers in mind, what can insurance companies and local governments do to encourage homeowners to invest in flood prevention measures? The largest barrier identified was homeowners not being able to understand their insurance policy, and the solutions to these problems centred on educational programming that is targeted at homeowners.

In chapter 4, students shifted their focus to the perspectives of households. By comparing survey data from 2007 and 2021, the authors identified shifting patterns of public perception. Regarding perceptions of future flood risks, 10% of homeowners in 2021 rated the chance of a stormwater flood in the next 10 years as very or somewhat likely. This statistic

indicates a drop of 38% in the perception of flood risk when compared to the 2007. his statistic compares to 38% in 2007, indicating a drop in the perception of flood risk. Other key differences in perception are compared in this study. But authors caution that while such differences may be a result of changing perceptions in the general population, they may also result from different survey research methods used in the 2007 and 2021 studies.

Looking more deeply at public perceptions, Chapter 5 introduces the concept of moral framing and nudges as a way to understand flood risk through a political lens. The authors hypothesized that conservatives are more likely to undertake flood mitigation efforts when influenced by authority, loyalty, and sanctity framing. Liberals were expected to be more influenced by moral frames such as care, fairness and reciprocity. Although the theory of moral framing would suggest these outcomes to be observed in the dataset, results from this study show that morally framed statements did not produce statistically significant differences between liberal and conservative-oriented respondents. These results may challenge some of the thinking behind moral framing theory, but may also indicate some weaknesses in the quality of survey data.

Finally, in chapter 6, students utilize pre-existing national survey data to examine differences in perceived versus objective flood risk and its impact on mitigation measures. Objective risk was measured using a GIS method of flood risk analysis for the Edmonton region. Using multivariate analysis, results indicate that objective risk has no impact on perceived risk of basement flooding. This conclusion was counter to that found in Chapter 4 with the more recent Edmonton homeowner survey. However, the students in this present chapter note that several socio-demographic variables are statistically significant in predicting perceived risk of basement flooding. These results (and those in Chapter 4) suggest a complex interaction between objective and perceived risks.

Chapter 1: Urban flooding in Alberta: A news media analysis

Abbigale Herbert, Kevin Owttrim, Raisa Salmin Purba, and Yaxi Luo

INTRODUCTION

Urban flooding is a major concern in Alberta. To illustrate, in 2005 a severe downpour caused over $300 million in damages in southern Alberta and a 2004 Edmonton storm caused $166 million in damages; the majority of damage was caused by sewer backup issues in urban areas (Sandink 2013). 2020 saw an average annual precipitation of over 500mm, the highest since 2004 (see Figure 1). Evolving local weather patterns and varied infrastructure developments that attempt to string together decades of growth has also left areas of Alberta's main cities vulnerable to urban flooding (City of Edmonton n.d). For these reasons, knowledge of how urban flood events are presented in the media is an extremely important area of study, as it may give insight to policymakers on how to best frame efforts to reduce these catastrophic damages (Thistlethwaite et al. 2018).

The media has a powerful impact on people's lives through a variety of means and mediums. Orbe points out that "all types of media function as a cultural socialization agent" (2013, p. 242). For example, Orbe studied the impact that television has had on personal, cultural, and societal perceptions due to its "pervasiveness" (Orbe 2013). Moreover, the development of new media technologies has also enhanced the impact that media has on people (Orbe 2013).

This paper investigates how the Albertan news media frames urban flooding, flood risk within cities, who is to blame for flood events, as well as how these frames are shifting due to the increasing awareness of climate change. Prior to this media analysis, we provide a

review of the published literature on the media's role in opinion formation and insights from academic studies which analyzed media on flood events.

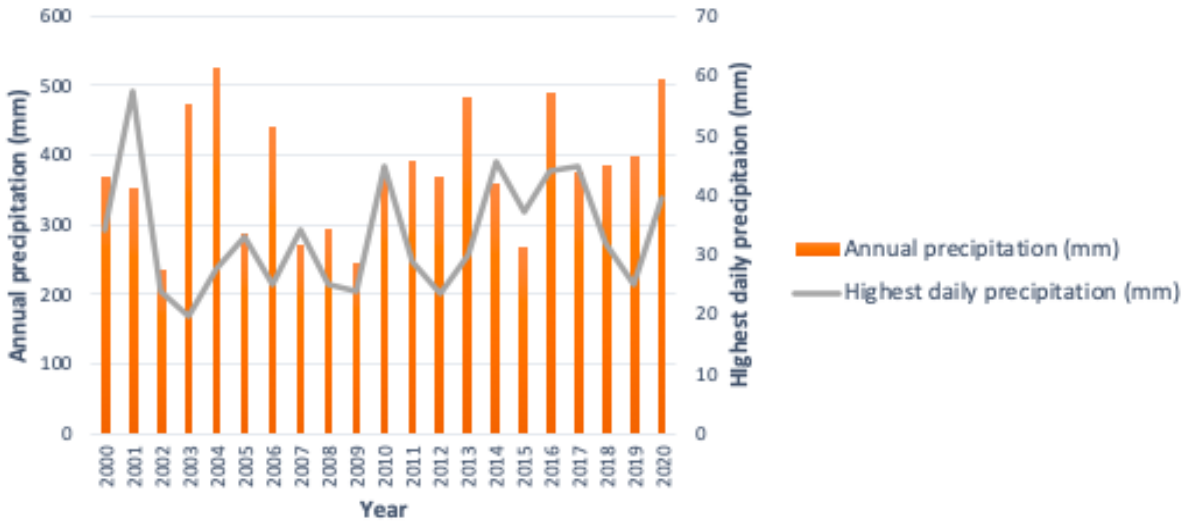

Figure 1. Comparison of the annual precipitation (mm) of Edmonton, Alberta with the highest daily precipitation (mm) by year.

Source: Edmonton Weather Stats (https://edmonton.weatherstats.ca/charts/precipitation-yearly.html) and the Government of Canada https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

LITERATURE REVIEW

Risk, Life, and The Role of the Media

To conduct a media analysis, we must first understand the impact the media has on our lives. Finnegan and Vinswanath identify ways to investigate how the media interacts with society at large, one being filling gaps in knowledge for the public (Finnegan & Vinswanath 2008). Perhaps the most relevant for the purposes of understanding urban flooding is risk communication. Public perception of risk is shaped both by information and by the portrayal of risk in media, politics, and their own lives (Finnegan & Vinswanath 2008). In examining risk, there are two factors to look at, what the issue or danger is and then how people respond

(Finnegan & Vinswanath 2008). As its name implies, the media acts as a mediator for information, events, and risks to the public (Associated Programme on Flood Management 2015). When we think of risk perception, the media often gives the perspective of both expert scientific explanations as well as opinions and concerns voiced by the public following an event (Associated Programme on Flood Management 2015). This allows the media to serve as "a communication channel in both directions" (Associated Programme on Flood Management 2015 p. 7).

In the world of disaster events, news media can have a huge role in reflecting and shaping public opinion by defining and limiting public discourse around events (Holliman 2004; Miles & Morse 2007). Gortner and Pennebaker (2003) stipulate that physical and psychological coping or recovery processes after a natural disaster event can also be affected by media. However, media reporting is also subject to bias. Socio-technical and institutional-political considerations can heavily affect not only which stories are reported, but also the way in which they are reported (Porter & Evans 2020). D'Alessio and Allen (2006) place media reporting biases into three broad categories: 1) coverage bias, where certain issues/events are given more/less attention than others; 2) selection bias, where only certain stories are selected for publication; and 3) presentation bias, which explores to what extent media reporting is geared towards particular events. This is further complicated when market forces such as news outlet ownership, audience preferences, advertiser demands, and censorship concerns are taken into consideration (Porter & Evans 2020).

The media can also amplify certain voices and opinions while diminishing others, and news media analyses can reveal the perceptions or cultural biases present within the public about certain topics based upon what is and what is not present within the news media (Hodgetts & Chamberlain 2014). In the context of floods and other crises, these biases can help influence people's views and opinions of who or what is responsible for the flood, and who is responsible for fixing the damage and mitigating further risk (Devitt & O'Neill 2016; Gavin et al. 2011). Attribution of responsibility is a commonly used theme found in crisis news media.

Climate change has also started to appear in news articles as a potential factor in how severe and frequent flood events can be understood (An & Gower 2009; Gavin et al. 2011). While this may show that climate change is becoming a more important issue for the public, Gavin et al. (2011) found that some references to climate change in news stories can convey doubt about climate change or its impacts. By casting doubt on the validity of climate change, news media may influence the public to be less concerned about the increasing likelihood and strength of storms that lead to flooding (Gavin et al. 2011). As climate change has already made storms more likely and more powerful, doubt about climate change in the media may deter current and future actions that are necessary to protect against more powerful storms.

Flood Risk in the Media

To gain an understanding of concerns around flooding in Edmonton, we examined the results of a public opinion survey performed for EPCOR in 2018 where respondents were given flood scenarios and asked to rank the various possible effects of flooding according to their priorities (Colenutt 2018). Possible effects covered included impacts to health care,

property damage, infrastructure, and environmental impacts (Colenutt 2018). Overall, health and safety concerns, such as damaged emergency infrastructure and essential utilities, were ranked the highest (Colenutt 2018). Environmental concerns, such as flooded trails or vegetation damage, were considered least important (Colenutt 2018). The method of describing risks according to specific scenarios (such as flooded roadways) allowed respondents to be more educated about specific risks that can result from flooding before completing their ranking. This allowed for a broad understanding of how flood-related risks are prioritized, that we can consider for the purposes of our analysis of Albertan news media.

Flooding is Canada's most common and most expensive natural hazard and also causes the bulk of both insurance claims and public disaster assistance costs (Office of the Parliamentary Budget Officer 2016). The impact of flooding is therefore quite common in Canadian news media who's reporting generally shifts public and political attention to the hazard that triggered the event (Thistlethwaite & Henstra 2019). This allows advocates and interest groups a period to propose alternative policies for disaster management and they often respond with small, incremental adjustments in particular policy instruments or offer minimal changes in policy direction (Thistlethwaite & Henstra 2019; Johnson et al. 2005). However, because uncertainties exist in natural disasters, policy choices are also influenced by the way in which media narratives frame the urgency and solvability of the problem (Valencio & Valencio 2018). Thistlethwaite & Henstra (2019) and Valencio & Valencio (2018) found the news media focused more on flooding's short-term hazards rather than treating it as a policy problem. By focusing only on the short-term the media may push policy makers to only have concern for short-term solutions rather than larger, more impactful, and effective, changes.

An analysis of Irish media by Devitt and O'Neill (2016) also found that most flood events, even in regions where they are common or historically prevalent, were usually depicted as surprises by the news media. Solutions to these 'unexpected' events are usually framed by the news in terms of what the government can do using technology, engineering, and construction to solve the flooding problems (Devitt & O'Neill 2016). However, Devitt and O'Neill (2016) found that by framing floods in these ways, the media can influence people to be less individually responsible for flood damages; instead, they trust and rely on government solutions and support and are therefore often unprepared for a flood event. This shows the impact that media framing can have on people's individual actions regarding flood risk; if floods are generally seen as unexpected and that the government is responsible for preventing damages, everyday people and homeowners may not take simple measures or precautions to mitigate flood risks.

Previous Media Analysis on Flooding

We also examined how other media analyses studied natural disasters and flooding. One example is from the Netherlands and Poland, where Kauffman et. al. (2016) examined political and public debates in the wake of two major floods that occurred at very similar times. They examined a set number of major newspapers that represented a broad political spectrum and used common search terms to perform a comparison between the two countries. The analyses were carried out in the years following the event to track changes in public awareness, importance, and the framing of floods. This technique helped limit the scope of the research by focusing specifically on news articles and, to complete a better comparative analysis, identified common search terms to narrow down the information they were looking

for. The researchers also completed the searches using constant and consistent timelines, meaning all news sources were collected at similar times to further improve the comparative analysis.

Another example of news media analysis comes from Nigeria where researchers conducted a quantitative content analysis to explore the frames of five groups of policy actors (government, local communities, business, multilateral organizations, and non-governmental organizations (NGOs)) (Adekola & Lamond 2018). The authors examined these actor narratives as reported in local and national newspapers between 2012 and 2016 to understand the causes and strategies to solve the problem of urban flooding in Nigeria. They captured data from print media, online newspapers, and magazines. The period for analysis was set between January 2012 and September 2016 with databases such as ProQuest and Internet-based search engines like Google used for the online searches. Next, they used Boolean searches, which is a structured search, to locate terms related to urban flooding in Nigeria. The Google search engine helped them in finding online archives, and it also screened articles for duplicates and relevance to the research questions (Adekola & Lamond 2018).

An and Gower (2009) used a different approach to complete a content analysis of how news media frame crises. After completing their own literature review, they identified five themes that represented frames that the news media commonly used when reporting on crises (An & Gower 2009). They then selected a timeframe to sample news articles from certain news organizations; news articles about crises that occurred during this period were analyzed further based upon how many of the five common frames they each had (An & Gower 2009).

This method represents a quantitative media analysis, which permits an in-depth analysis of what story the media is trying to push during the study period (Hodgetts & Chamberlain 2014). Quantitative media analyses like An and Gower (2009) are also better for developing and testing research questions, and allow for easier replicability (Hodgetts & Chamberlain 2014). However, Hodgetts and Chamberlain (2014) note that a major risk with producing a quantitative media analysis is just because a news articles states a view, people may not subscribe to those views. Readers may interpret the same news article in a variety of ways, therefore quantitative media analyses should be cautious if they are assuming beliefs and attitudes are directly correlated with the media consumed (Hodgetts & Chamberlain 2014).

Bohensky & Leitch (2014) conducted a media analysis on the 2011 Brisbane flood to gain an understanding of how media framing influenced individual, community, and regional adaptability to future extreme events. The research study is of particular interest not only due to the relatively long duration and disastrous magnitude of the flood, but also because of the large-scale clean-up efforts of 62,000 registered, and an estimated 180,000 unregistered, volunteers. Many of these volunteers said they were motivated to volunteer by media images of flood damage. This media analysis selected media articles written by journalists, opinion columnsists and community responses (such as letters to the editor) from two time periods: during the flood event and the one-year anniversary coverage of the event. Their analysis found that rather than focusing only on stories of helplessness, the media made referred to ideas of community spirit, cohesion, and coping, all of which were considered to contribute to resilience (Bohensky & Leitch 2014).

In summary, when conducting a media analysis of flood events, it is important to consider the search terms used, the time frames of articles examined, and the news sources. Findings from previous literature indicate that there is a broad range of concerns presented by the media from those who are impacted by flooding, and a divide in where the public and the experts turn to for answers to this problem.

METHODS

Data for this project was sourced through both academic databases and online archives from specific news sources, such as the Edmonton Journal and the Calgary Herald. Our most used database was Factiva as it allowed greater accessibility to a more diverse spread of newspaper articles, with a significant level of control over specific search settings that worked well for sourcing articles with particular keywords from particular areas. It also allowed us to search and sort news articles by publishing date with relative ease and expedience.

A variety of different search parameters were used within the Factiva database to search for relevant news articles. Examples of searches included but were not limited to: “storm damage” OR “basement flood” OR “urban flood”, “storm” AND “flood” NOT “river”, “urban flooding” OR “storm flooding” NOT “river flooding”, “storm flooding” OR “urban flooding” AND “climate change”, “storm damage” OR “flood damage” AND “climate change”. These search terms were chosen based on our desired research objectives, the information collected in our literature review, and from simple trial and error during the data collection process; for example, searching up “urban” OR “city” AND “flood” turned up

plenty of results, but also included many irrelevant articles. Searches such as these led us to further narrow our search terms to get more relevant and useful articles.

Searches focused on the geographic region of Alberta with complimentary searches within Canada to examine Alberta comparatively with other provinces as well as examine broader topics such as federal flood mitigation strategies. No time period was set for Factiva searches to ensure a broad range of both modern and historical articles could be collected.

Outside of databases, we were able to source articles through direct searches of the online archives from specific news sources. We mainly focused these efforts on the major local Albertan newspapers as they were the best representation of urban news coverage, and therefore contained more relevant data about serious urban flooding events. This approach also allowed us to identify similar narratives between articles from the same news source, and to easily focus on articles published for the local urban audience. National and regional news sources, such as Global News and CBC News, were also searched as they contained many relevant articles about Alberta, especially major events that received more news coverage.

After our initial search of databases and online archives produced a preliminary list of 63 articles that had some connection to our topics, we began deeper analysis to determine relevant articles that could help to answer our research questions. Some discretion was used regarding articles covering river flooding, especially in Calgary where much of the media coverage on flood events was focused on the fallout of the major river floods in 2013. In the case that articles discussed specific solutions to river flooding, we deemed those to be unsuitable for this analysis on urban flooding. However, there were also many articles from

Calgary that focused on issues of flood insurance coverage, flood insurance cost, and the general feelings towards and awareness of floods, which we deemed important and relevant for this study. Some articles were also filtered out of the final report because of a lack of evidence. For example, initial searches turned up many articles that simply listed the approximate strength and timing of storms with no other information available. These types of articles did not contribute to answering our research questions and were omitted from the final list. As mentioned, we found a preliminary set of 63 news articles; after deeper analysis, we ended up identifying a total of 37 relevant articles for our study. Our leading sources were the Calgary Herald and the Edmonton Journal with 11 articles each, but Global News was also heavily used. Overall, we discovered that local news was the most valuable to our media analysis. A breakdown of which media outlets our final articles originated from is shown below in Figure 2.

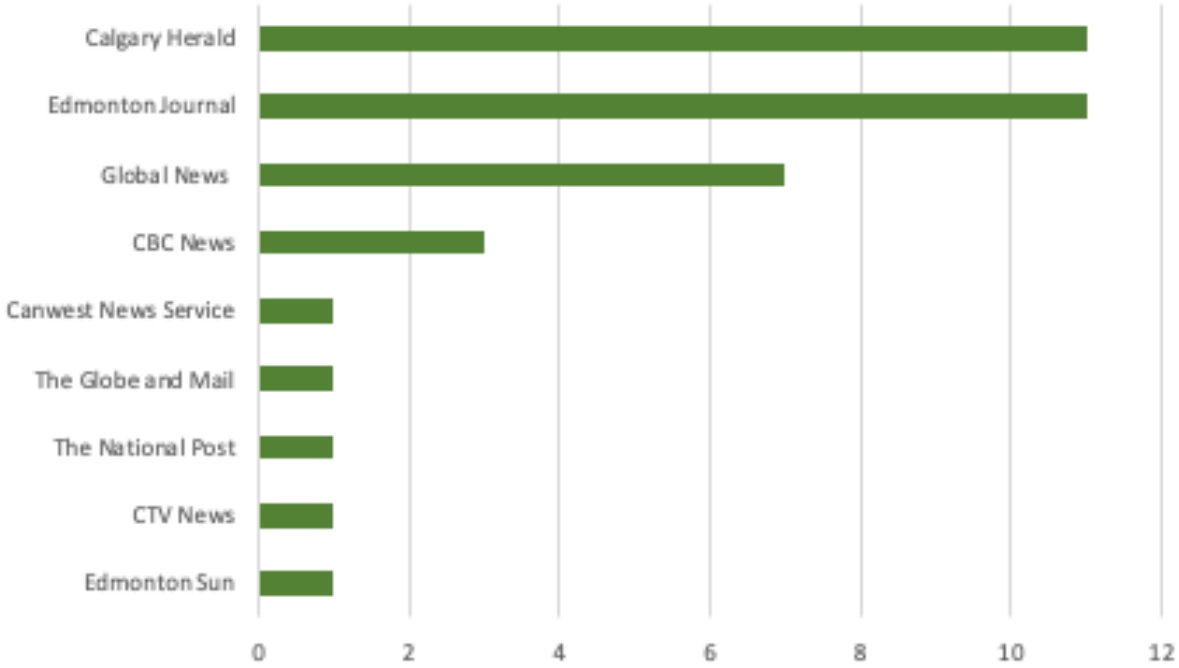

Figure 2. The number of articles used in our report from each news source listed.

RESULTS

Concerns about urban flooding in the media

Our research revealed a variety of concerns expressed by Albertans regarding urban flooding as summarized above in Figure 3. Lack of awareness and preparedness in the face of a flooding crisis is a recurrent concern that takes several forms. An Edmonton Journal[1] (2018) article showed that only 38% of Albertans think they have flood insurance and 27% do not know if they have it. Homeowners also have limited awareness about how to mitigate flood risks to their homes and are unaware that basement flooding is not always covered by their insurance (Calgary Herald 2007; 2008b). When homeowners are aware of their insurance status and benefits, they have low expectations for any significant amount of help (Calgary Herald 2013). This lack of awareness can be attributed to the shortcomings of federal and

[1] All media references have been formatted to highlight the news source rather than the author. This is reflected in-text and in the reference list.

provincial authorities who have “not done nearly enough to spread awareness among Canadians about the risk of flooding and the need to purchase insurance” (Global News 2017).

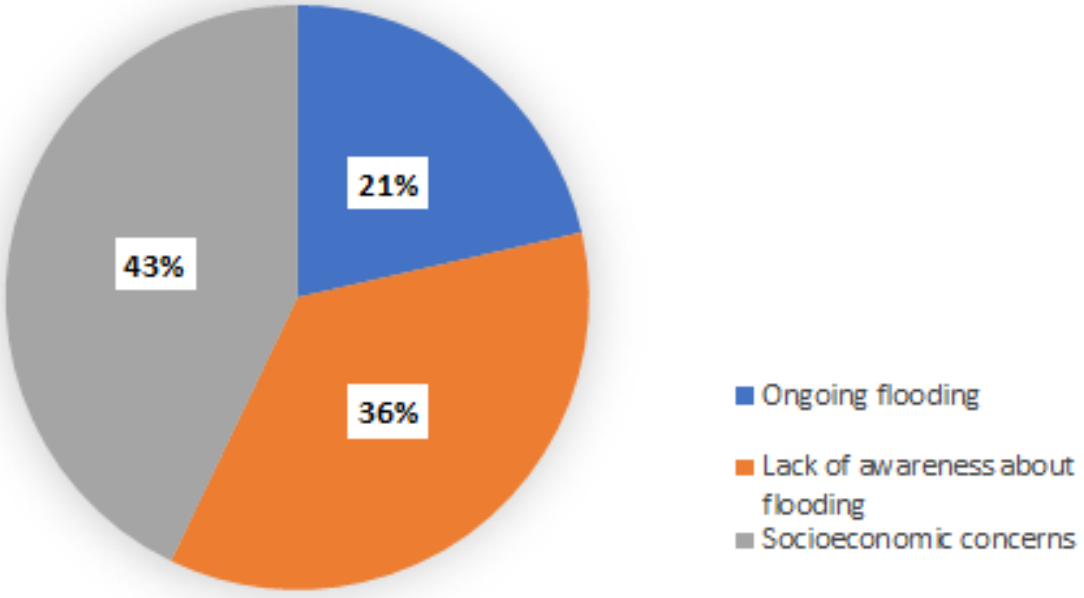

Figure 3. Concerns associated with urban flooding in the Albertan news media.

Albertans have also expressed concerns about flood events and how they relate to their socioeconomic position in society. Some expressed difficulty in finding affordable or adequate insurance coverage; this was especially the case for many Calgarians in the wake of the 2013 Calgary river floods when insurance was not an option for everyone due to surging costs (Global News 2020a; Calgary Herald 2018). Flood events come with “significant financial costs” for many Albertans who experience ongoing flooding on their properties; reports also included claims that insurance frequently failed to cover some or all these costs, negating the usefulness of insurance (Global News 2020a; Calgary Herald 2013). Furthermore, storm damage can be lengthy to repair and quite challenging, with many

Albertan residents expressing that they had nowhere to go if flooding occurred (Calgary Herald 2007; Edmonton Journal 2016).

Responsibility for Solutions to Urban Flooding

Our media analysis found that news articles discussing flooding also examined who is responsible for implementing solutions to flooding and who is to blame for the damages caused. Results for the solutions to flooding are summarized in Figure 4. The two most frequently proposed solutions were homeowners improving their homes to mitigate against flood risks or damages, and major infrastructural improvements or development to withstand flood damages. Additional solutions to urban flooding included collaboration between the public, private sector, and/or all levels of government, as well as improving communication tools to give citizens access to information regarding flood preparation and response. Our research also found news media articles that asked for a national flood mitigation plan and mandatory overland flood insurance to be purchased in addition to home insurance.

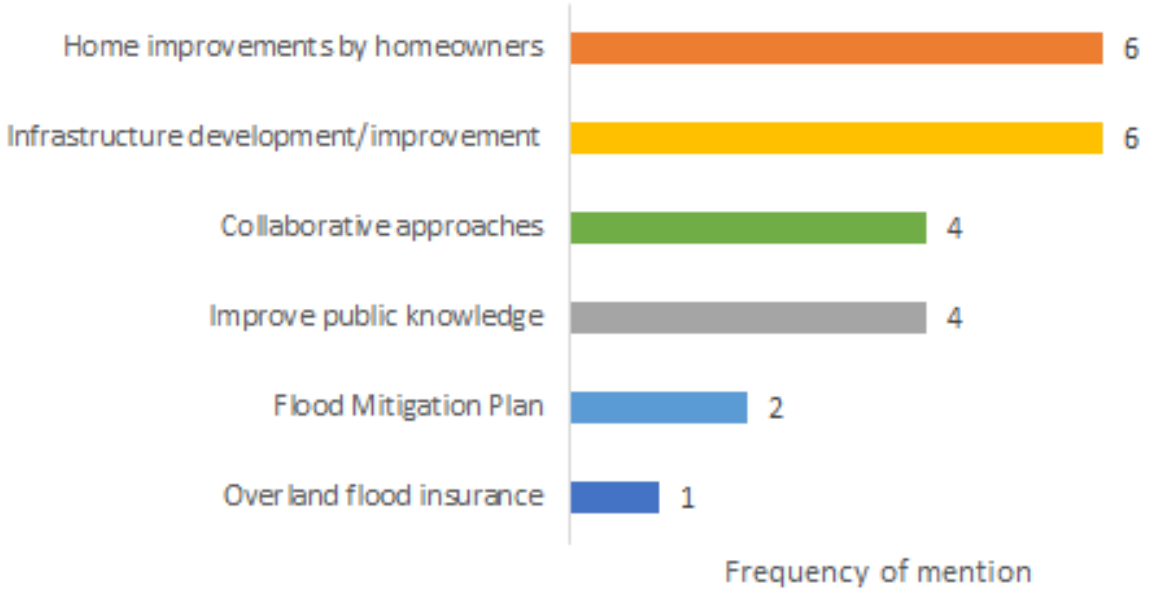

Figure 4. Proposed solutions to urban flooding as portrayed in the Albertan news media.

Deciding who was responsible for implementing and financing solutions was highly contested. There were generally two perspectives: experts who believed that homeowners should take additional mitigation measures on their own without government assistance, and homeowners who believed the solutions should come from government officials, providing education or financial support for flood victims. The attribution of blame followed a similar pattern. Experts were more likely to blame climate change and homeowner's failure to prepare for storms. Homeowners and flood victims blamed the government and insurance companies for a variety of reasons. These results are summarized below in Figure 5 and show that governments are blamed in nine out of 14 articles that mention this theme. Our research found an equal number of articles putting the blame/responsibility of flood events and flood damages on municipalities and the federal government, whereas five out of 14 of the articles put the onus on home/property owners to finance flood damages on their own.

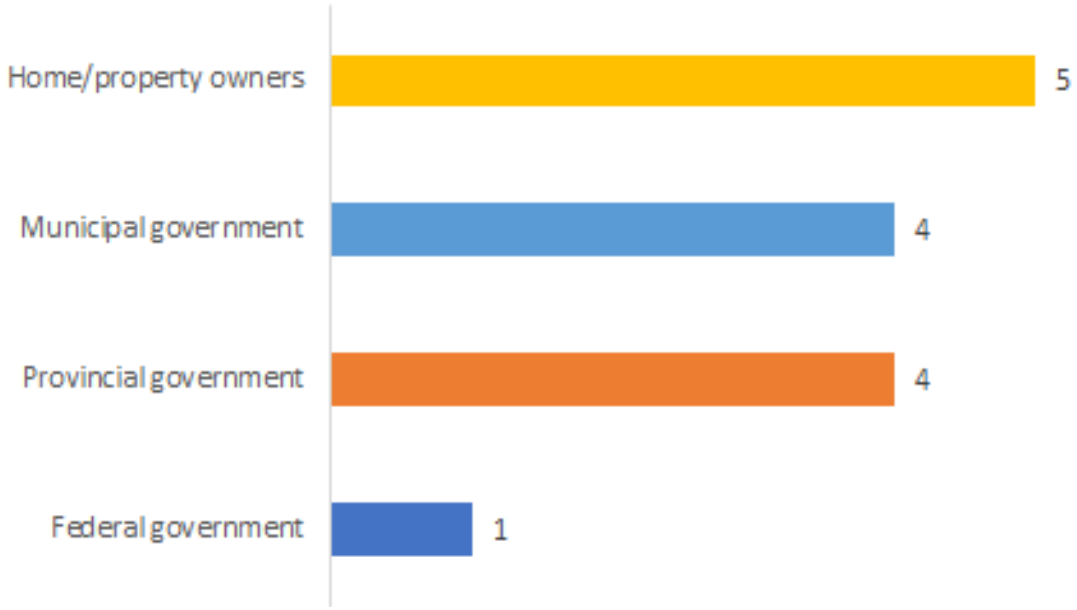

Figure 5. Blame or responsibility attribution associated with urban flood damages in the Albertan news media.

We found that government bodies, including municipal, provincial, and federal officials, were frequently mentioned to be at fault, especially by homeowners (Figure 5). Global News (2013b) interviewed an Edmonton resident who had personally experienced repeat flooding in their flood-prone neighborhood. The article recounts:

> "The city has a system in place to evacuate the water from here and it always seems to take hours before they get down here to do it, ... This happened a couple of years back… I would think they should have a look down here and know that this happens every time you have a heavy downfall. They should have something in place to alleviate this condition quicker" (Global News 2013b).

A caveat is that the type of flooding mentioned here was indirectly caused by the city, as they had closed flood gates in response to a rising river, which means stormwater that would

usually drain into the river could no longer make it there, causing excess stormwater to build up; in this case, the city was responsive to creating solutions for the homeowners (Global News 2013b).

Global News (2019) covered the aftermath of a flood affecting the Mistatim Industrial area of Edmonton. This article included an interview with a business owner whose property had flooded seven times in the three years he had owned the property (Global News 2019). The business owner blamed the flooding on a lack of a storm drain in the area, which frequently led to flooding of nearby ditches and subsequent property damage (Global News 2019). The article presented an opposing opinion from EPCOR, who maintained that drainage in the area was provided by the ditches, and that "the pooling is a private property issue" (Global News 2019). Interestingly, the business owner did express some confusion in what the solution was:

> "It gets blocked up - either from my neighbors, who didn't follow the proper drainage plan when they were building their areas… or whether or not they need another pooling pond and just haven't put it in. I don't know." (Global News 2019)

Despite this lack of an understanding of a clear solution to the flooding, the article summarizes that "business owners said they've been waiting years for the city to fix the pooling problem" (Global News 2019). In this case, EPCOR, who works with the city of Edmonton, is confident that the solution would be for each individual private property to invest in flood prevention to ensure the water on their property can reach the drains. However,

the business owners here believe that is not enough, and they expect the city to provide the solution, even though they themselves are not clear on what the solution is.

We found many news articles that believe the government could do more to prevent flooding and that the government as failing in its duty to protect the public. Several media reports on urban flooding featured the public expressing frustration with the government for failing to act. For example, a report by Global News showed a depiction of public frustration with the government for inaction on recurrent urban flooding (Global News 2019). Another article criticizes authorities and uses direct quotes from frustrated citizens and even experts to convey a mostly negative and accusatory tone towards government officials (Global News 2013a). The article also displays this blame through general commentary; it states that "apparent lack of urgency caused consternation … as mammoth floods wreaked havoc on communities across southern Alberta, causing multi-million-dollar damage that many argue could have been mitigated" (Global News 2013a). Accusatory articles such as this indicate a few of the perceptions and reactions that the media typically highlights regarding the Alberta floods; as most Alberta residents have been victims of floods, they may be more easily influenced.

There are more examples of public frustration with the government. In an article from 2013, a resident describes the floods by saying "we don't have a flood, we have a disaster" (CTV News 2013). The article quotes another resident blaming the government for the collapse of small-scale businesses due flooding. The resident says, "we're hoping that both the

provincial and federal governments will come out with a more strong position on making sure that small businesses are supported as a result of the floods" (CTV News 2013).

CBC News highlighted a University of Waterloo study which found that provincial governments were not doing enough to prevent flooding and protect private buildings and homes (CBC News 2020b). The report showed few provinces kept updated flood maps, stating these maps need to be updated every five to seven years (CBC News 2020b). British Columbia and Saskatchewan were emphasized as they had not updated their flood maps for over 20 years (CBC News 2020b). There was also a call for governments to do more in terms of regulating development in flood-prone areas (CBC News 2020b).

Beyond being responsible for footing the cost of the flood damage, there is evidence for public belief in the government's responsibility to educate and inform citizens about flood risks specific to their property. A Global News article identified in its opening line that "governments at both the provincial and the federal level are increasingly trying to pass the buck when it comes to shouldering the cost of flooding" (Global News 2017). A concern is then raised that the government has not appropriately prepared the general Canadian population for fairly taking on that responsibility, writing "reporting by Global News suggests...homeowners often don't have enough information to know they need flood insurance, nor are they guaranteed to find adequate or affordable coverage" (Global News 2017). The article addresses a lack of knowledge homeowners have about issues such as whether their property is in an at-risk location, and mentions that dialogue about flooding in real estate and insurance conversations is severely lacking (Global News 2017). It is noted

that this is increasingly true for homeowners who do not own property near a river, as "sewer back-up, which occurs when heavy rains overwhelm the sewer system, is a much more common source of flooding… many plain-vanilla insurance policies do not include water damage from sewer-backup" (Global News 2017).

Conversely, we found that many articles that interviewed experts contained large amounts of flood-awareness information and suggested strategies that homeowners could use to better prepare themselves and their properties for flood events. For example, the executive officer with the Canadian Homebuilders' Association-Alberta was interviewed and gave advice on better building guides to reduce storm damage (Edmonton Journal 2007). Experts from the Institute for Catastrophic Loss Reduction, the City of Edmonton, and the Insurance Bureau of Canada were commonly found to be supportive of homeowner responsibility over government responsibility when it came to mitigating and repairing flood damages to private properties (Calgary Herald 2008a; Edmonton Journal 2007; 2012a; 2012b). Insurance companies and city officials were also found to be supportive of homeowner responsibility for resolving flood damages; a common sentiment within several articles was that while governments and insurance would cover public property and insured losses, while homeowners should be liable for damages that they failed to mitigate on their own private property (Calgary Herald 2008a; Edmonton Journal 2007; 2012a). These articles featured options homeowners could take to mitigate these damages. Within our analysis there was limited evidence of articles featuring homeowners expressing the efficacy of these mitigation measures, and there were only a limited number of articles that showed praise for the efforts of the government (Globe and Mail 2016).

A different perspective is represented in the Globe and Mail (2016), portraying the solution to urban floods in Alberta cities as a collaborative effort that must involve government, private industry, academia, and property owners. This article addresses the more expert-focused view that the government may be responsible for stormwater management, discussing changing building codes and regulatory options to ensure building in flood risk areas does not take place (Globe and Mail 2016). One key difference in this article is the mention of private property owners needing to implement mitigation measures and understand their part in flood mitigation. This article was less common, as a moderate news report where the government was not the only actor responsible for fixing flood damage in Alberta.

Socioeconomic factors

Unfortunately, the difficulties and complications of urban flooding are often more devastating for less affluent socioeconomic groups. Our analysis found that the socioeconomic impacts of floods are another topic that is frequently addressed in the media coverage of flood events. Global News (2020) covered a flood that greatly impacted Edmonton's most vulnerable, as the Boyle Street Community Services building was "once again dealing with a flooded basement, just as it was preparing to resume a wide range of services for Edmontonians in need" (Global News 2020b). A spokesperson for Boyle Street Community Services mentioned in the article that their basement had flooded three to four times, although the time frame for this was not specified (Global News 2020b). Boyle Street had purchased flood insurance already, but the spokesperson was quoted saying, "our deductible is really sky-high now. Every time it happens it incurs a pretty significant financial

cost for us" (Global News 2020b). A similar situation was covered in 2012 with the flooding of the Bissel Centre in Edmonton by the Edmonton Journal, following a severe thunderstorm that left many donations ruined (Edmonton Journal 2012c).

Global News (2017) also brought forward socioeconomic concerns, critiquing the lack of reasonable and affordable flood insurance for homeowners who are aware of the need to purchase it. Those in the most flood-prone areas may not have access to any type of flood insurance and if the damages from floods are frequent and expensive, insurance companies will most likely not agree to insure these areas, or else demand exceedingly high rates to cover these more at-risk areas (Global News 2017). The article concludes "the fact that not all homeowners can buy flood insurance curtails the government's ability to shed the role of insurer for last resort" (Global News 2017).

The Calgary Herald (2018) echoes this concern for those not able to afford flood insurance for their high-risk properties. The article recounts an interview with a Calgary citizen who lives in the river valley and was impacted by the 2013 river flooding.

> "In 2013, [the interviewee] avoided major damage by pumping water out of his basement for two days after defying the city's evacuation order. He's since purchased expensive flood insurance and rebuilt a basement with new sump pumps, electrical panels and powerful generators. But he worries about many of his neighbors who don't have the means to make such costly changes. 'This time of year is always stressful for my neighbors'" (Calgary Herald 2018).

Although appropriate mitigation measures differ between river and stormwater flooding, these articles show that concerns about the affordability of flood insurance or flood prevention measures were a common theme portrayed throughout the media we analyzed.

Media reports about the costs associated with flooding were also extremely common, with many articles headlines even including eye-popping numbers (Calgary Herald 2012; 2018b). Most articles dealt with the overall costs of storms that had occurred in previous months or years, with the Calgary Herald and the Edmonton Journal publishing multiple articles over the years about 20, 100, or even 200 million dollars in damages caused by flooding (Calgary Herald 2007; 2012; 2018b, Edmonton Journal 2012a; 2015). While not as common in the headlines, costs to homeowners were also prevalent within the articles. These articles usually cited both monetary concerns, such as payments to drain basements or fix mold, and non-financial costs caused by the stress and frustration resulting from flooding (Calgary Herald 2008c). A general trend we found was articles that mentioned the costs associated with flood prevention measures were also dominated by expert interviews that pushed homeowners to act before damage occurred, and usually included suggestions of how to mitigate flood damage and costs through cheaper preventative measures (Calgary Herald 2007; 2012; 2018b).

Climate change and storm flooding

Our media analysis showed minimal mentions of the relationship between climate change and storm flood events. We found a total of 9 articles that mentioned climate change in association with flood events. There was a slight increase in articles making mention of

climate change in 2020, for a total of three articles. These findings were of interest to us as we expected a more dramatic increase in the mentions of climate change and storm flooding in the media. Our research found that the earliest explicit mention of the association of climate change with storm or urban floods was in 2007, where the author mentions that storms are going to worsen because of climate change (Edmonton Journal 2007). In the following year an article from the Calgary Herald posited that flood damages were expected to keep growing due to factors like environmental change, urbanization, poor infrastructure, and climate change, and that insurance coverage policies need to be examined to accommodate these factors (Calgary Herald 2008a).

Due to "climate-related incidents" becoming "more frequent and intense", the head of the Insurance Bureau of Canada called on governments and industry to create a national flood program to deal with the growing costs of destruction of weather events propelled by climate change (Calgary Herald 2015; Edmonton Journal 2015). In a 2018 Global News article recounting the 2013 Calgary flood, climate change was mentioned in addressing flood risk management and resilience (Global News 2018).

In our research, the highest frequency of climate change mentioned in new media articles was found in the year 2020. The Calgary Herald in covering preparations for the 2020 flood season included an update on the Calgary climate resilience strategy, saying that their emissions were increasing and that they would have to improve their strategy (Calgary Herald 2020). This was contextualized with flooding as the article read "some of the biggest risks Calgary faces from climate change include more frequent and destructive flooding" (Calgary

Herald 2020). In April 2020, Fort McMurray experienced a spring flood that caused more than $520 million in insured damage, according to the Insurance Bureau of Canada (IBC) (CBC News 2020a). A hailstorm in Calgary, Airdrie and Rocky View County, flooding in Edmonton, and another storm in Calgary, alone resulted in a total of more than $2 billion in 2020 insurance payouts (CBC News 2020a). Celyeste Power, western vice-president of IBC, said that these flood events indicate that Alberta is a very expensive place to do business (CBC News 2020a). She remarked, "especially at the rate things are going with flooding events in Alberta and across the country, it's becoming not easy to find flood insurance for your residential property" (CBC News 2020a). In an article in Global News earlier in 2020, Craig Stewart, the vice-president of federal affairs at IBC, mentioned that there is an increase in severe weather across all of Canada and as a result "it's costing Canadians and insurers and costing taxpayers. But it's also costing us in losses, direct losses to property across the country, whether it be from windstorms, ice storms, flooding or wildfires" (Global News 2020a).

These articles show that the media is beginning to report on climate change in relation to flood events in Alberta. However, the awareness of increased flooding events due to climate change may not be a major concern for Albertans. The Calgary Herald recounted that "Canada's insurance lobby says Albertans are less likely to be worried about weather trends linked to climate change than others in the country, despite a recent six-fold increase in insured damages from severe storms, fires, and flooding" (Calgary Herald 2013). The article also cites a lack of awareness of Alberta's greenhouse gas contributions as well as a lack of awareness on the flood-prone areas of urban centres (Calgary Herald 2013).

DISCUSSION

Responsibility for Solutions to Urban Flooding

Our results showed that there were more articles that placed the onus on governments to do more in both fixing flooding problems and in accepting responsibility for allowing flooding to occur in the first place. In emphasizing the role that government's play, the media has deemphasizing the role that homeowner's have in flood mitigation. This may be one of the reasons for low uptake of flood mitigation measures by Albertans.

We noticed that harsher sounding headlines were used in articles with flood victim interviews; the use of such headlines may grab readers' attention to issues that concern them and further the emotional connection between the reader and the news article. These types of responses may have an important role in influencing the public on how they see this issue. If a large portion of media on flooding is filled with accusatory headlines against the government, media consumers may be more prone to also blame the government for flooding.

Attributing blame for flood damages on the government was shared by political groups as well. For example, the Wildrose party called for a coordinated provincial investment and planning in flood mitigation, citing the protection of homeowners, businesses, and municipalities as a motivation (Edmonton Sun 2013). Political parties trying to defend homeowners to gain political appeal from the public can be considered an indicator of the general public opinion of both who is thought to be responsible and who is victimized in an urban flooding scenario.

There is also insight to be gained on the city's response to being blamed for flooding. Some articles, such as the Global News article covering repeat flooding in the Mistatim industrial area of Edmonton, reiterated that the solutions had to do with private property and were the responsibility of the property owner (Global News 2019). However, as seen Global News (2013), governments can be part of the problem, in this case causing sewer backups. The city representative stated that the city is willing to accept a need to reconsider its strategy and create a solution to this problem (Global News 2013b). This shows that municipal governments are not unwilling to accept responsibility for flooding in some situations. However, in most of the flood related news articles we researched the issue was with properties not being properly prepared for flood waters. In these cases, we did not see mention of the city, or other levels of government, considering financial support to property owners or taking responsibility for the damages.

Most headlines represented the public's opinion about the government's role in urban flooding, with negative depictions when the articles interviewed victims of flood damages. The Globe and Mail reveals how verbatim quotes shape readers' opinion, directly quoting a respondent saying, "I pay my taxes, fix it" (Globe and Mail 2016). This phrase helps to absolve citizens from any responsibility in managing the floods and shows how the media can work to affix the responsibility on certain groups, in this case the government. The trend that emerges from the above articles is that the media frames this problem in terms of the public's frustration with the government for not doing enough to handle the floods in Alberta.

Other articles praise the government's response but criticize the prevention mechanisms. The National Post (2017), for example, thanked the government for its efforts and commended military personnel's efforts in providing an estimated 250,000 sandbags to control the flow of water into residential areas. However, the article also contained criticism for the government for failing to prevent the floods in the first place stressing that responsibility lies first with the government before any other entities (National Post 2017). Since floods can affect entire towns or even regions and lead to massive destruction of properties the constant frame of "government alone is responsible" may reflect an aspect of what the media thinks the public wants to read or hear about when it comes to flood control. In this way, the media may influence the public to be more aware of governmental failures rather than their own.

Therefore, in general, the media presented the government as willing to accept blame based on the conditions of the flooding. There were few examples of the media showing homeowners accepting the responsibility for not taking proper flood control measures. Combined with the knowledge collected from our literature review, these findings indicate that the Albertan media is more focused on presenting public frustration with the government for failing to take action to reduce flooding. Additionally, these findings also indicate that the Albertan news media is less concerned with what individuals can do and is more likely to present fixes to this problem as a role for the government. A takeaway from these findings is that the media failing to highlight homeowner's responsibility alongside governmental responsibility may be contributing, at least in part, to low uptake of flood prevention measures by homeowners in Alberta.

Socioeconomic concerns

Socioeconomic concerns were included as an example of the devastation floods can bring to lower-income and struggling civilians. The Global News article about the Boyle Street flood showcased the devastating and complicated effects that urban flooding can have on an institution responsible for helping the most vulnerable (Global News 2020b). Most interestingly, the article notes that the facility had purchased flood insurance but was still suffering due to a high deductible and the lengthy period to complete repairs (Global News 2020b). This might undermine the perception of insurance as a solution to urban flooding because of its cost and its inability to prevent devastation. Media reports on the failures of insurance may also have an important impact on what actions private individuals take to prevent flood damages to their own property. For example, if media reports are constantly extolling the failures of insurance, private individuals may not buy insurance in the first place, leaving them more exposed. However, these types of reports may also drive homeowners to do more if they believe their insurance is insufficient to protect them. The lack of knowledge about how the public interprets media reports is also exposed by this dichotomy; this lack of knowledge is a problem for our study as even though we have identified common themes and frames in the media, we do not know how the Albertan public actually interprets these frames. Therefore, further study of the impact of media reports on the public, and perhaps specifically on the Albertan public, is an interesting and important topic that could lend greater insight into the findings of our media analysis.

Concerns about the cost of flood mitigation being placed on property owners was also part of the socioeconomic concerns of flooding. Global News (2017) showed the

socioeconomic barriers to the purchase of flood insurance in the first place, if it is even offered, because the risk and the cost is not the same for everyone. The media drew attention to the fact that not everyone can afford to put all the measures in place - including insurance, sump pumps, and property fixes - to prevent flooding, causing greater stress because of their socioeconomic situation (Edmonton Journal 2018). These articles also reveal part of the reason why homeowners may not see mitigation strategies as their problem; it may be simpler and easier to believe it is the government alone who is responsible, and advocate for help rather than prepare for the worst. This could also tie into why property owners do not make use of incentive programs that help cover some of the costs; however, to be sure of this more study beyond a media analysis is required.

Climate Change

Our research found that climate change is slowly starting to become part of the discussion surrounding urban flooding. These results were surprising as we expected there to be larger attention in the media towards climate change. The shift towards reporting on climate change was exemplified in the 2020 article which updated Calgarians on the flood prevention strategy that year, which connected Calgary's poor emission performance with likely increases in flooding in the wake of climate change (Calgary Herald 2020). However, climate change is still relatively undiscussed in the media when it comes to flooding, and in Alberta we may face a challenge in connecting climate change awareness to flood risk (Calgary Herald 2013). Due to the limited number of articles discussing climate change and flooding, we must conclude that the media is relatively more concerned with the socioeconomic impacts of flooding rather than the impact climate change has on increasing

urban flood risk. As this area rapidly evolves however we may see a shift in reporting and future studies may find a stronger trend line as these problems continue to worsen.

CONCLUSION

From our literature review, we know that media articles present views and interviews which incite public emotion and can shape opinions regarding urban flooding. Our media analysis found that the constant depiction of certain frustrations from a group of respondents shaped an entire discourse about the government's response to the flood problem. The articles we investigated revealed that there is a common theme in the media that the government should be responsible for preventing flood damage, and that most concerns regarding flooding are related to socioeconomic factors. Alternatively, there is also another theme supported by different articles that focuses on expert views on solutions to flooding; these articles put the onus on homeowners. We also found that, even though these expert views and suggestions are in some media reports, few also interviewed homeowners. Other articles focusing on government failure do not reference homeowner responsibility. However, this reality has not stopped these media articles from blaming the government for putting minimal efforts to prevent urban flooding.

A final consideration for our media analysis is that these articles are from various media outlets to ensure bias by one news source or time period does not impact the accuracy of our results. However, there is always a need to analyze more articles since we do not have an absolute reflection of all articles or media reports. There is also a need to continue further

research into whether climate change is becoming more of a topic discussed by the media in relation to urban flooding.

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Chapter 2: A step towards climate resilience: Perspectives on flood mitigation from municipal planners in Alberta, Canada

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INTRODUCTION

Due to climate-change, flood damage has increased in recent decades in both intensity and frequency. This pattern is expected to increase should the course of climate change go unchecked (Nofal & Van de Lindt 2020; Adger et al. 2009; Tonn et al. 2020; Haer et al. 2017). Urban flood damages are a recurrent and growing issue for municipalities, insurers, and homeowners across Canada (Sandink 2013). Continuous urban developments in many flood-prone areas increase people's exposure to floods (Kron et al. 2019).

Management of floodplains usually requires a localized approach (Kubal et al. 2009). Due to the differences in physical environments, land use, and socioeconomic characteristics of a particular region, mitigation strategies relevant to flooding should be conducted on a local scale, while those efforts are developed at the national and regional level (Foley 2010). Thus, effective flood mitigation practices continue to play an important role in preventing repetitive damage in flood-prone communities, thereby fostering resilience to residential flooding (Mobley et al. 2020).

Canadian municipalities are vulnerable to climate change risks, particularly in the form of extreme weather (Henstra & Thistlethwaite 2017). Municipalities have traditionally relied on a hazard-based approach to managing severe weather events, which is used to inform policy that emphasizes separating people and assets from the hazard. In recent years, governments have started to explore alternative policy approaches to manage their exposure to the effects of climate change based on the principles of risk management (Henstra & Thistlethwaite 2017). The new approach tries to emphasize the consequences of hazards and

draws on a range of instruments with a broader objective than just protection, including mitigation, response, and recovery (Henstra & Thistlethwaite 2017).

This research aims to increase understanding of factors contributing to and limiting the effectiveness of decision-making processes as part of flood risk management efforts, particularly within the province of Alberta. Central to this aim is an examination of the current policies and plans developed by the municipalities to mitigate flood hazards. This research investigates how municipal planners understand flood risk, and their perceptions of collaboration and community engagement in flood risk management decision-making processes. This paper focuses on the perspectives of several municipalities within the province of Alberta, including the City of Edmonton, the City of Calgary, and the City of St. Albert. These municipalities were selected, as study participants were more easily identifiable and available for interviews. Qualitative analyses have been undertaken following semi-structured interviews, which were conducted with key actors within the government agencies with tasks relevant to Alberta flood risk management. This research will primarily examine the following questions: 1) What best practices employed at the municipal level are effective for mitigating flood risk where existing infrastructure currently exists? and 2) What geographic factors are incorporated into the assessments of flood risk? We aspired to gain a more robust understanding of the role pluvial flooding plays in Alberta decision making processes related to flood risk management.

Despite our attempts at gaining insights into pluvial flood (overland or surface flood) management, a significant portion of the responses related to fluvial flood (river flood) risk.

In this paper, we discuss both pluvial and fluvial flood risk mitigation processes in an Alberta context. We did not deliberately intend to explore the effects of any type of flooding on commercial or industrial assets. As these were deemed beyond the scope of this research, the effects of flood mitigation policies on commercial and industrial sectors were not evaluated.

LITERATURE REVIEW

Overview

The word "resilience" has been increasingly acknowledged as an important reality for urban development (Berrang-Ford et al. 2015). The most comprehensive definition of resilience is developed by the United Nations Office for Disaster Risk Reduction, as "the ability of a system, community or society exposed to hazards: to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard" (UNDRR n.d.). Community resilience reflects the community's capacity to preserve and restore its essential basic structures and functions through risk management policies. Moreover, an essential component to resilience involves the protection of the community's most vulnerable assets. Developing robust resilience policies may reduce the catastrophic impact of disaster (Godschalk 2003). Canada's latest emergency management (EM) strategy focuses on disaster resilience by prioritizing resilience building, disaster prevention, and mitigation activities (Government of Canada 2019). The EM strategy supports all levels of governments to develop more resilient communities. Resilience may look different from one community to the next but broadly speaking includes strengthening capabilities to prevent/mitigate, prepare for, respond to, and recover from disasters (Government of Canada 2019).

A consequence of climate change is the growing severity and frequency of floods which can have catastrophic consequences for communities. The capacity to manage and adapt to unpredictable and changing flood risk is especially relevant in western Canada, where many communities have been impacted by increasingly severe flood events (Morrison et al. 2019). In Canada, provincial, territorial and municipal governments all share the responsibility for emergency management (Government of Canada 2019).

Municipal planners have the primary task of planning for floods within their district or jurisdiction. Assessing these risks is generally done using quantitative and qualitative measures; however, when assessing flood risk, quantitative methods such as modelling, statistics, and geographic information systems are more widely used (Tanner 2013; Oulahan et al. 2018). As a way of gaining deeper insights into issues of flood risk, qualitative methods such as interviews are often useful in obtaining a subjective understanding of flood risk perception and how to come up with policy to mitigate the issue (Heitz et al. 2009). In Ontario, Moghal and Peddle (2016) interviewed stakeholders and planners from 18 municipalities and concluded that 70% of the municipalities believe that they are at major risk for urban flooding in their localities; however, only 15% of municipalities have flood management plans. This statistic is particularly concerning given the increasing frequency of floods.

Alberta Flood Mitigation Policy

Alberta is the only province in both western and central Canada that takes responsibility for floodplain mapping as well as flood hazard maps with a 10-year update cycle for its entire territory. Under its Watershed Resiliency and Restoration Program, the

province has also created a $35M project to support restoration and resilience of wetlands and riparian areas in order to reduce the intensity, magnitude, duration and effects of floods and droughts (Alberta Environment and Parks 2014). Generally, the province is leading in sustainable flood management, critical infrastructure assessment, and public health and safety (Feltmate et al. 2020).

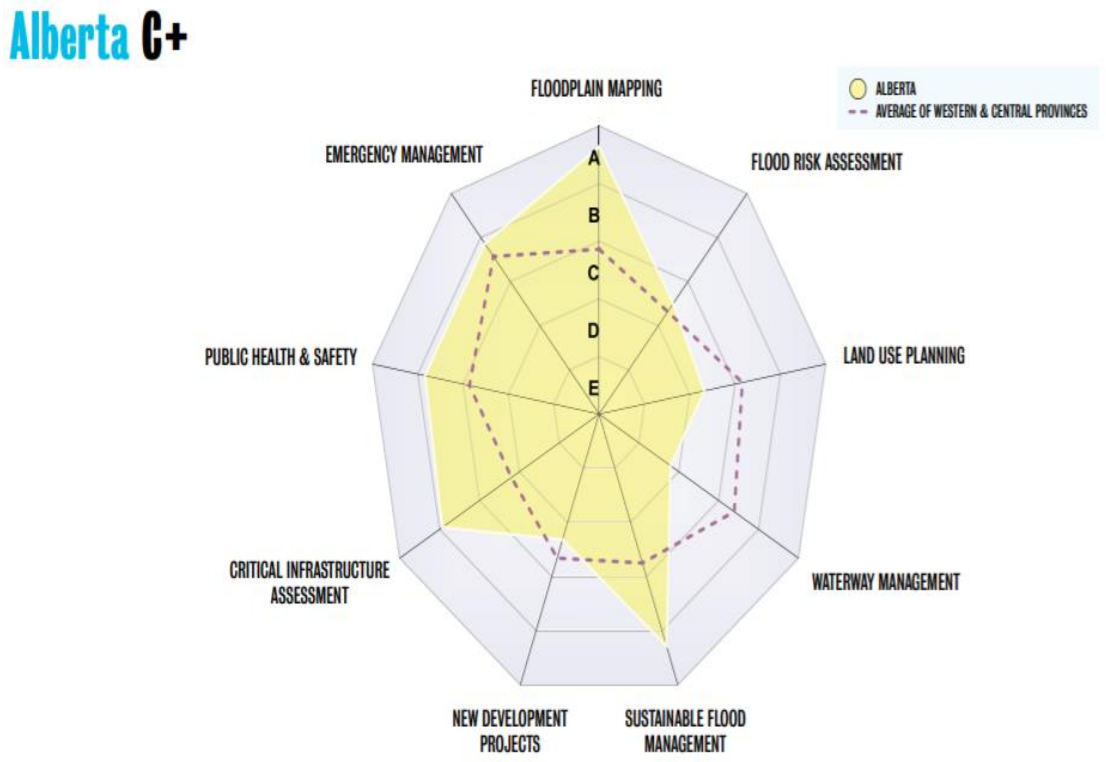

Figure 6. Flood Preparedness Scores of Alberta (2019).

The figure shows nine criteria used by jurisdictions across Canada to self-assess flood preparedness. The yellow area shows Alberta's preparedness score (C+). The dashed line depicts the benchmark score calculated as the average of the results of all Western and Central Canada provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec).

As of 2019, Alberta's flood preparedness stands at 'C+' on a five-point scale which ranges from an 'E' for a low state of preparedness to an 'A' for a high state of flood preparedness (Feltmate et al. 2020) (Figure 6). To improve water infrastructure, municipalities in Alberta are prioritizing the construction of dry ponds, preventing backflow in pipes to protect drinking water, and installing embankments and other flood mitigating measures (Cook 2019). These upgrades are essential for Alberta residents as climate change will continue to impact drainage systems (some of which were built decades ago). Numerous municipalities in Alberta also offer subsidy programs designed to mitigate flood damages. In Edmonton, EPCOR provides up to $800 for backwater valve installment to prevent sewer backup in basements while Lethbridge offers up to $2500 to offset costs of protective plumbing upgrades (Intact Centre for Climate Adaptation 2019).

A 2016 report notes that provincial governments need to work on their regulation and enforcement of relevant policies and associated flood risk management (Office of the Parliamentary Budget Officer 2016). PBO's (2016) report also states that Alberta has inaccurate flood maps which do not consider rising groundwater. To improve its flood preparedness score from C+, Alberta needs to improve land use planning, waterway management, and new project development policies (Feltmate et al. 2020).

Socioeconomic Aspects of Urban Flood Management

Flooding is currently the costliest hazard in Canada in terms of urban property damage and hydrology-related losses based on property insurance claims (Government of Canada 2019). According to the report (2014) from Insurance Bureau of Canada (IBC), insured losses from the 2013 floods in southern Alberta were nearly $2 billion (mostly from sewer backup)

while total economic losses were about $6 billion. Cities are particularly vulnerable to flood damages as a result of high population density, complex infrastructure, and valuable property assets (Thistlethwaitewaite & Henstra 2017). According to Self & Penning-Rowsell's study (2017), with intensifying urbanization process, there will be many conflicting uses of land, and many conflicting influences and interests in floodplain management within Alberta. Therefore, increasing urbanization puts demands on existing flood management systems thereby increasing the likelihood of future flooding and flood damages. Flooding generates many negative socioeconomic consequences for urban communities, including population displacement (Levine et al. 2007), critical infrastructure damages (Kidd 2011), business interruption (IBC 2014), output loss due to capital damage and displacement of workers (Davies 2015), and threats to public health (Burton et al. 2016; Carroll et al. 2010).

The complex nature of flooding problems means that local decision-makers are faced with the critical task of determining the optimum level of investment in flood risk control strategies based on risk-safety trade-off decisions (Mobley et al. 2020). Thus, reliable cost-benefit analysis (CBA) of flood risk mitigation measures helps decision makers and stakeholders by providing quantified information to support various choices proposed (WMO 2017). Since the implementation of risk mitigation is often very costly and calls for new regulations, compliance, administration, or maintenance, there are many uncertainties presented in the flood risk control in municipalities (Steen & Ferreira 2020). Traditional flood management approaches that fail to consider socioeconomic factors are likely to generate conflicts and inequities (Allaire 2018).

Low Impact Development and Green Infrastructure

One of the contributing factors that leads to the intensified risks of flooding in Western Canada is the steady transformation of the natural environment due to intensifying urbanization, the expansion of the built environment, and the continued growth and spread of transportation infrastructure networks (Feltmate et al. 2020).

Rising costs of stormwater events cannot be solely attributed to extreme weather (CMOS 2018). There are many other factors that exacerbate flood claims such as aging municipal infrastructure, lack of flood proofing in housing construction and loss of natural infrastructure (Feltmate et al. 2020). Green infrastructure has been shown to improve property values (Kim et al. 2020). Not only does green infrastructure provide ecological, aesthetic, and economic benefits, but the approach to flood mitigation using low impact development (LID) is an opportunity to rethink the approach to solving engineering and urban planning problems from a "fail-safe" mindset to one that is more "safe-to-fail" perspective (Kim et al. 2017). A risk-management based approach to the problem of flooding is too simplistic and therefore cannot be used exclusively as a sufficient means of managing flood mitigation (Park et al. 2013; Park et al. 2011).

Further complicating flood management from an engineering perspective, grey infrastructure is largely underground, therefore determining the source of the failure is challenging. Grey infrastructure is centred on a risk-based approach to flood management where design and operation are typically conducted in isolation, magnifying any failures. In contrast, green infrastructure is a resilience-based approach to risk management (Holling 1973). Such resilience management practices need to be used in concert to adequately address

potential failures. The appropriate combination of these two management approaches is where optimal practice for flood mitigation management lies.

Sociological Elements of Flood Mitigation

The goal of building resilient cities is contingent on the values of the individuals who comprise the community in question (Adger et al. 2009). Adaptations can either be framed as a means to reduce vulnerabilities (i.e. protecting individuals on the fringes of society) or as a means to enhance resilience for future climate change events. Given this distinction, our group can frame interview questions for other municipalities based on these two value systems (Haer et al. 2017). However, it is important to note that the individuals with the most to lose from flood damages are the least likely to participate in flood mitigation programs as the costs associated with them are oftentimes too high (Adger et al. 2009; Brouwer & Schaafsma 2013).

Initiatives that have been the most successful in mitigating climate-change related damage are rooted in individual and small-scale community change, which, when situated within a larger context, generate tangible risk reduction (Tonn et al. 2020; Nofal & Van de Lindt 2020). Tonn et al. (2020) argue that it is the role of the government to act as a driver for collective action on matters such as flood mitigation. While they do highlight the value of community-based flood mitigation methods such as incentives or buyouts, they underscore the often-overlooked value of lateral community participation and the power individuals have in shaping a community's value systems and subsequent decision-making pathways. Such community-based initiatives have been employed with success in other municipalities (Tonn et al. 2020; Brouwer & Schaafsma 2013). To tackle the huge challenges in reducing flood

consequences and improving flood resilience within the province of Alberta, municipalities should have a profound understanding of flood risk and their perceptions of collaboration among different actors and community engagement in the decision-making processes.

METHODS

We reached out to experts responsible for planning, designing, and overseeing flood mitigation systems in several Alberta municipalities. Participants were identified and invited to participate in a semi-structured interview designed to gain their insights and perspectives working in flood mitigation and management. Participants from different governmental agencies were contacted based on their key roles in flood mitigation. Researchers identified individuals from different government agencies who: (1) had expertise in flood management or infrastructure planning; (2) were familiar with the study area; and (3) were in a position of leadership in addressing development and disaster management in the study area. There are 4 different governmental agencies that have been involved in this study: the City of Edmonton and EPCOR, the City of Calgary, the City of St. Albert, as well as two non-profit organizations. A snowball sampling technique was used, whereby the current interviewee was asked to make recommendations on other individuals whose insights could develop the research further. Based on this sampling technique, semi-structured interviews were conducted with 12 individuals as profiled in Table 1.

Table 1. Coded Interview Profiles.

Participant ID	Government Agency
Interviewee #1	Institute for Catastrophic Loss Reduction (ICLR)
Interviewee #2	City of Edmonton
Interviewee #3	City of Edmonton
Interviewee #4	EPCOR
Interviewee #5	EPCOR
Interviewee #6	City of St. Albert
Interviewee #7	Alberta Low Impact Development Partnership Society
Interviewee #8	City of Calgary
Interviewee #9	City of Calgary
Interviewee #10	City of Edmonton
Interviewee #11	City of St. Albert
Interviewee #12	City of Calgary

The interviews were guided by the ethics protocol that was established by the University of Alberta. Participants were required to sign consent forms prior to the interviews. The interviews were conducted with a single individual depending on their availability. The semi-structured interviews helped to shape a better understanding of the current strengths and weaknesses in flood risk management and to potentially provide feedback to improve the decision-making processes within the province.

Data Analysis Tools

Online audio transcription programs, Otter.ai and Temi, have been used to assist researchers in the analysis of the data collected. Interview audio data was uploaded into Otter

to be transcribed into text automatically by the computer program. A hybrid of the data-driven or open coding process was used for our analysis. Each transcript was read in full to prepare summaries of each interview. The first step in the two-step coding process involved the creation of major themes and categories observed among and between the interviews. The themes identified within the interviews were then coded manually in Google Doc to form the initial coding. The 'second pass' was conducted after the thematic analysis was conducted, the transcripts were then applied to the themes to create a large picture of comments relating to each overarching category. The qualitative research follows both an inductive approach, beginning with specific data, to gain a broader understanding of phenomena and interactions (Lichtman 2014) and a deductive approach to ensure we were still working towards our research goals.

RESULTS

Types of Flooding

In Alberta, the interviewees identified two types of flooding: fluvial and pluvial that are of most concern to policy makers and engineers within an Alberta context. Fluvial flooding occurs where a precipitation event increases the water level of a river or stream to exceed its natural capacity, thereby flooding nearby neighborhoods. Variable seasonal and weather events such as ice jams and heavy snow melts can also cause fluvial flooding. Pluvial flooding, also referred to as overland or surface flooding, is when there is a heavy precipitation event and the flooding is independent of an overflowing waterbody. As Alberta has a range of topographical features, the primary concerns between municipalities and within municipalities vary with those topographical features. For this paper, three municipalities

within Alberta were looked at: Edmonton, St. Albert, and Calgary, which each face their own distinct challenges as a result of fluvial, and pluvial flooding.

Fluvial

Fluvial flooding, also referred to as riverine flooding, can have profound impacts on nearby communities; due to the nature of rivers and streams, the damage from fluvial flooding can be widespread ranging from headwaters to further downstream in smaller tributaries. There are two types of fluvial flooding: flash flooding and overbank flooding. Our research revealed that both flash flooding and overbank flooding affect municipal flood mitigation programs.

Running through the heart of Edmonton, the North Saskatchewan River has a deep defined river valley. As a result, outside the river valley, the City of Edmonton experiences a fluvial flooding probability of 1/500. Essentially, the majority of Edmonton is not vulnerable to fluvial flooding (Interviewee #3). Within Edmonton, the fluvial flood risk areas are located in the river valley. The majority of the river valley in Edmonton is referred to as the "Ribbon of Green" and has been set aside as parks, trails, and golf courses as part of the strategic plan for ecological, cultural, recreational and environmental uses (City of Edmonton 2021). As an example, there are areas through the park system that are routinely closed for public safety such as the Terwillegar dog park due to seasonal fluvial flooding. It is these assets that are vulnerable to fluvial flooding and factor into the city's flood mitigation plans.

Likewise, there are some residential neighborhoods located within the North Saskatchewan River valley. The Rossdale, Riverdale and Cloverdale neighborhoods are

located in the North Saskatchewan River floodplain, and all of these neighborhoods have histories dating back over 100 years. These neighborhoods not only contain historical buildings but were established before there were the land use and zoning by-laws of current day, adding a layer of complexity within the City of Edmonton's flood mitigation practices.

The Sturgeon River is a significant consideration in St. Albert's flood mitigation program. The river is a major tributary of the North Saskatchewan River; however, the slopes of the river are shallower. The difference in morphology between the North Saskatchewan River and the Sturgeon River results in unique challenges for each municipality, although both post a fluvial flood risk. The shallow banks mean that St. Albert's downtown core is particularly susceptible to seasonal fluvial flooding given its close proximity to the Sturgeon River. Particularly concerning is that over the last three years this area has experience longer and more serious flooding, and there is speculation as to what is happening upriver to be causing this (Interviewee #11). Some interview respondents note that this may be a result of differences in flood mitigation systems upstream in a different municipality; however, it's purely speculation and could be the subject of further research.

In St. Albert's downtown core, there are several historical buildings in this floodplain, but the area is primarily designated for parks and recreational usage. The multi-use designation of this space adds a layer of complexity for St. Albert's flood mitigation program. Situated in St. Albert, one multiuse pedestrian trail goes under the bridge and when it floods, pedestrians and cyclist feel the consequences as it is the only way to cross the river for individuals using these transportation methods (Interviewee #11).

Factoring heavily in Calgary's flood mitigation program is the Bow River. The Bow River flows through the center of Calgary and passes through the downtown core. The Elbow River merges into the Bow River in east downtown Calgary. On the west end, the Glenmore Reservoir is situated on the Elbow River. The Glenmore Reservoir is not only instrumental in the City of Calgary's flood management but also serves to ensure that there is an adequate supply of water during a drought. The City of Calgary has to simultaneously offer flood protection, drought protection, and manage a closed river basin (Interviewee #9)[2].

While the City of Calgary has already upgraded the Glenmore Reservoir, there is a need for an upstream reservoir to better manage the downstream flood risk. Currently, the Springbank Off-Stream Reservoir Project (commonly referred to as SR1) is in Natural Resources Conservation Board (NRCB) hearings for public comment (Interviewee #9). The SR1 Project is "designed to work in tandem with the Glenmore Reservoir in Calgary to accommodate water volumes equal to the 2013 flood on the Elbow River" (Government of Alberta 2021). However, this project is for the smaller of the two rivers that are of fluvial flooding concerns for the City of Calgary. There are reservoirs upstream on the Bow River, one being managed by TransAlta. Unfortunately, those reservoirs are not large enough.

A further complexity affecting Calgary's flood mitigation policies arises from the diversity of services offered on the banks of the Bow and Elbow Rivers in downtown Calgary.

[2] The BOSS (Bow River, Old Man River and South Saskatchewan River) River Basin is Closed. Under the Water Act, there has been a directive in place since August of 2006 for the City of Calgary, *Water Allocation Policy for Closed River Basins in the South Saskatchewan River Basin Directive.* While this is outside of the scope of this paper, this speaks to the complexities of their flood and water management program.

First, the banks of the rivers are prime real estate. When flooding does occur, it is not unusual for the houses on the banks to experience flooding up to the ceiling of the ground level. In the case of the 2013 flooding event, many of these houses were write-offs (Interviewee #9). Next, numerous community services are situated along the banks of these two rivers. Such services include courthouses, schools, and crucially, drop-in centres. Such services such as drop-in centers and affordable housing centres means that when flooding does occur, marginalized communities will be affected. One interviewee noted that the City of Calgary endeavors to

> "make sure those people are safe and protected because they do not have the same resources and may require significant resources to evacuate" (Interviewee #9).

The consequence of such diversity along the riverbanks means flood mitigation policies are complex, multidimensional, and require innovative solutions to minimize the flood damages experienced by all Calgarians- not just the wealthy.

Pluvial

Pluvial flooding occurs when the amount of precipitation overwhelms the saturated urban storm management system and water flows out onto the landscape and structures (backflow). Pluvial flooding also results from a lack of infiltration so the precipitation either runs to lower elevations or pools at that location.

The North Saskatchewan River flows through Edmonton, the Sturgeon River through St. Albert, and both the Elbow and the Bow Rivers in Calgary. As the North Saskatchewan River has steep embankments, in Edmonton pluvial flooding is of primary concern. In downtown St. Albert along the Sturgeon River, the concerns are primarily fluvial where in the

suburban and residential areas the concerns are primarily pluvial. In contrast, Calgary's, the city's primary concern is in managing flood damages is fluvial as a result of the Elbow and the Bow rivers.

Mitigation Measures

Approaches to mitigation are diverse and vary significantly depending on a community's geography, age, and local flood risks. Some forms of flood mitigation identified during this research included physical measures to manage flood risk while other flood management practices were more procedural in nature. The dynamic nature of flood risk management means that policies and procedures to mitigate flooding have evolved considerably over the last 30 years. Prior to the 1990s, stormwater and sanitary systems were combined. Heavy precipitation events in older combined stormwater/sanitary systems often resulted in these drainage systems being overwhelmed contributing to residential backflow. In addition, the older, combined systems were not designed to accommodate overland flooding (Interviewee #8). Therefore, separating stormwater drainage from sanitary water systems ensures that sanitary drainage gets adequate levels of treatment during a major precipitation event, a problem common within older combined systems.

Additionally, the primary objective of historical approaches to mitigating pluvial flood risk was to immediately move water from where the precipitation has landed into nearby rivers, streams, or other water bodies as fast as possible. Based on the findings, contemporary flood mitigation systems have shifted to focus on slowing the movement of water and improving infiltration rates. Therefore, when considering flood mitigation for pluvial flooding, the age of the infrastructure must be taken into account.

Physical Measures

For neighborhoods established prior to the 1990s, the sanitary and septic sewer systems are combined. The combined sewer system is not only of environmental concern but also can cause property damage, because the system is easily 'overwhelmed' leading to water 'back-flowing' onto roadways and surfaces. The separation of sanitary and sewer systems means that two pipes, and systems connected to those pipe networks, manage the volumes that were expected to be handled in one. This reality is why areas built prior to the 1990s are at higher pluvial flooding risk based on our findings.

As these systems are underground with existing infrastructure overtop of the sewer networks like roadways and buildings, flood mitigation in mature neighborhoods is a complex and costly endeavor for municipalities. As a result, dynamic mitigation approaches must be employed in older neighborhoods. We found that there is a three-pronged approach to flood mitigation in mature neighborhoods: 1) relining pipes 2) increasing storage capabilities within the system, and 3) controlling stormwater at the source such as holding back the water (Interviewee #3). The relining of older underground sewer pipes improves the existing pipes smoothness which in turn increases the volume of water they can accommodate. Many of these existing pipes may even be made of clay tile, and it is cost prohibitive to replace them with new larger pipes. Improving the smoothness of these pipes enables the water to move more freely, making the smaller and older pipes more efficient. Furthermore, mature neighborhoods, due to their established nature, are constrained by a lack of space. As a result, installation of storage ponds is challenging. A solution to this issue may be found in the installation of underground storage tanks; however, this is cost prohibitive. (Interviewee #1).

These limitations present an opportunity for municipalities to place hold-back requirements on projects and larger institutions in mature neighborhoods. In these instances, when larger projects apply for permits in mature neighborhoods, the permit process requires such developments to include mechanisms for storage and timed release of water. Likewise, low impact development is increasingly being included in such development projects.

Newer developments see a reduced pluvial flood risk with some interviewees noting that new developments do not face this concern at all. Further mitigating measures include separated sanitary and storm water sewer system wherein the system is designed on newer standards and is adequately sized (Interviewee #3). In newer subdivisions, as they are greenfield development, there are opportunities to incorporate storage facilities. Moreover, low impact development (LID) such as dry ponds and retention ponds can be integrated into neighborhoods from the initial planning stage.

Based on the findings of this research, the low impact development (LID) provides numerous benefits to the communities. First, LIDs offset the risks imposed by extreme precipitation events that contribute to flooding events. Furthermore, LIDs also do a small part in combating climate change, increasing the vegetation cover and tree canopy thus improving infiltration rates and therefore storage of water within the municipality. LIDs reduce the 'heat island effect' where urban areas experience higher temperatures than outlying surrounding areas. As one interviewee recounted, "[LID] actually helps with climate change, because by increasing green infrastructure, you're reducing heat island effect" (Interviewee #5).

Additionally, these green spaces improve the quality of life for citizens, referencing a retrofitted school yard, Interviewee #5 discussed the success of one project:

> "it's one of our best dry ponds that we've done to date. It has a gazebo [...] we added all the bells and whistles to it (Interviewee #5)."

Even though the site is lower than the street people can walk their dogs and use the sports fields, contributing to improved citizen health and wellbeing.

Management Practices and Policies

Most mitigation measures are implemented through policies and by-laws. Municipalities under the Municipal Government Act, have the power to create their own bylaws to manage the pluvial flood risks within their jurisdiction. Beyond bylaws, physical management practices are employed by municipalities and contractors alike to mitigate flood risks. One such example is dry ponds. Dry and wet ponds are used as part of the larger storm water mitigation network. Storm water management officials can use these ponds to not only passively direct water away from assets such as residential and capital infrastructure, but also as surge ponds to hold back water until the storm has passed. Used in this way, such ponds can keep water levels within desirable parameters in both the man-made components of the system and the natural water bodies to minimize damage.

Integrating technology within flood management has been gaining traction. The communication aspect of technology is a very useful and emerging tool with numerous applications. Some municipalities anticipate being able to communicate real-time warnings and alerts to residents in the case of flooding. Doing so will also allow municipalities to

redirect funds where they could be of more use, in areas of higher risk (Interviewee #5). Additionally, there is the potential to use doppler and storm tracking technology and integrate that technology with the hold-back aspect of the flood management system ensuring that the release of water is not done until the risk has passed for all areas along the system and even further downstream. The use of technology would be more proactive than reactive in a lot of these instances.

Damages

Public Property

The majority of interviewees affirmed that public property is affected negatively by flood risk. Crucially, the same effect is not consistently reflected in market values. Damages to public property were summarized by the interviewees based on three different aspects: the environmental loss (e.g., bank erosion), public infrastructure loss (e.g., road, railways, bridges, etc.), socioeconomic loss (e.g., recreational activities). The loss and damage to public property can be both direct and indirect. Measuring physical or direct damages is increasingly seen as an effective step towards risk reduction and promoting disaster resilience. Determining direct flood damage is commonly done using depth-damage curves based on analysis of past flood events and expert judgment (Interviewee #4). Published following the 2013 floods, the province of Alberta established comprehensive flood damage depth curves (Interviewee #4). Despite their attempts at quantifying the damages, some indirect damages caused by flooding to society are hard to assess in monetary terms. Damages to public infrastructure may have different repercussions than private losses. This distinction is a result of public infrastructure and buildings providing services the whole population relies on. As

indicated by Interviewee #11, the disconnectivity of a city's road networks may also decrease the recreational values of a region, as walkers, cyclists, and some of the local citizens are inaccessible to their daily routines and activities.

Private Property

The interviewees shared a common view that private property owners are particularly negatively affected by flooding in Alberta. Private damages are generally related to basement flooding from sewer backup, which results in a significant portion of private property loss, especially in those older communities which continue to rely on dated plumbing systems.

Damages to commercial buildings account for another significant portion of private property loss. Water depth inside the building is an important indicator to reveal property loss of households. Typically, six inches in water depth may result in household loss values of $40,000. If the water hit the building's main floor, it might be 1.5 times the property's value compared to the property in the basement (Interviewee #4).

In recent years there has been an increase in the frequency and severity of extreme weather conditions. Thus, there is a need for the municipal planners to closely examine the process and considerations when selecting sites for new development or upgrading existing facilities already in flood-prone areas. Despite the risk, a finding within our research revealed that the majority of private property owners have a limited intention or means to implement disaster mitigation measures. Instead, the private household put pressure on the municipal government to compensate for their loss (Interviewee #1). One of the challenges faced by the municipalities is to modernize mature neighborhoods and communities to meet the modern

standards employed in greenfill developments. This topic is discussed in more detail in the responsibilities section.

Roles and Responsibilities

Our research revealed that there is considerable contention around the roles and responsibilities of homeowners, municipalities, and the provincial government. Interviewee #5 put it best,

> "the Insurance Bureau of Canada has started to kind of push for overland flooding [coverage], which wasn't typically part of your insurance packages. As that gets put into place, and more people are actually getting it on their insurance, the government's going to back off, and so they're not going to cover people anymore. That's where the municipalities have to step in and start protecting people a little bit better. The insurance company will increase your rate after you flood once, whereas traditionally, municipalities don't go in and fix anything until you flooded a couple times or you've had a major event. So there's that disconnect, because your insurance rates won't drop again, until you've experienced four or five, maybe sometimes six rainfall events that could have caused flooding and they didn't" (Interviewee #5).

Currently, there is a transitional period of responsibilities wherein the insurance companies are expected to step in to offer more comprehensive and applicable coverage based on the individual homeowner's risk. This shift was prompted by large disaster events such as the 2013 fluvial floods in southern Alberta. At the same time, government flood recovery programs are scaling back and insurance has yet to fully step in.

Homeowner

An emerging theme observed among this research is that there is an increasing expectation that homeowners will take a more proactive role in mitigation flood risk within their own homes. The broad consensus among interviewees affirms that though the municipality is instrumental in mitigating flood water damages homeowners play an equally important role in minimizing the damages, particularly those done to private property.

There are incentive programs offered to homeowners by their municipalities and homeowners, particularly those who are at greater risk, are encouraged to participate in these programs. However, as indicated by the Institute for Catastrophic Loss Reduction (ICLR) "Municipal Basement Flooding Subsidy Programs", the City of Edmonton sees a 59% uptake of eligible participants of the municipal basement flood subsidy program (Institute for Catastrophic Loss Reduction 2017). While Edmonton is the municipality that sees the highest percentage of participation, followed closely by only the City of Cornwall, a participation rate of less than 60% is low when considering that this is based on the number of homeowners who experience a higher flood risk.

Considerations such as these are particularly noteworthy as the research revealed that insurance companies and government entities are taking less responsibility for homeowner decisions and resultant losses in high-risk flood areas.

Municipal

The majority of the interviewees were selected based on their roles and expertise on flood mitigation and management within local Alberta municipalities. Within Alberta, municipalities are able to create their own by-laws to manage flood risk within their

jurisdictions based on the Alberta Municipal Government Act. Municipalities, working within their consultation and review processes, set zoning and land use bylaws to establish what type of developments can be constructed and where to mitigate flooding risk. Following the zoning and bylaw decisions, the storm water design and specific flood management program is designed and implemented. Capital infrastructure is not limited to roadways, bridges and public buildings, but also the stormwater systems located below these services and buildings as well as the stormwater ponds. Maintenance of these systems is also under the purview of the municipalities.

Older neighborhoods present the most significant challenges for municipalities. Many communities were established due to their close proximity to major waterways, as this made earlier life for settlers easier. As settlements grew into towns and cities, the majority of development happened outwards. As a result, the areas with the oldest infrastructure tend to be situated near water sources. The proximity to rivers and streams coupled with the reality of old infrastructures means that many of older communities face the challenge of mitigating both fluvial and pluvial flooding risks.

In some areas, attempts at community revitalization initiatives have started to emerge. A prominent element in these community revitalization efforts is the emergence of infill housing. Infill housing involves developing old neighborhoods through the demolition of older, oftentimes run-down houses. Such developments often result in the subdivision of the lot and subsequent construction of high-density housing. Situating more houses on the same land that rests over older infrastructure has been flagged as a concern among multiple

research participants. As a result of increasing infill developments, municipalities have begun to implement design standards for infill developments to ensure new homes do not create undue strain on existing systems. In summary, municipalities broadly feel that when it comes to mitigating flood risk for residential properties, it is the responsibility of homeowners to manage their personal flood risks within the property line and be cognizant of their personal level of risk.

Provincial

Our research has determined that the provincial government plays a significant role in flood mitigation policies and programs at a municipal level. The key distinction, however, is that the provincial government's involvement is at arm's length. The Alberta Ministry of Environment and Parks identifies two separate services: flood mitigation and flood recovery. In addition to the Alberta Municipal Government Act, there are the Alberta Environmental Protection and Enhancement Act and the Alberta Water Act that guide municipal practice.

Numerous interviewees stressed the importance of provincial flood mapping and guidelines, and how these provincial sources inform local decision making and bylaws, particularly in terms of flood prevention. Furthermore, the provincial government provides funding to municipalities for flood mitigation projects. In the instances where flooding still occurs despite flood mitigations measures, the Government of Alberta has historically bailed out businesses and homeowners alike. The fluvial floods in southern Alberta resulted in the establishment of a home buyout program where the provincial government offered buyouts to homeowners in identified floodplain areas "funding was provided through the Disaster

Recovery Program (DRP) which is managed by the provincial government" (The Alberta WaterPortal Society 2013).

Federal

In conversation with Interviewee #4, we discovered that the federal government does play an important role in terms of funding. Beyond this conversation, the federal government's participation or involvement in flood mitigation and management was absent from our research findings.

Insurance

From the interviewees, insurance was referred to in a few different contexts. Beyond the comment from Interviewee #5 describing the transition of responsibilities of flood recovery from a government program to being primarily under insurance, insurance is seen as a tool to ensure that those who are assuming a higher level of risk are paying individually rather than it being a societal encumbrance. The insurance industry is seen as a partner in flood mitigation especially as there is a depth of knowledge regarding where the risks are and what the costs associated with the resulting damages are. However, there is a concern that homeowners who are at a high risk of flooding are not going to be able to afford the insurance they may be required to carry for their particular level of risk.

DISCUSSION

While that was a prominent theme among interviewees, there is no clear evidence of legislation or public engagement to communicate the reality that flood mitigation on residential property is the responsibility of the homeowner. The consequence of this means that for Albertans looking to purchase new homes, it is the homeowner's responsibility to

identify if the homes they are interested in are in high-risk flood areas. In addition, should homeowners find themselves owning property identified by their municipality as being high risk, it is their responsibility to make informed decisions about how they use their home space. This includes doing an individual cost-benefit analysis on whether developing their basements is worth the potential risk in the case of flood damages; a reality that many homeowners may have overlooked in the past.

Within the property line, is generally regarded among the majority of interviewees as being the homeowners' responsibility. One interviewee notes that, "the property line is often viewed as this magic wall that nobody can ever cross" (Interviewee #4), suggesting that despite all municipalities' expertise, knowledge tools, they are unable to directly impact flood mitigation programs on private property. Moreover, the provincial and the federal flood mitigation programs are generally solutions applicable to the public sphere. Such limitations place flood mitigation in the private sector in high need of solutions; however, the diversity of private homeowners adds a layer of complexity for many municipalities, as they now find themselves working with individuals from a variety of backgrounds, socioeconomic standings, priorities, cultures, and value systems. The diversity in values and ranges in homeowners' capacity to leverage financial resources among results in inequalities within flood mitigation programs for Albertans.

Complicating matters further, are the socioeconomic standings of many residents of older neighborhoods. Cheap land and deteriorating housing conditions translates to generally lower living costs which in turn attracts marginalized communities as well as gentrification.

Consequently, the installation of private flood mitigation systems, particularly in older neighborhoods, fails to occur. As a result, there is a continuously self-affirming cycle that is observed to occur: older neighborhoods are neglected, contributing to low housing costs. Low housing costs generally attract individuals of a lower socioeconomic status who are unable to retrofit existing homes. The absence of private flood mitigation systems (in conjunction with older underground infrastructure) contributes to a lower overall standard of living thereby maintaining low living costs, and the cycle affirms itself in these communities.

To address the concerns arising from outdated infrastructure, numerous interview participants affirmed municipalities' responsibility to upgrade old, dated infrastructure in order to bring them up to current standards that are used in new construction neighborhoods; however, this does not address the further complexities occurring within these neighborhoods. Homeowners of older homes in these central areas, with close proximity to waterways, are not going to invest in flood mitigation measurements for their personal property when the real estate markets and property value assessments are reflective of the land only and not the land and building.

Limitations

The findings of this study are observed in light of some limitations. The first limitation is the relatively short time allocated for the research to be carried out. This research was carried out as an assigned objective in the blended Capstone project for the RSOC and AREC 410 class. As a result, the research was carried out over the course of approximately 3-½ months and conducted by five undergraduate students. Being full-time students taking multiple courses placed further constraints on the researchers' time, a limitation complicated

by the realities of the pandemic and remote correspondences for the interviews. The results of these limitations are demonstrated by the relatively small interviewee pool. Having interviewed only 12 individuals allowed the researchers to gain an elementary understanding of the considerations, limitations, and priorities in flood mitigation and management practices; however, more robust findings could be developed with a larger interviewee pool, time and resources permitted. Therefore, these results must be interpreted with caution given the small interviewee pool.

The second limitation concerns the subject materials. This capstone project was assigned to students in either the BA Environmental Studies or the BSc Conservation and Environmental Sciences programs. A lack of formal theoretical or practical exposure to flood mitigation, specifically relating to flood mitigation policies made the synthesis and analysis of our findings challenging.

CONCLUSION

When your tap begins leaking, what is the first thing you do to remedy the situation? The majority of sensible people find the source of the leak and repair it. Only then do we clean up the mess created by the leak. Consistently, our interviewees noted that flooding is becoming more of a concern. Flooding events are occurring more frequently, and the damage they cause are slowly increasing over time. It is important to understand that while flood mitigation is a reality faced by many municipalities, managing contemporary flooding events is akin to trying to clean up the mess while the tap continues to leak. At the heart of the increased severity and frequency of flooding events observed by interviewees is climate

change. To mitigate the increasingly damaging effects of flooding in the future, the researchers emphasize that climate change should not be omitted or ignored from the flood mitigation discussion.

Behind the questions of what are the best practices and geographic considerations for flood risk management is an important, unexpected question: how is this all communicated to those who are personally affected? While one interviewee commented,

> "the way we've interpreted it as looking at it from the perspective of we have knowledge to share. So making sure that homeowners know that they're in a risky area, which isn't as obvious for the fluvial flooding" (Interviewee #4),

this stood out as an anomaly. There were few comments regarding the dissemination of information to homeowners. Ultimately, municipalities and other entities are the experts but how that expertise is communicated, particularly to individuals at risk, needs to be explored further.

APPENDICES

Table 2. Glossary of Terms.

Term	Definition
CBA	Cost–benefit analysis (CBA) is a method for assessing the economic efficiency of proposed public policies through the systematic prediction of social costs and social benefits.
Detention Ponds or Dry ponds	Sometimes referred to as a retarding basin or a holding pond. These 'ponds' are designed to prevent or limit flood damages and erosion downstream. They are an area of land set aside by the municipality to catch and hold storm water and direct it away from . Recreation fields often serve the dual purpose of having dry ponds embedded within them.
Downriver or Downstream	In this context, refers to a location along the river or stream that is further away from the source (or headwaters) or the river or stream than the reference point. The position downstream or downriver would have been in contact with the water after the water passes the point of reference.
Closed River Basin	When river basins have higher demand than the basin's headwaters are able to provide, the river becomes 'closed'. The water bodies do not physically close but rather policy is employed to curb the issue.
EM	Emergency management (EM) assessments focus on flood risks affecting emergency response and recovery operations including contingency planning for businesses and infrastructure owners/operators.
Fluvial Flooding	A fluvial, or river flood, occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores and neighboring land.
Floodplain	A floodplain is a generally flat area of land next to a river or stream.
FPM	Floodplain management policy.
Greenfield	Development that is not impeded by existing development. New-subdivisions are greenfield development as they are typically built on annexed farmland.
Greywater	Greywater is gently used water from your bathroom sinks, showers, tubs, and washing machines.
Hazard Map	Used by the territories to delineate areas predisposed to hazardous events.
Headwater	The headwater is the farthest place in that river or stream from its estuary or downstream confluence with another river. It is also known as a river's source.
LID	Low impact development (LID) is a term used in Canada and the United States to describe a land planning and engineering design approach to manage stormwater runoff as part of green infrastructure.

Pluvial Flooding	A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body.
SIRP	Stormwater Integrated Resource Plan(SIRP) is a risk based approach through Integrated Resource Planning techniques developed by EPCOR to reduce the risk of flooding in Edmonton due to extreme weather.
Surge Ponds	References either retention/wet ponds or detention/dry ponds. The term surge is in reference to more of the control of the water within the pond and network rather than pond design itself. Surge ponds have the water level controlled using active or passive measures such as pumps or sized pipes to move the water from one storm pond to another or an outlet.
Stormwater Flood	Short duration, high intensity flooding event.
Tributary	A river or stream that flows into a larger river or lake. The Sturgeon River is a tributary of the North Saskatchewan River. The Elbow River is a tributary of the Bow River.
Retention ponds or Wet Ponds	Retention ponds or Wet ponds are small natural or man-made ponds that hold water all year round. In the case of stormwater, wet ponds serve as a storage mechanism for surplus water to be stored. Wet ponds provide important ecosystem services as they filter the water of pollutants and sediment before returning to the natural water cycle.
Upriver or Upstream	In this context, refers to a location along the river or stream that is closer to the source (or headwaters) or the river or stream than the reference point. The position upstream or upriver would have been in contact with the water before the water passes the point of reference.

Table 3. Summary of Burdens and Responsibilities.

Homeowner	Municipal	Provincial	Federal
Basement flooding is the number one way homeowners are impacted.	Managing flood risk on public property.	Primarily responsible for mitigating fluvial flood risks.	Administering funding for municipal flood mitigation projects.
Can be impacted by both pluvial and fluvial flood risks.	Primarily responsible for mitigating pluvial flood risks.	Providing flood mapping to data to municipalities.	
Retrofitting existing homes with updated food management systems.	Responsible for establishing Land use regulations.	Primarily responsible for mitigating fluvial flood risks.	
Partaking in Municipal Basement Flood Subsidy Programs	Responsible for creating Bylaws for infill construction.	Published Flood Damage Depth Curves.	
Personal cost-benefit analysis when making decisions on use and development of private property.	Implementation of Municipal flood management program.	Alberta Municipal Government Act empowers Municipalities.	
	Maintenance of flood management infrastructure.		
	Facilitate Municipal Basement Flood Prevention Subsidy programs		

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Chapter 3: The influence and rationale of flood risk mitigation – An insurance adjuster's perspective

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INTRODUCTION

Flooding is one of many natural hazards that can quickly become a disaster, depending on individual and collective responses to the event. According to the Intergovernmental Panel on Climate Change (IPCC), the frequency and severity of flood events are expected to rise in the next 20 years and beyond (IPCC 2014), so it is important that communities and individuals are prepared to deal with these events. Experts are confident that climate change is expected to cause major river floods that not only affect coastal regions, but landlocked areas as well (IPCC 2014). Consider Slovakia, an inland country in Eastern Europe, that has faced a rather drastic increase in the frequency and intensity of flooding events over the past 20 years in municipalities surrounding the country's major rivers (Zeleňáková 2011). The example of Slovakian floods shows that places like New Orleans that are literally sinking into the ocean are not the only ones who need to be worried about flooding events in the future. The topic of our project centres around why homeowners are not investing in flood mitigation measures and what can be done to encourage increased uptake of these preventative measures.

Our research questions are as follows: (1) What do insurance adjusters see as the biggest barriers for customers to invest in flood prevention measures for their homes? (2) With these barriers in mind, what can insurance companies and local governments do to encourage homeowners to invest in flood prevention measures?

We hypothesize that a major barrier to investing in flood mitigation measures may be the associated costs. Many people may think getting flood insurance is enough and that no other measures are needed because they are protected through insurance. We also hypothesize

that additional barriers may exist through lack of awareness of mitigation measures, or the knowledge of how to implement them. If people are aware of mitigation measures, people may not want to put in the time or effort to implement them. Furthermore, customers may not invest in flood mitigation measures because they do not perceive their property as at risk of flooding. This may contribute to the customer's perception of their own personal susceptibility to floods and their willingness to prepare for floods.

With regards to the second research question, we hypothesize that insurance companies could provide clients with resources and personalized information during the initial conversations about flood risk insurance (such as the Institute for Catastrophic Loss Reduction (ICLR) flood risk handbook) to help homeowners better understand what they can do to prepare their homes for possible floods. Insurance companies could also provide referrals to other professionals who can help with the assessment of the home and installation of some of the mitigation measures. Perhaps subsidies or grants from the government could be effective in encouraging people to invest in flood mitigation measures for their home (similar existing programs to promote energy efficiency). There could also be policies in place where people have to meet certain standards in the technologies they use (e.g., pumps) for flood mitigation.

LITERATURE REVIEW

There are a variety of ways that households and communities can increase their resilience to flood risk. The Institute for Catastrophic Loss Reduction (ICLR) is one organization that offers pragmatic solutions for individuals and cities alike to reduce their

vulnerability to the impacts of floods, for both inland and coastal regions. For example, the ICLR put together a handbook to help residents assess flood risk of their own home and how they can take preventative measures such as installing downspout extensions and splash pads, or having a plumber assess the foundation and flooring of their homes (ICLR 2011). The ICLR also mentions that flooding is often not covered under regular house insurance, and therefore, recommends exploring additional insurance options to cover flood damage should a flooding event occur (ICLR 2011). Companies such as TD Insurance work to educate residents on flood risk reduction and offer insurance policies to protect their property and personal belongings.

However, despite all of the different options and resources available, many households who are more vulnerable to flooding still are not implementing flood mitigation measures. A study by Rajapaksa et al. (2016) states that a major barrier to investing in flood insurance is a lack of consumer understanding about what their home insurance policy covers and the level of risk that they face. Our research project will focus on the insurer perspective around why individual households are reluctant to invest in flood risk reduction initiatives and what can be done to try to encourage people to take these preventative measures.

There is a substantial body of literature that explores the connections between flood risk reduction and insurance premiums. A significant proportion of the research conducted so far has focused on perspectives from the consumer, that is the homeowners and individuals exposed to flood risks. Petrolia et al. (2013) combined household-level data on the choice to purchase flood insurance with experiment-based risk preference data and subjective risk

perception data. The sample covered a wide geographic area (the entire U.S. Gulf Coast and Florida's Atlantic Coast) and included individuals exposed to varying levels of risk. Royal and Walls (2019) conducted a survey of floodplain residents in Maryland and found that stated risk perceptions predicted voluntary flood insurance take-up, while perceptions themselves varied widely among surveyed residents, owing in large part to differences in past flood experience.

These findings align with earlier findings from Baumann and Sims (1978) who illustrated that there were three factors influencing the purchase of flood insurance. These three factors were: experience with floods, social background, and acceptance of flood protection. Experience with flooding ended up being the most important factor. Baumann and Sims (1978) stated when people have experienced floods, then people will buy insurance, but that this effect is temporary. Moreover, the higher the education level and the income of the homeowner, the larger the proportion of them will purchase flood insurance.

Other factors impacting flood insurance uptake were identified by Brown et al. (2020). These factors included consumer knowledge of flood zones and consumer attitudes toward community hazard mitigations projects (Brown et al. 2020). Botzen et al. (2009) found that many homeowners are willing to invest in flood disaster mitigation in exchange for the benefits of hypothetical flood insurance. The type of flood insurance is also a key factor that will affect the willingness of people to buy flood insurance or not.

The literature also discusses what barriers to flood insurance exist. Further analysis on consumers and flood risk perception was conducted by Robinson and Botzen (2019), who

focused on psychological variables impacting demand for flood insurance. They found two factors that influenced whether someone purchased flood insurance: concern over flooding events and regret about paying for flood insurance when no flooding occurred (Robinson and Botzen 2019). Other findings by Seifert-Dähnn (2018) discuss barriers for uptake on insurance measures. These barriers included the lack of information for consumers about their individual property and education about how to protect that property (Seifert-Dähnn 2018). Seifert-Dähnn (2018) also expressed concern about other insurance products being combined with flood insurance, as it would act as a financial barrier.

There are a variety of research methods employed to study the relationships between flood risk, flood insurance and residents, and factors that affect residents' purchase of flood insurance. These methods include meta-analysis, qualitative analysis, and quantitative analysis. Baumann and Sims (1978) randomly selected households living in the floodplains for investigation, and collected information on these households about their views on future floods, income levels, flood experiences, awareness of floods and measures taken to prevent floods, social background, and acceptance of flood protection. Other methods utilized by Lamond et al. (2019) were to interview insurance professionals to assign value to properties regarding flood management and mitigation. Through literature reviews and interviews, the group concluded that there is no one best way to assign valuation to commercial property. Rapidly changing risk and government regulation requires a more guided and cautious approach to property valuation. Thistlethwaite et al. (2020) also tested prior research that disputed the utility of purchasing insurance coverage by property owners by drawing on

Canadian public opinion survey data to assess factors that influence decisions about the utility of flood insurance.

Flood insurance is provided by insurance companies to subsidize families suffering from flooding impacts. However, there are also insurances that reward households who proactively adopted measures that prevent floods and reduce flood risks. Botzen et al. (2009) investigated whether Dutch homeowners are willing to invest in flood mitigation, such as adding protective measures in exchange for the benefits of hypothetical flood insurance. They conducted a survey using Sawtooth software.

In addition to quantitative and qualitative analysis, some studies have also conducted meta-analysis. Sebastian et al. (2017) conducted a meta-analysis of the possibility of threat exposure, the perceived consequences of threat exposure, the perceived effectiveness of protective actions, and the ability to perform protective actions. From their meta-analyses they came up with six constructs. Afterwards, they used keywords such as “flood” on different academic websites to screen out 221 papers that met the conditions. They further screened for articles containing empirical data related to the association of at least two targeting constructs in the meta-analysis. Sebastian et al. (2017) concluded that both threat assessment and response assessment are closely related to flood prevention intentions and behaviors, and trust in public flood prevention measures is positively correlated with private flood prevention intention and behavior.

Through analysis of previous studies and the methods they have used in their research, we have seen the favored mode of analysis be qualitative studies; six of the sources have at

least partially incorporated qualitative research in their findings. Quantitative and meta-analytical research is incorporated less often, with two and three sources using them, respectively.

Our research seeks to draw on flood risk perspectives from insurance adjusters, whose role in the insurance industry is crucial and as such, their input is invaluable and will help advance one's understanding of the connection between flood risk reduction and mitigation measures.

METHODS

Data were obtained from insurance adjusters from across Canada that currently work for TD Insurance company (n=15) in the form of semi-structured interviews. The participants for the interviews were recruited by Huma Pabani from TD Insurance. She provided names and contact information for 15 individuals who expressed interest in the study. We then contacted the adjusters via email to set up a time to meet with them virtually via Zoom, Google Meet, or phone. We encountered only a couple of challenges in contacting our participants - one was an incorrect email address that meant we could not get in touch with the adjuster, and the other was that one participant who had stopped working for TD Insurance. Huma Pabani helped us to solve these issues by obtaining the correct email address for one participant and getting us in contact with a different participant to replace the one who had switched jobs. The sample of 15 insurance adjusters may be somewhat representative of insurance adjusters who work for TD Insurance, but are not representative of adjusters from

other insurance companies, which may have different policies or perspectives on flood risk mitigation.

We conducted semi-structured interviews with each of the 15 participants by phone or videoconference. We have 5 group members and each of us conducted 3 interviews. We created a semi-structured interview guide consisting of 6 questions (see Appendix I). Interviews lasted between 20 minutes and 40 minutes in length and were all recorded using Zoom recording software or other voice recording software. The semi-structured nature of the interviews allowed us to have a natural, coherent conversation with participants, and meant that questions did not need to be asked in the same order each time. It also meant that we had prompting questions available to encourage participants to add additional information as needed.

Upon completion of the interviews, we used a transcription software through Microsoft Word on Office 365 Online to create written transcripts of each interview. The transcription software created rough approximations of the interview, but required approximately 30-45 minutes of editing to ensure coherence and accuracy. Using the transcripts, we then conducted thematic analyses for each of the 6 questions from our semi-structured interview guides.

RESULTS

Effective Flood Mitigation Measures

The first question that we asked interviewees was about what flood mitigation measures they felt were most effective for homeowners to pursue. The measures that the adjusters suggested, and how many adjusters mentioned each of these measures, are summarized in Figure 7. Of the 15 interviewees, 14 of them mentioned the importance and effectiveness of sump pumps. All but two of the interviewees that discussed sump pumps (n=13) also mentioned that backup batteries for the sump pump were essential to keep the pump running in case of power outages, which often happen during floods. Eleven interviewees identified having a backwater or backflow valve installed in the home as one of the most effective residential mitigation measures. Lot grading came up in seven of the 15 interviews we conducted. Specifically, interviewees mentioned that it is important to ensure that the ground is sloping away from the foundation of the home to promote the flow of water away from the dwelling. One interviewee brought up that many new builds use the swale system where,

> ***"lots are graded to run towards the front of the property, and away from the neighbor, so it's got a slight swale and that swale creates a circle where the water goes up and then comes back towards the municipal storm line" (Interviewee).***

Some other common answers related to the foundation of the home, including doing annual inspections to ensure there are no cracks or damage in the foundation and coating the foundation if possible (n=6), ensuring the homeowner keeps up maintenance on weeping tile systems (n=6), and keeping downspouts extended out from the home and pointed away from

the foundation (n=6). Two interviewees brought up the importance of homeowners considering where they purchase or build their home, explaining that they need to be conscious about whether their home is in a floodplain. One adjuster discussed the usefulness of storing items in plastic bins rather than in cardboard moving boxes or storing items directly on the floor. They mentioned that cardboard boxes will disintegrate quickly, leaving items vulnerable to water damage. Instead, they suggest that plastic bins are an inexpensive way to better protect your belongings and will often float in the event of a flood. Two adjusters talked about the importance of acting immediately during a flood event. One described that homeowners should start moving their belongings out of the affected area immediately to prevent further damages. The other mentioned that laying sandbags down could be useful in containing the water.

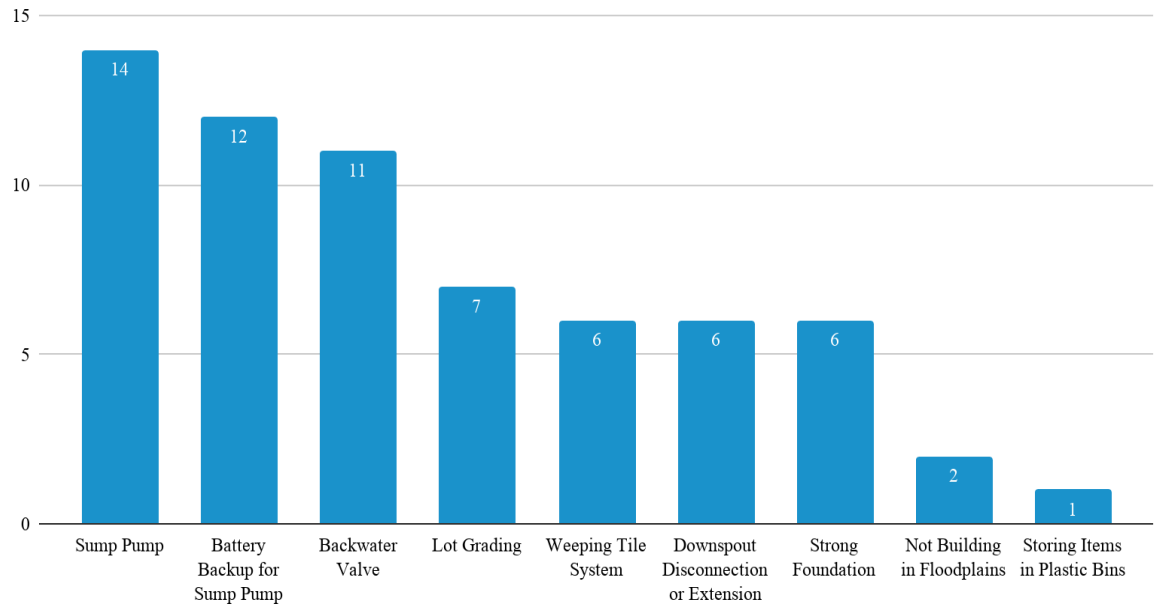

Figure 7. Flood mitigation measures identified by interviewees. The data represents the number of interviewees out of the 15 total interviewees that mentioned the measure as being effective.

Barriers to Implementation

The second question that we asked interviewees was about what they thought were some of the biggest barriers or common hesitations that clients faced with regards to investing in flood prevention measures. The 15 interviewees gave four main answers: (1) clients do not understand their insurance policies or coverage, (2) clients do not know what measures to take or how to take them, (3) clients are deterred by the cost to implement these measures, and (4) clients do not think they are at risk.

Twelve of the 15 respondents felt that residents lacked an understanding of their insurance policies and coverage. When signing insurance policies, adjusters noted that people usually do not read them carefully, and thus, do not understand their coverage. Sometimes this is a result of seeking the cheapest possible insurance rates and seeing insurance as a monthly bill rather than a protective measure. Respondents mentioned that people may feel that they do not need other measures because they have flood insurance. However, when a flood happens, the insured often discovers that their policy does not cover the damage and that there were other things that could have been done to help mitigate the damages. Another issue that was mentioned was that often homeowners underestimated the value of the items in their home and their coverage ends up not being enough to cover the total costs of the damage.

Another significant barrier mentioned by 12 of the 15 interviewees was that there is a lack of awareness about flood control measures. Preparation for flooding is usually not a conscious thought for people buying or renovating homes. Purchasing a home is a large

investment, so the prospect of spending more money on flood mitigation measures is not appealing. Furthermore, the majority of homebuyers are not experts in flooding or insurance. They may not recognize how much damage flooding can cause, what prevention measures should be installed, how to go about installing those measures, or how to remedy flooding after it occurs. Respondents indicated that there is a lot of information available about flood mitigation measures, and that it can be easily found online through sites like TD Insurance. However, one would have to actively seek the information out, as flood mitigation is not something on top of mind for most homeowners.

Among the 15 people interviewed, 11 stated that cost is likely the biggest barrier to adopting flood prevention measures. The installation of backup batteries on sewage pumps or flood prevention measures can be expensive. For houses whose basements have been finished, the costs increases. For example, the installation of a sump pump may require the removal of flooring and concrete. One of the interviewees believed that people thought these costs were expensive but that they may not be aware that the costs of experiencing water damage are much higher.

> ***"I just don't think it's something people think to do. Until you've really had a claim, I don't think it's a conscious thought to claim-proof your house" (Interviewee).***

The last finding relates to people's perception of risk. Ten of the 15 people interviewed mentioned psychological aspects associated with installing flood risk mitigation measures, where people believed that floods would not happen to them. Due to this mindset people are hesitant to implement additional measures to prevent flood damage to their home.

Respondents were asked whether people who have suffered floods are more likely to invest in flood prevention measures. Eight of the 15 interviewees said yes, believing that people who have suffered flooding will learn from and act upon their past experience. These people have better knowledge of prevention measures and will be more likely to buy insurance or install flood mitigation measures. However, one interviewee believed that people who have suffered flood events are not more likely to invest in future flood prevention measures than people who have not. The reasoning for this was that people living in flood-affected areas already have some flood prevention measures implemented.

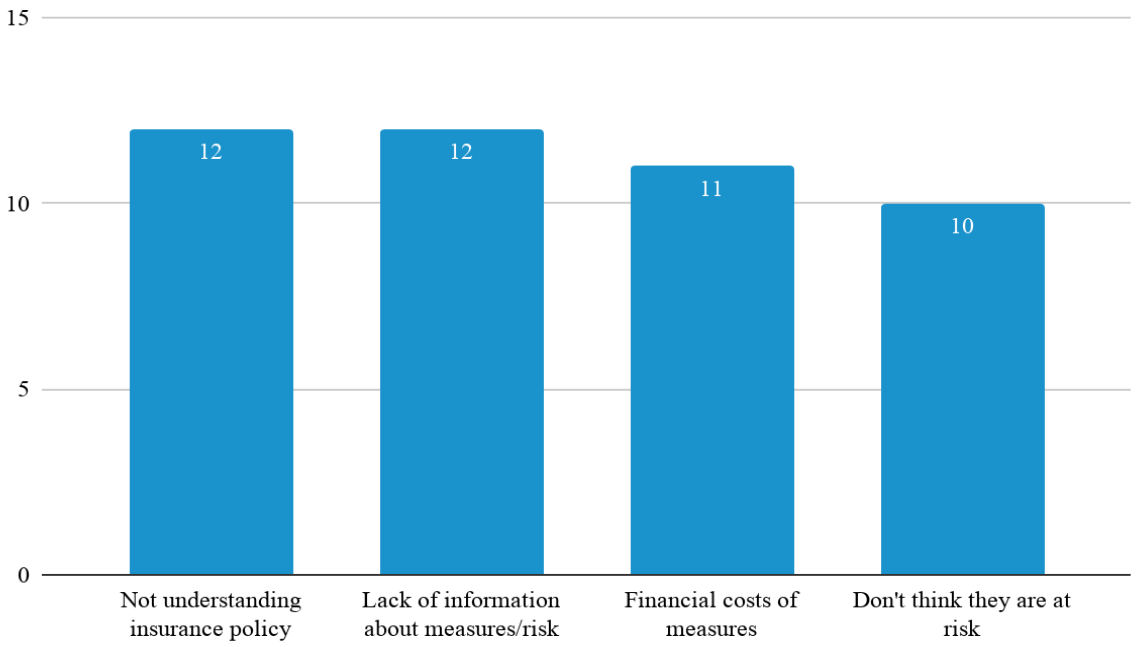

Figure 8. Barriers to implementation of flood mitigation measures. The data represents the number of interviewees out of the 15 total interviewees that mentioned each barrier.

Effects on Insurance Premiums

Another area of focus in our interviews was the impact that previously installed flood mitigation measures would have on insurance premiums, as we felt that this could be an incentive for people to implement mitigation measures. Specifically, we recorded responses to

the question “are flood insurance premiums lower for people who have installed or implemented measures to mitigate flood risk?” Of the 15 insurance adjusters that were interviewed, eight respondents indicated that insurance adjusters were not responsible for the formulation of the insurance premiums, because of this, they were unaware of the factors that went into developing that premium. Most consistently, this was because of the lack of training that they went through with respect to insurance premiums. One adjuster would go on to state that the policy department would be the ones responsible for the development of insurance premiums. Furthermore, two adjusters indicated that insurance premiums were more so the underwriter’s role.

Although there was consistency in the lack of knowledge the interviewees had on the subject matter, there were some recurring themes that emerged in their responses. Firstly, the age of the home would have some influence on the insurance premium. Three insurers brought up the age of the home in their responses. Specifically, it is common to see newer homes having more flood prevention measures in place; however, newer homes are also more likely to have finished basements. Because of this, if a backup event were to occur, damages in the newer home would be more extensive. On the other hand, the likelihood of a flood occurring in an older home is greater because there are likely less preventative measures in place. But because of factors such as underdeveloped basements, the damage will be less extensive. This could lead to higher premiums for buyers of new homes because newer homes have higher damage potential. The age of the home also plays a role in the quality of materials that were used in its construction, as well as the longevity of those materials. For instance,

one interviewee brought up how older homes are likely to have clay weeping tiles around the foundation and clay breaks down and cracks over time. This can cause greater risk of floods relative to the tile or plastic weeping tiles that are used in newer homes. The interviewee goes on to say that this has the potential to play a role in the construction of premiums.

Government Involvement & Subsidies

One theme we wanted to investigate was who is best suited to encourage people to invest in flood mitigation measures? This question was broken up into two parts: the government's role and the insurance company's role. Respondents were asked about the extent they thought that government subsidy programs are effective in encouraging people to invest in flood mitigation measures. Many respondents answered this question stating that they were not sure if governments' offered preventative programs and instead felt that governments were more focused on providing assistance after an event had occurred, specifically in relation to disaster events. Most respondents believed that governments would be an effective source to encourage investment in flood mitigation measures.

> ***"If people knew that these things were available and that the government was going to give them a little bit of a kick back for it, I think we'd see a massive uptake in it" (Interviewee).***

Although respondents agreed that government subsidy programs could be effective, they identified possible reasons they would not be. One possible reason that a subsidy would not be effective is the amount that the subsidy would cover. Respondents discussed the need for the subsidy to cover enough for people to adopt mitigation measures. Another respondent

stressed the importance of people's awareness of the subsidy programs stating, Similar concerns were echoed regarding the need to advertise these subsidy programs as well.

A few respondents identified what levels of government they thought would be the best to work on these subsidies. One respondent identified the provincial level of government as being appropriate because some municipalities may have mitigation offerings but other municipalities may have nothing. A second respondent suggested the provincial government as being able to make programs more mandatory. A third respondent suggested that municipalities were an appropriate level of government because they could do a better job promoting the program. There was an overall belief that some level of involvement from the government would be effective in encouraging the uptake of investment into mitigation measures.

The Insurance Companies' Role

Due to their intertwined nature, two of the questions we asked to interviewees were analyzed together during our analysis of the data collected from the adjusters. We wanted to find out what they thought could be done on the insurance company's behalf to encourage customers to invest in flood mitigation measures and to what extent the interviewees thought insurance companies should be the ones responsible for encouraging people to invest in flood mitigation measures, versus other stakeholders, such as government or non-profit organizations.

Out of the 15 adjusters interviewed, seven said that education was an item insurance companies could do to encourage customers to invest in flood mitigation measures. Two

interviewees stated that educating insurers is an important step, as that would enable them to better educate their customers to encourage them to invest in flood mitigation measures. In terms of educating the customer, emphasis was placed on making sure that the customer understands their policy, and how when flood damage occurs, what might seem like an adequate amount of money to fix the damage is in reality insufficient. In addition, one interviewee stated that ensuring the client knows what to do during a disaster, like checking their basement during a heavy downpour, is one way insurance companies can educate the customer regarding flood risk mitigation. One interviewee suggested that in the same manner that TD Insurance hosts small investment seminars on investments and stocks, they should host seminars on flood risk reduction, and perhaps have short videos on YouTube or other websites explaining what people ought to do and what policies cost. Corroborating with the previously mentioned statement, another interviewee suggested the use of the TD Insurance App, website, and other media to relay information to customers.

Furthermore, one interviewee stated that changing advertising strategies would be one thing that insurance companies could do, however, they are limited by legislation and as such, a change in legislation enabling the claims and policy departments to work together would be effective in providing the best policies to customers. Another interviewee stated that many customers are discouraged by costs, therefore insurance companies could reduce the cost of policies as a means of incentivizing the customer. A suggestion from an interviewee was an insurance company (TD Insurance specifically) can encourage people to sign a new policy, which unlike the old one, has flood risk coverage.

Additionally, an interviewee stated that insurance policies should require customers to have flood mitigation measures (such as a sump pump) installed on their property in order to purchase coverage. Three of the interviewees were of the view that governments and municipalities were better placed to encourage customers to invest in flood mitigation measures due to the intimidating perception people have of insurance companies. Three more interviewees said that TD's reimbursement program, where they refund the costs of replaced sump pumps, backflow valves and batteries, is an incentive the company does to encourage customers to invest in flood mitigation measures. Another interviewee stated that targeting flood mitigation information to areas of high risk is another mechanism insurance companies can use to encourage customers to invest in flood mitigation measures.

As for the extent to which the interviewees thought insurance companies should be the ones responsible for encouraging people to invest in flood mitigation measures, the overall consensus amongst all the respondents was that while it should be a shared task, the government ought to take the lead in encouraging people to invest in flood mitigation measures.

DISCUSSION

Effective Flood Mitigation Measures

To be able to answer our research questions around what barriers exist and how to encourage the implementation of flood prevention measures, we need to understand what those flood prevention measures actually are. Many of the measures that were mentioned were ones that came up in our preliminary research, including sump pumps, backwater valves,

and lot grading (ICLR 2011). We did receive a range of other answers as well, including installing backup batteries for sump pumps, storing belongings into Rubbermaid containers, disconnecting downspouts from the sewer system, using sandbags to prevent water flow, maintaining the home's foundation or weeping tile system, and avoiding building or living in floodplains altogether. The response to this question largely depended on the interpretation of what flooding events the adjuster was talking about - whether it was sewer backups, flash floods, or fluvial (river) flooding. The type of flood impacts the effectiveness of these measures. For example, lot grading and downspout extensions and disconnections are important during stormwater flooding or flash floods caused by heavy rainfall to help keep water away from the base of the home, but these same measures have little to no impact on a flood caused by sewer backup. This study was intended to focus on stormwater flooding, but this was not always what interviewees discussed which is one limitation of our research. Future research could focus specifically on differentiating between measures for different types of flood events. Nonetheless, many of the insights we gained are useful in understanding what mitigation strategies could be used and what adjusters consider to be the most effective strategies in helping to mitigate flooding in the home. In particular, we can start to look at how much of an investment (time, money, and effort) would be involved in implementing some of these measures, which leads into the next theme that was analyzed around barriers to implementation.

Barriers to Implementation

What are the barriers to adopting flood mitigation measures? The answer given by the interviewees matched our hypothesis that cost was a substantial barrier. The insurance

adjusters said that people think that installing flood protection is expensive. Usually, people are unwilling to spend a lot of money on flood protection. An additional factor was that adjusters also believe that residents do not understand the content and coverage of their insurance.

Most adjusters believe that people who have suffered floods are more likely to invest in flood prevention measures or insurance. For Alberta, the climate is dry, and people do not think that floods will occur, so do not feel the need for preventative measures. In addition, people who have suffered floods are more likely to invest in flood protection in the future. Ultimately it is up to individuals to ensure their own safety and the safety of their families.

Effects on Insurance Premiums

Unfortunately, this line of questioning was not appropriate for the insurance adjusters to answer. While the adjusters do work with insurance policies and handle most of the work post flooding, they are not involved in developing policy. Most of our interviewees had little to no insight when it came to direct ways that people could decrease their insurance premiums. Those who did have general knowledge on the subject suggested methods that may not be entirely in the homeowners' control, with these suggestions primarily surrounding the age of the home. Because of this, this question did not help answer our research question very well - either there was not a concrete answer or something was mentioned revolving around the age of the home, which is not always something that the client can control.

Instead of asking the insurance adjusters, this may be something we would want to ask the underwriters, as it would be more in line with their responsibilities. Our interviewees

informed us that the underwriters were the ones that formulate the insurance premiums and that they would be more helpful when trying to address if insurance premiums were lower for clients who already had flood mitigation measures in place. Another element for future research could be added where underwriters would be interviewed which could provide insights into our research question.

An alternative would be to restructure the question so that it is better suited to be answered by the insurance adjusters. A good line of questioning suited to the adjuster's strength could follow: How often are the insurance policies clients have chosen not able to cover the damage caused by flooding? Something along these lines would allow for the adjusters to have a more concrete response that is backed by their experiences, which would serve the research question much better.

Government Involvement & Subsidies

From the interviews that we conducted, the insurance adjusters believed that there is a role for governments to encourage investment into flood mitigation measures. This encouragement could take the form of subsidy programs and education campaigns. The education campaigns could be twofold; first in educating homeowners about flood mitigation and flood risk in general and secondly focusing on education about the subsidy programs that exist. Critically, information needs to be made easy and accessible for people to understand and find.

While identifying a specific dollar amount that subsidy programs should be at was out of the scope for this project, that is an area for further research. One respondent had suggested

that $1500 was a better point of encouraging change than the previous amount of $800. There was no consensus on whether municipal or provincial was the best level of government to be involved but there is room for both levels to help influence the behaviour of individuals.

The Role & Responsibility of the Insurance Company

Most of the adjusters suggested that undertaking educational programs is one of the crucial things that can be done on the insurance company's behalf to encourage customers to invest in flood mitigation measures. Customers tend to underestimate how costly the damage from floods can be, hence the need for education. As for the extent of their responsibility, we learnt that they believe it should be a shared task, with the government taking the lead because they are responsible for how cities are run.

One adjuster mentioned that customers too, have their own responsibilities, some of which include asking the right questions and reading their policies thoroughly. Future research questions could seek the perspectives of the adjusters on the role of the customers in flood risk mitigation.

Recommendations

1. Advertising campaigns about flood risk reduction measures and available subsidies sent directly to insureds during policy renewal.

A recurring theme throughout was that there are many measures that can be taken to reduce flood risk, but that not everyone knows about them, thinks to do them, or can afford to implement these measures. We propose that advertising campaigns be run to inform homeowners about what measures can be taken and the resources available to take these steps.

Advertisements could be run that prompt homeowners to think about what measures

they have in place already, how much it might cost to add measures, why they should be concerned about implementing measures, or mentioning any available subsidy programs. Ads could also link back to a webpage or document that outlines this information in further detail (since ads are usually brief and designed to prompt people to act or learn more).

While this is an upfront investment for the insurance company, it could end up saving costs for both the insurance company and the homeowner going forward if people take action to actually implement some of these measures which could reduce damages. There is also the possibility that governments (at any level) could provide funding to run these campaigns, but have the actual marketing done through private companies (such as insurance companies or utility companies) who have closer, more personal relationships with homeowners than the government does.

2. Collaboration between ICLR and insurance companies to develop information packages for clients about flood risk reduction.

Lack of information about flood risk, mitigation measures, and what to do in the event of a flood were common trends in our research project. Information on these subjects that is from credible sources and that is easy to understand (using plain language, diagrams, etc.) needs to be relayed to homeowners to help them make better informed decisions and prepare for hazard events. We propose that ICLR work with insurance companies such as TD Insurance to develop information packages that can be given to insureds to increase awareness about how to prepare their home.

The Institute for Catastrophic Loss Reduction is a wealth of reliable information on

natural hazards and emergency response, so they would be an excellent partner in working with insurance companies to put together well-written, informative handouts for homeowners. Furthermore, a number of interviewees said that they are familiar with ICLR, specifically their publications and research, which indicates that the organization already has a reputation amongst insurers as being a reliable source.

These information packages would need to be developed in partnership with and endorsed by insurance companies, rather than created as external documents, as some insurance adjusters noted that there may be issues with providing third-party information to clients. These information packages could be given out to homeowners upon signing a new policy, renewing an existing policy, or upon a claim being made.

3. Government subsidies that work in partnership with developers, contractors, and utility companies to help offer flood risk reduction services at a reduced cost.

Through our research, we looked at the effectiveness of subsidy programs. We propose that subsidies are provided to developers, contractors, and/or utility companies rather than individual homeowners to try to encourage uptake of these measures on a larger scale.

One issue is that many homeowners are not aware of subsidy programs so uptake of these programs is very low. This is one major reason that we believe subsidies for developers, contractors, and utility companies may be more effective, because then they can offer services to their customers at more competitive rates. For example, if there were a subsidy for a home builder to offer sump pumps with battery backups, they could offer customers this option for less, which may be comparable to the cost of just getting a sump pump with no backup,

depending on the amount of the subsidy.

Another issue is that subsidies may not cover a sufficient amount of the total project cost, where the homeowner feels that it is not worth it to invest in the measure. This method of offering subsidies to the developer has been tried by the City of Edmonton in their energy efficiency projects and has been successful because then energy companies are able to offer more efficient and desirable options for a lower cost. Offering subsidies to private institutions to encourage implementation may reduce the financial barriers of flood risk prevention actions.

CONCLUSION

Whether an individual chooses to adopt flood mitigation measures for their home is influenced by many factors. What our findings indicate is that cost, education, and risk perception are the three most important areas of influence. Costs of adopting mitigation measures are more than just the actual mitigation measure itself (for example, a sump pump). There are situations where homeowners have finished basements that require floors and concrete to be removed in order to install a sump pump. Costs also include time and effort required in undertaking mitigation measures. Combining this factor with risk perception, that people do not perceive that flooding incidents will happen to them, provides clarity as to why people would not adopt mitigation measures. Finally, education about existing programs may be minimal as well as education about risks of flood events.

Future research could be focused on interviewing individual homeowners to find out what their perception of these barriers are. There is also room for work to be done on the

optimal price of what a subsidy level should be. In terms of education, analysis could be done to look at what sort of advertising or messaging reaches the most people and prompts them to take action. Ultimately, the goal is to reduce the impacts of flood events. Encouraging people to invest in flood mitigation measures for their homes can be one way to address that.

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Appendix I: Semi-Structured Interview Guide

Interview Introduction

Thank you so much for meeting with me today. As you know, we are doing a research project on flood risk reduction. I'm really looking forward to hearing about your experiences and ideas on the topic, because you have a unique perspective as an insurance adjuster. The interview will take approximately 30 minutes to complete, and will be recorded so that we can transcribe the interview and have a more complete and accurate record of the discussion. Please answer the questions with as much detail as you're able and feel free to add in anything else you think is important. Do you have any questions for me before we get started?

Interview Questions

1. What do you think are some of the most effective things a homeowner can do to decrease their susceptibility to floods?
    - Prompt: One article we read said that 3 of the most effective flood risk reduction strategies are (1) installation and maintenance of a backwater valve, (2) ensuring that downspouts are far enough away from the house foundation, and (3) making sure their sump pump is operational and has a backup battery. Would you agree with this? If not, what measures are more important?
    - Prompt: Why do you think that these measures are effective?
    - Prompt: Do homeowners who are making claims have flood prevention strategies in place already? If so, which measures?
    - Prompt: How often do people have flood alert systems installed in their homes?
2. What do you think are some of the biggest barriers or common hesitations that clients face with regards to investing in flood prevention measures?
    - Prompt: To what extent do you think cost/time/labour is a limiting factor?
    - Prompt: To what extent is the homeowner's knowledge of what measures can be implemented and how to implement them a barrier? Do homeowners know what they can do or who they can turn to for information or help?
    - Prompt: Are people who are making insurance claims more likely to invest in flood mitigation measures for the future than those who haven't faced a flood incident before? How hard is it to get people to take preventative measures?
3. Are flood insurance premiums lower for people who have installed or implemented measures to mitigate flood risk?
    - Prompt: Do you think that a strategy like this encourages people to invest in

flood prevention measures in addition to flood insurance?

- Prompt: What kind of information is collected from a customer about their current flood prevention measures when they purchase flood insurance? Are suggestions for improvement offered at this point?
- Prompt: Is the age of the home a factor in flood risk insurance? (because newer homes are more likely to have flood prevention measures built in)

4. What do you think can be done on the insurance company's behalf to encourage customers to invest in flood mitigation measures?
    - Prompt: Do insurance companies have resources, referrals, and information that they can pass on to the customer about what can be done to decrease their vulnerability to floods?
    - Prompt: Do you think that promotion campaigns targeted to flood insurance customers would be effective?
    - Prompt: Why do insurance companies want people to invest in flood risk mitigation measures? Don't insurance companies make more money if people don't invest in these measures?
    - Prompt: Should insurance policies be changed to require that flood mitigation measures are taken before insurance is given or renewed?
    - Prompt: Have there been any recent changes to encourage people to invest in mitigation measures?
5. To what extent do you think municipal or provincial subsidy programs can be effective in encouraging people to invest in flood mitigation measures?
    - Prompt: There was a study done by the Institute of Catastrophic Loss about flood risk mitigation subsidy programs offered by municipalities, and the uptake of subsidy programs was very low. Why do you think this is? Why do you think that uptake in Alberta is higher than in other provinces?
    - Prompt: Do you think that people know about these subsidy programs or is more promotion required to get people to use them?
6. To what extent do you think insurance companies should be the ones responsible for encouraging people to invest in flood mitigation measures?
    - Prompt: What specific actions, policies, regulations, or other measures do you think are or could be effective in dealing with flood risk and mitigation?
    - Prompt: Are there building code changes that should be in place? Are there issues with the construction quality of new developments?

- Prompt: Should there be more government involvement? What types of policies or programs do you think would be effective? At what levels of government would these policies need to be implemented? (e.g., municipal, provincial, federal).
- Prompt: What involvement do you think that non-profit organizations and special interest groups like the Institute for Catastrophic Loss Reduction could have in encouraging homeowners to invest in flood mitigation measures? Could they play a greater (or different) role than they do now? Would this be an effective way to address the issue?

Conclusion

Okay, that brings us to the end of the questions we have prepared. Do you have any comments, experiences, or anything else that you would like to add? [*allow interviewee about 10 seconds to think and add any other thoughts or comments they may have*]. Do you have any other questions or concerns for me about the study? [*answer questions if there are any*]. Thank you again for your participation and sharing your experiences with me.

Chapter 4: Storm flooding: Investigating relationships between risk perception and mitigative behaviour of households in the City of Edmonton

Katherine Prior, Rayleigh Conley, Lingjun Zhong, Tony Shao, and Heather Stinson

INTRODUCTION FOR THE TWO SURVEY GROUPS (Chapter 4 and 5)

Storm flooding has the potential to be devastating for both individuals and communities; therefore, it is highly concerning that flooding risk is expected to increase in severity due to climate change. Globally, flooding is one of the most common natural hazards and is especially problematic for the City of Edmonton, which has been ranked as one of the most flood prone cities in Canada (United Nations 2015; Cook 2021).

Stormwater events are also often unpredictable which makes preparing to mitigate flood damage essential to avoid preventable property damage. During high-intensity precipitation or runoff events water can overflow the underground sewage system's carrying capacity. This results in storm flooding which can cause significant property damage, such as sewer backup and basement flooding, especially if properties are located within flood susceptible areas. Changing weather conditions in Edmonton have also had devastating impacts on the municipal drainage system. This drainage system was created over several decades, and over time the standards for construction have changed. Due to this change in construction standards, older pipes are overwhelmed by extreme weather and the influx of new residents while the newer drainage systems have been better adapted to handle these modern conditions (Government of Alberta 1999). This variation in drainage systems has resulted in certain areas around the city being at a higher level of risk of flooding.

Furthermore, there are numerous examples of the consequences of previous flood events and the implications of the varied stormwater systems in Edmonton. In 2004, an extreme storm flood event occurred in Edmonton, resulting in a sewage backup that caused

serious damage throughout the city with the cost of repairs reaching $303 million (Mahoney 2004). Only eight years later, in 2012, another highly destructive flood rampaged the city. During this 2012 flood event sections of a primary thoroughfare, Whitemud Drive, were completely submerged underwater and 20 people had to be saved from their trapped vehicles (Maimann 2012). These two major flood events promoted the establishment of an extensive and creative flood mitigation plan aimed at preventing future damage to the city; furthermore, this plan has even been touted as the best flood mitigation plan in Canada (Cook 2021). As a part of this plan, EPCOR took responsibility for Edmonton's drainage system in 2017 and by 2020 the city was singled out as leader for flood mitigation planning in a study conducted by the Intact Centre on Climate Adaptation at the University of Waterloo (Cook 2021). The success of Edmonton's mitigation plan has been due in part to offering free home flood assessments which are intended to help residents understand their flood risk (Cook 2021).

Climate change further compounds flood issues as it is likely to drastically affect the frequency and severity of flooding in Edmonton; therefore, it is beneficial for the municipality to continue to adapt and improve the flood mitigation plan to mitigate the potential of future flood risk. Insurers indicate that a rise in claims resulting from the climate crisis will likely affect homeowners through increased premiums and limited coverage. Inability to acquire insurance could leave homeowners with damages from $10,000 up to $80,000 in some cases (Sandink 2007).

The previous chapters utilized media analysis and semi-structured interviews as their methodology. After reaching out to insurers and municipal planners the next group that we

believed should be contacted was homeowners. The next two chapters focus on survey results to understand insights from Edmonton homeowners.

METHODOLOGY SECTION FOR THE TWO SURVEY GROUPS (Chapter 4 and 5)

To examine current Edmonton homeowners' knowledge and experience with stormwater flooding a relatively short questionnaire was develop by two research teams. The questions relied to some extent on the telephone survey conducted by Sandink (2007) where samples of homeowners in Edmonton and Toronto were surveyed. Given that the Sandink survey took place over 13 years previously, utilizing those previous questions allowed some temporal comparisons of Edmonton homeowner responses. The questionnaire was created with the goal of finding: a) communication strategies for nudging risk reduction, and b) the flood risk perception of homeowners based on proximity, exposure, and experiences with flooding.

The final survey instrument, provided in Appendix 1, began with four screening questions, described below, to eliminate respondents not relevant to the analysis. Once a respondent qualified for the study, seven questions followed which asked respondents to indicate their previous experience with stormwater flood events, including property damage and its severity, and how likely they consider themselves to be at risk of a flood event in the future. Next, seven questions asked respondents to provide information regarding potential measures to mitigate damages from stormwater flooding to their home. This included how likely they would be to undertake mitigation measures (provided in a list), if they had actually

adopted any of these mitigation measures in the past, and what barriers they face preventing them from adopting measures. Statement-based and morally framed questions then followed by outlining scenarios and asking respondents how likely the information in the statement would be to influence them to adopt mitigation measures. The survey then asked them to provide basic demographic information such as income, age, education level, political orientation, and gender.

The questionnaire was administered over the internet using a sample of homeowners from the online survey company, Dynata, an American research marketing company with a varied and diverse dataset of 62 million respondents and 40 years experience with business-to-business insights (Dynata 2021). The company maintains an internet panel of potential respondents and panelists can be screened to ensure they conform to pre-selected characteristics. Once the questionnaire was developed, it was programmed by Dynata staff for initial internet administration on March 8th, 2021. The two research groups then made revisions, visually examined the questionnaire online using a test link, and reorganized certain sections of questions. Following this, a pre-test was launched to Edmonton homeowners and data was gathered and examined from 43 respondents. Following the pretest, further adjustments were made to the survey instrument and the official survey was launched on March 13th, 2021.

The target sample was 400 homeowners in Edmonton over the age of 18 years. Dynata examined responses to ensure that a minimum of 20% of respondents resided in the areas of Edmonton considered to be at higher risk of stormwater flooding. These areas are depicted in a map shown in Figure 9 in light grey, and essentially represent that part of Edmonton where

homes are older than those in the dark grey region of the map, and the stormwater infrastructure is dated. Other respondent screening questions involved ensuring that respondents lived in Edmonton, that they owned their property, and that their residence was a semi-detached or detached house. In other words, renters and residences living in town houses or condominiums were excluded from the sample.

Data collection was completed on March 15th, 2021, and a final sample of 395 valid responses were received. The initial sample of respondents was manipulated to exclude information from those who completed the online questionnaire in less than 300 seconds. The questionnaire was constructed to be completed in a relatively short time, but completion times less than 5 minutes were considered to indicate that the respondent did not take time to comprehend and answer all of the survey questions. We also included additional indicators or "flags" suggesting spurious completion. The first was a component of a question involving response to a 1-7 rating scale where respondents were prompted to select the number "3" for a particular statement. If the respondent did not provide a rating of "3" as required, all of their responses were considered "suspicious". The second indicator flagged respondents who selected the same rating level on the 1-7 scale for all 10 statements in a particular question.

The Risk Perception team opted to use the time for completion and the first flag to filter out respondents who may not have taken the survey seriously or were robotic responses. This yielded a final sample size of 315 "valid" respondents. The demographic characteristics of this filtered sample of Edmonton homeowners are shown in Table 4.

The Moral Nudging team reviewed each case for the second indicator flagged and chose to remove any respondents that had “impossible case” responses, or if they had also answered the other scale questions’ statements with the same number. “Impossible case” responses are statement responses that contradicted each other (i.e. choosing responses that indicate that the respondent “strongly agrees” that multiple separate parties should be solely responsible for flood mitigation). The Moral Nudging team eliminated 86 surveys during the data cleaning and analyzed a sample size of 309 “valid” respondents.

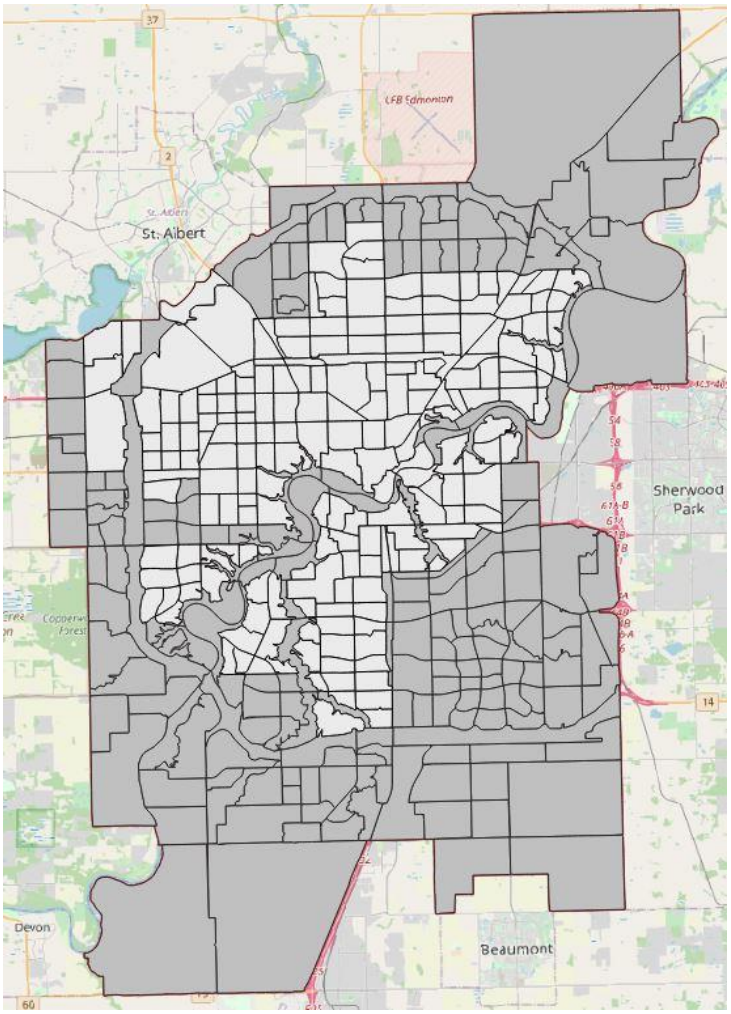

Figure 9. The map used in the online questionnaire to depict areas in the City of Edmonton where higher risks of stormwater flooding could occur; depicted in light grey.

Table 4. Some demographic characteristics of the Edmonton homeowner respondents in the internet panel survey.[1]

	Percent total valid responses	
Female	48.6	
Total valid responses		315
Age (years)		
18 - 24	0.3	
25 - 34	6.0	
35 - 44	11.7	
45 - 54	137	
55 - 64	27.6	
65 and older	40.6	
Total valid responses		315
Highest level of education		
Grade 1 - 9	0.3	
High school	20.6	
College/University	70.2	
Trade school	8.9	
Total valid responses		315
Annual income before taxes ($)		
Under 15,000	1.9	
15,000 - 24,999	0.8	
25,000 – 49,999	14.4	
50,000 – 74,999	27.3	
75,000 – 99,999	22.0	
100,000 – 149,999	21.6	
150,000 – 199,999	6.8	
200,000 – 249,999	3.0	
250,000 or more	2.3	
Total valid responses		264[2]

[1] Note that these characteristics are for the portion of the sample that was cleaned of those who completed the survey in less than 300 seconds, and who did not respond appropriately to the "flag" question described in the text. [2] Note that 51 respondents did not provide their income level.

INTRODUCTION

We noted above that municipal governments and providers of home insurance can play a role in mitigating damage from stormwater flooding. However, as noted by Sandink (2007) homeowners can play a critical role in damage mitigation through investments in lot grading and installation of equipment in the home (e.g. sump pumps and back up generators). Many of the mitigation options, however, vary in impact, effort, cost, and time. Homeowners assuming responsibility for mitigation lessens the burden on community infrastructure and could serve to increase the efficiency of flood mitigation efforts in a community (Sandink 2007). Thus, it is important to consider the role of homeowners in minimizing damage, and in encouraging them to invest in adopting flood mitigation measures.

This paper utilizes the results of the homeowner survey to explore homeowner risk perceptions and some of the factors that may influence these perceptions. It also seeks to examine knowledge of mitigation behaviours and factors that might influence and hopefully increase their adoption. According to results from a previous survey of homeowners in Edmonton, relatively low perceptions of the risks of stormwater damage and low uptake of flood mitigation behaviours by homeowners was due to a lack of knowledge and information regarding stormwater flooding and the potential for property damage (Sandink 2007). This first paper also serves to update these earlier findings.

The City of Edmonton is a leader in flood risk management (Cook 2021) with $53 million planned to be invested in stormwater flood mitigation measures (Joannou 2020). Sandink (2007) found that Edmonton homeowners were more aware of flood hazards, more

likely to acquire flood information from the city, and more likely to take steps towards mitigation than those in the city of Toronto. Nonetheless, residents in both Edmonton and Toronto assigned more mitigation responsibility to builders and municipalities rather than to themselves as homeowners (Sandink 2007). Sandink (2007) attributes increased flood adaptation in Edmonton to the city's education and flood mitigation subsidy programs.

LITERATURE REVIEW

Since this study seeks to identify factors affecting homeowners' willingness or abilities to implement flood mitigation a review of the literature on risk perception and socio-demographic characteristics that might influence these perceptions was undertaken. Flooding is a growing concern, as infrastructure damaged in storm events has the potential to disturb transportation, utility services, and human life (Suarez et al. 2005). Flood perceptions and flood mitigation techniques have been studied in urban areas worldwide in attempts to reduce the damage caused by unpreparedness (Carbone et al. 2014). Factors influencing adaptation efforts include risk perception, which is informed by socio-demographic factors, experience, knowledge, location, and efforts on the part of subject matter experts to inform homeowners. Experience is one of the most noted factors affecting positive change to risk perception and mitigation investments, perhaps due in part to the direct relationship between flood knowledge and readiness to invest in mitigation (Lechowska 2018).

Flood experience

Past experience with flooding can force homeowners to respond and is significantly associated with the ability to protect one's home from flooding (Heijmans 2001; Miceli et al.

2008; Pagneux et al. 2011; Sandink 2007). Prior damages from a flood (an indicator of experience) can encourage mitigation efforts (Lechowska 2018). While experience can impact flood perception and mitigation behaviour (Sandink 2007; Mann & Wolfe 2016; Lechowska 2018), Sandink (2007, 2011) reports a concerning lack of mitigative actions undertaken by those with flood experience. Experience helps homeowners build skills to appraise threats and adapt; however, this may have a small, expiring effect on perception and response. Other research found that fear of potential human fatality provoked insignificant responses to flood risks and flood preparedness (Arndt et al. 2004; Mann & Wolfe 2016). Therefore, reminders of severe or indirect experience may not be effective enough to push homeowners to adapt to increasing flood risks (Fritsche & Hafner 2012). Risk perception can even be weakened by insignificant flooding experiences (Lechowska 2018) and the sporadic nature of flooding (Raaijmakers et al. 2008; Biernacki et al. 2009; Colten & Sumpter 2009). Any positive effects on perception may be short-lived (Biernacki et al. 2009; Colten & Sumpter 2009).

Flood knowledge

One's knowledge of flood risk affects the perception and potential adoption of mitigative behaviours (Lechowska 2018; Raaijmakers et al. 2008; Botzen et al. 2009; Biernacki et al. 2009; Działek et al. 2013). Unfortunately, many hazard-vulnerable respondents do not acknowledge their flood risk (Sandink 2011). When disasters are infrequent, perceptions of threats become weaker (Wachinger et al. 2013; Lechowska 2018; Biernacki et al. 2009). Fortunately, Sandink (2007) finds homeowners are more likely to mitigate flooding if people know how to do so; even second-hand knowledge improved the likelihood of undertaking adaptation efforts (Wachinger et al. 2013). Despite efforts to engage

homeowners to address flood risks in many cities, Sandink (2011) reports a lack of awareness among homeowners regarding both the risk and preparedness, indicating a lack of effective education or other barriers.

Socio-demographic factors

The same flood experience generates differing risk perceptions in people with different lived experiences. Likewise, people have varying desires and abilities to mitigate flooding based on their socio-economic circumstances. McKenzie-Mohr (2000) stressed the need to identify similarities or differences between individuals who do and do not engage in a desired behaviour. Identifying personal barriers to a desired behaviour can help municipalities and insurers begin framing information to overcome said barriers. Proximity to hazards has a small effect on mitigative behaviour, primarily due to lower levels of mitigation outside flood zones; however, there are also contradicting studies on this (Lechowska 2018). Some studies (e.g. Sandink 2011; Siegrist & Gutscher 2006) find that residents' likelihood to attempt to adopt mitigation measures are not affected by their location (i.e. residence location in high-risk zones or not). Lechowska (2018) found improved risk perception among women, seniors, and those with higher education, but limited effects regarding income levels. Households with men, children, and higher incomes are more prepared, but preparedness has a negligible correlation to age (Lechowska 2018). Most social and demographic factors have been found to have some observed effect on levels of risk perceptions and mitigation efforts.

RESULTS

Perceptions of Future Risk of Events and Previous Experience with Stormwater Flooding

Regarding perceptions of future flood risks, 36 of the 315 respondents (10.4%) rated the chance of a stormwater flood in the next 10 years as very or somewhat likely (see Figure 10). In comparison with the 2007 data reported by Sandink (2007) it appears that the perception of flood risk by Edmontonian homeowners has decreased over time.

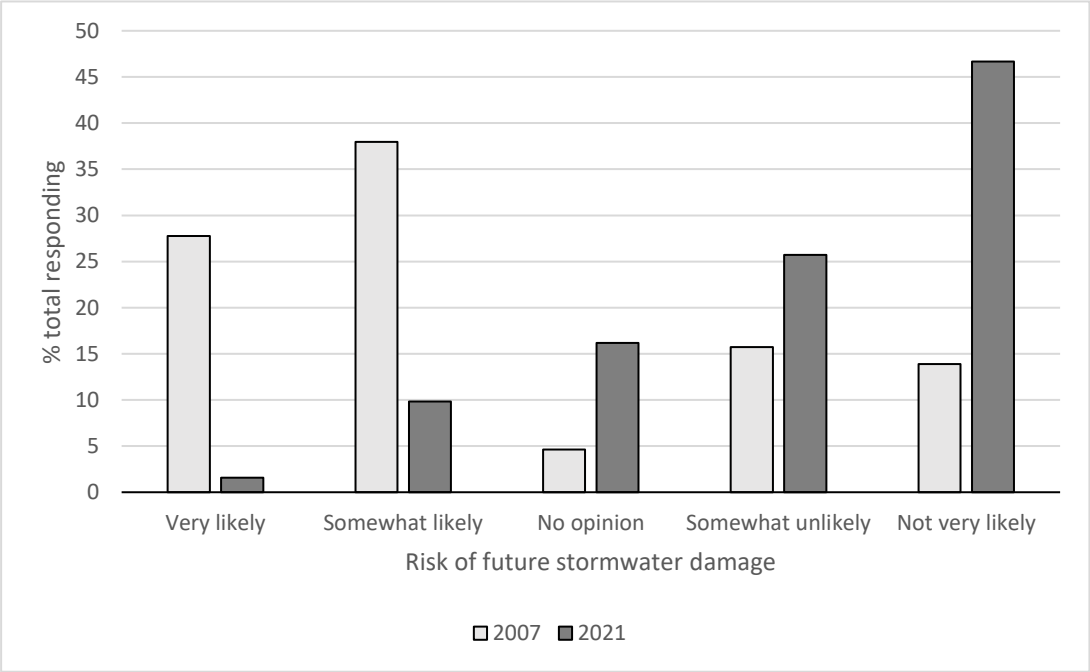

Figure 10. The distribution of risk perception of stormwater damage in the next 10 years by homeowners in the City of Edmonton.

The majority of respondents in the 2021 homeowner survey reported no experience with stormwater flooding in the past (250 (79%) of the 315 respondents). Of the 51 who reported when their experience occurred, 6 did prior to the year 2000, 14 in the period 2000-2012, and 28 in the subsequent more recent years. The severity of the damages was reported as minor by 34% of respondents. However, over 59% reported damages as moderate, meaning that there

was damage to their basements and contents. Only 3% of the respondents reporting damages classified these damages as severe, resulting in possible health risks and evacuation.

Since risk perception can be correlated with previous experience (Lechowska 2018; Wachinger 2013), these perception ratings were further examined by splitting the sample into those with past stormwater flood experience and those without and were compared with information reported in the earlier Edmonton survey (Sandink 2007). Table 5 shows that respondents in the 2021 survey with prior flood experience are more likely to think that they may face stormwater flood damages in the next 10 years than those without experience. The 2007 data displays a much higher percentage of such respondents than the 2021 information. In fact, comparison of the distributions of risk perceptions between the two studies suggests that overall homeowner perceptions of flood risk have lessened in the more recent period. However, this difference could be due to differences in sample size and mode of questionnaire administration (internet panel in 2021 and telephone in 2007).

Table 5. Edmonton homeowner perceptions regarding the risk of future stormwater flooding events in 2007 and 2021.

Reported perception of risk of stormwater flooding in the next 10 years	**Number of respondents (% total number of respondents)**			
	Past experience with stormwater flood events		**No past experience with stormwater flood events**	
	2021	2007[1]	2021	2007[1]
Very likely	5 (8)	27 (39)	0 (0)	3 (8)
Somewhat likely	14 (24)	27 (39)	16 (6)	14 (39)
Uncertain	10 (17)	3 (4)	38 (15)	2 (5)
Somewhat unlikely	12 (20)	8 (11)	68 (27)	10 (27)
Not very likely	18 (31)	5 (7)	128 (51)	10 (27)
Total number of respondents	N = 59	N = 70	N = 250	N = 37[2]

[1] 2007 information collected from Sandink (2007).

[2] The discrepancy in totals and percentages is noted but the data in this table uses the reported information in Sandink (2007).

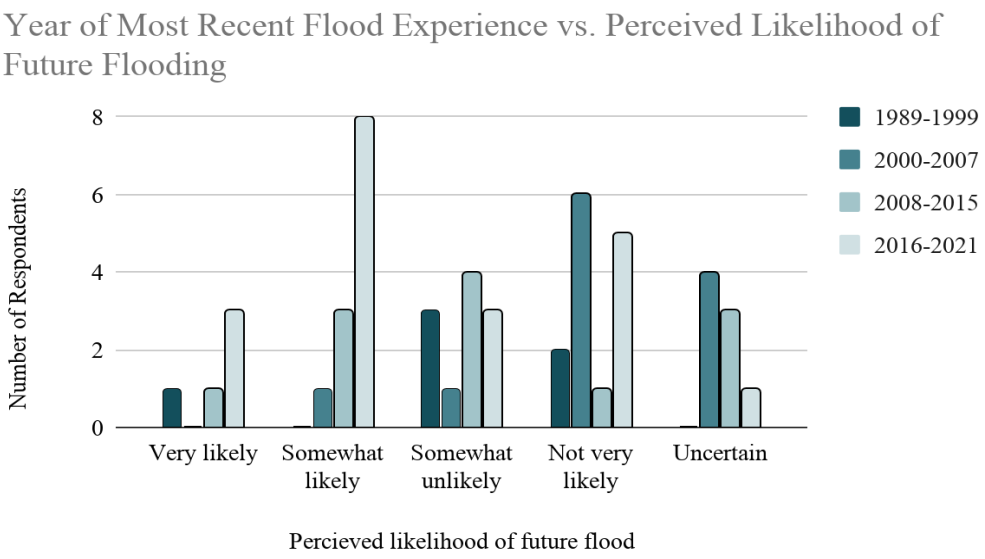

Figure 11. The perceived likelihood of future stormwater flooding by a sample of Edmontonian homeowners and the time period of their most recent flood experience.

Flood risk perception appears to be affected by how recent a homeowners' flood experience has been. In Figure 11, the year of the last flood experienced is categorized into four major time periods. The four periods for the data analysis are 1989-1999, 2000-2007, 2008-2015, and 2016-2021. In general, higher levels of risk perception are observed among respondents with more recent flood experience, as shown by the lighter shaded bars in Figure 11. Of the respondents who believed they were 'very likely' to experience a flood in the next 10 years, all have experienced storm flood events in Edmonton already. Only one participant had experienced their last flood experience in 1989, while the rest reported the most recent experience within the last six years. This information suggests that flood experiences within five years could be influential to a homeowner's perception of stormwater flood risk in the future.

Most of the flood experiences in the 2021 data occurred in the month of July, which is expected given historical rainfall patterns in Edmonton. A decline in the years since a flood experience may be due in part to relatively stable annual precipitation levels within the last 10 years (see Figure 12). In Sandink's (2007) study, 71% of flood experiences were reported within the previous five years (2002 to 2007, Table 5). Within that period, two peaks in annual precipitation occurred (2003-2004, and 2006); the strongest being from 2003 to 2004 (Figure 12). These results correspond to the 2021 data, as respondents receiving the most rainfall in the past 1 to 5 years (2016 to 2020) comprised 38% of the 2021 sample with previous flood experience. While interesting, this research cannot determine a correlation between precipitation and flood experience due to the scope of data collected.

Table 6. The number of years elapsed since the last flood experience of homeowners in the City of Edmonton in 2021 compared to 2007.

Number of years since last stormwater flood experience	**Percent of total respondents**	
	2021	**2007[1]**
Less than 1	2	19
1 – 5	37	52
5 – 10	16	11
10 or more	45	16
No answer provided	0	3
Total number of reporting respondents	N = 51	N = 200

[1] 2007 information collected from Sandink (2007).

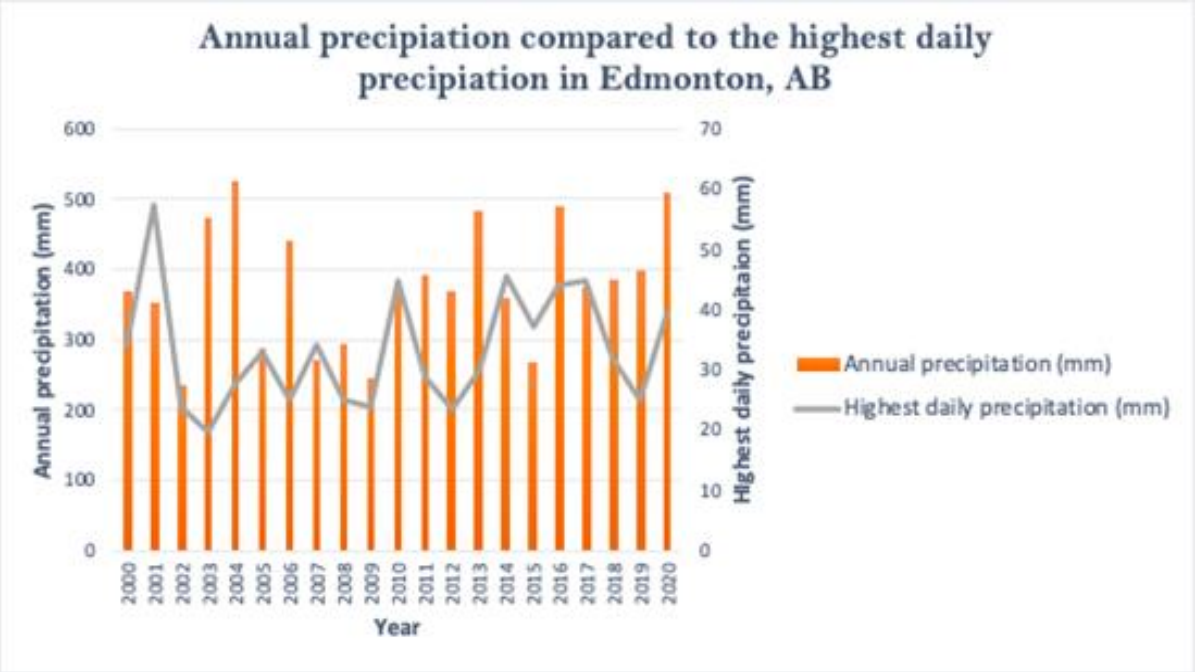

Figure 12. A summary of the annual precipitation (mm) levels in Edmonton compared to the highest daily precipitation (mm) per year. (Source: Canada, E. and C. C., 2021)

An interesting element in this present analysis of risk perceptions is the fact that the City of Edmonton has developed a map of stormwater flood risk zones in the city. This map was provided to respondents in the survey where they indicated their zone of residence using the map.[3] We view this map as an indicator of the objective risk of stormwater flood risk for each responding homeowner in the study. To examine this indicator Table 7 displays the number of respondents reporting past flood experiences in each of the two flood risk zones. About 18% of respondents in the zone of flood risk reported such experiences, while about 19% of respondents not in the flood zone did. This suggests that our measure of objective flood risk may be tenuous (or the City map is incorrect), but it should be noted that homeowners can experience basement flooding as a result of the infiltration of tree roots into their sewer

[3] This map is provided above in the introduction to the homeowner survey research (see Fig. 9 in that section).

systems. To what extent this form of sewer backup was considered in the responses in this survey is unknown, and represents an avenue for future research.

Table 7. The number of responding homeowners in the 2021 survey residing in and outside of flood prone zones and their reported level of experience with stormwater flooding in the City of Edmonton.

Location	Number of respondents with experience of stormwater flooding				Total number of respondents
	Once	Multiple	Never	Don't know	
In flood zone	24	3	117	3	147
Not in flood zone	26	6	133	3	168
Total	50	9	250	6	315

To examine relationships between perceived and objective levels of flood risk and to uncover possible impacts of sociodemographic variables and other homeowner characteristics we utilized regression methods. Our hypothesis was that perceived levels of flood risk damage is related to objective levels, and that past experience may also play a role in explaining perceived risk levels. We utilize OLS regressions methods and develop dummy variables for variables such as past flood experience, objective flood risk (residence in or outside the flood zone), and various sociodemographic variables.

Estimation results are shown in Table 8. Since the dependent variable, perceived flood risk increased as risks became *less* likely, the negative coefficient on objective risk suggests that the perceived flood damage risks for homeowners living in the flood prone area of Edmonton, *ceterus paribus*, were higher than for those not living in that area. This suggests, as expected, that perceived risks are related to objective risks, although the simple binary variable used to measure objective risk simplifies the relationship.

Other results in Table 8 suggest that being female and younger than 45 years of age is associated with higher perceived risks. The parameter on the variable First language not

English is negative and significant at the 10% level, suggesting that this also is associated with higher perceptions of flood damage risk. Unsurprisingly, past experience with flood damage also has a positive impact on risk perceptions. The college/university education variable parameter was statistically insignificant.

Table 8. Linear regression coefficients for various variables explaining Edmonton homeowners' (N=315) reported perceived risk of experiencing stormwater flood damages1 in the next 10 years.

Variables	**Coefficient**	**Standard error**
Constant	4.655	0.134
Objective flood risk	-0.314**	0.112
Female	-0.236**	0.113
First language not English	-0.262*	0.141
College or university education	-0.056	0.122
Age less than 45 yrs	-0.611**	0.150
Past flood experience	-0.695**	0.144
R^2	0.190	

* p < 0.1 ** p < 0.05

[1] Note that the perceived flood risk variable was coded as 1 signifying a response of "very likely" to 5 being "not very likely" thus the signs of the coefficients should be interpreted accordingly.

Homeowner Knowledge and Engagement in Damage Mitigation Measures

Regarding the potential for homeowners to undertake and/or invest in property improvements to mitigate stormwater flood damages the questionnaire included a number of questions that provide some insights. The first are two questions that asked respondents to indicate on a 7 point scale how informed they are about mitigation actions they could take to reduce damage, and how informed they are about sources of financial assistance available to do so. The percent frequency of the ratings for each question are shown in Figure 13. Very small percentages of the respondents are sufficiently informed about the actions they could take, and an even smaller percentage are aware of the existence of financial assistance to help them do so. This indicates the potential for municipal governments and/or insurance providers to educate homeowners about the actions and financial support.

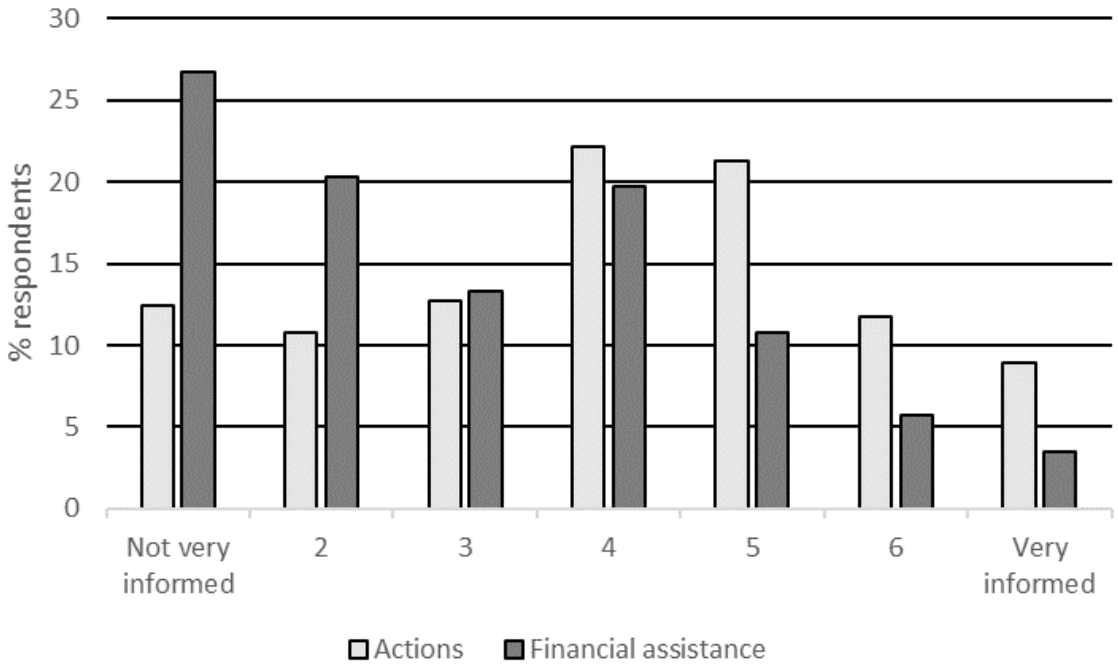

Figure 13. The distribution of how informed a sample of Edmonton homeowners (N=315) are about actions they could take to reduce the potential for stormwater flood damage and the availability of financial assistance to undertake those actions.

Information was also collected regarding specific damage mitigation actions that respondents had actually undertaken. A list of possible actions was provided in the questionnaire, and respondents were asked to indicate if they had undertaken each of the listed actions. The results are shown in Table 9. One of the most common actions adopted was adding insurance coverage for flood damages at about 37% of respondents. This percentage may be low and we wonder if the respondents may not be aware of the specific elements of their home insurance coverage. Other common actions adopted were the installation of sump pumps (although one wonders if these devices came with newer properties) and installation of systems to collect rain. Fewer percentages of homeowners installed backflow valves and water alarms.

Table 9. The percentage of Edmonton respondents indicating specific actions that have undertaken on their properties to reduce stormwater flood damages.

Action taken by respondent	**Percent total respondents selected (N=315)**
Installation of backflow prevention device or valve to prevent backflow of sewage	26.3
Water alarm installation/access (remote software or notification)	12.7
Removal of important belongings in the basement/lower level of home	19.0
Installed a sump pump	37.8
Disconnected eavestrough downspouts from the sewer system	18.1
Rain collection (e.g., rain barrels, rain gardens, low density paving)	30.2
Leaving basement unfinished	13.3
Moved away from stormwater flood prone areas	5.7
Added coverage to my home insurance to pay for sewer backup damages	36.8

We attempted to explain the levels of investments made by Edmonton homeowners in our sample in mitigating flood damages using simple linear regression procedures. We hypothesize that investments made are influenced by perceived risks, past flood experience,

and sociodemographic variables such as income. We created three dummy variables that we used as dependent variables in the regressions. These were: i) Investments in relatively inexpensive measures (disconnected eavestrough downspouts and/or removal of important belongings in the basement); ii) Investments in more expensive measures (installation of backflow prevention device and/or rater alarm installation and/or installation of a sump pump); and iii) Added coverage to my home insurance to pay for sewer backup damages. These dummies were regressed against perceived flood risk, past flood experience, income[4], and the other sociodemographic variables in Table 8. The resulting parameter estimates are displayed in Table 10.

Table 10. Linear regression coefficients for various variables explaining Edmonton homeowners' adoption or investment in flood damage mitigation measures for their homes.

Variable	**Invested in inexpensive measures**		**Invested in expensive measures**		**Added flood damage insurance**	
	Coefficient	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
Constant	0.518**	0.167	0.178	0.172	0.307*	0.174
Perceived risk	-0.037	0.029	0.011	0.030	-0.014	0.030
Past flood experience	0.203**	0.078	0.222**	0.80	-0.126	0.081
Income	-0.017	0.200	0.058**	0.200	0.029	0.020
Female	0.029	0.60	0.040	0.061	0.031	0.062
First language not English	-0.053	0.071	0.057	0.073	0.026	0.074
College or university education	0.005	0.065	0.006	0.067	-0.007	0.068
Age less than 45 yrs	0.035	0.077	-0.035	0.080	-0.008	0.081
N	264		264		264	
R^2	0.052		0.073		0.016	

* p < 0.1 ** p < 0.05

[4] Note that there 51 of the 315 respondents refused to report their income level – hence the smaller sample size in Table 10 of 264 respondents.

For investments in inexpensive measures, the only statistically significant variable was past flood experience. Given that the actions are "inexpensive" it would make sense that prior experience would influence this behaviour, and probably also explains the lack of statistical significance for income. However, income becomes important in explaining the adoption of expensive mitigation measures (second regression results in Table 10). Given that the actions examined required some investment on the part of the homeowner in terms of hiring contractors etc. income level may be a barrier explaining the relatively low levels of adoption of these measures. It is also noteworthy that having past flood experience also had a positive effect on the adoption of expensive mitigation measures.

None of the explanatory variables used to explain the purchase of additional insurance had a statistically significant effect, although income was significant at the 16% level and past flood experience was at the 12% level. It could be that the sample sizes were too small to detect significant effects.

The final set of analyses examined in this study involved having respondents rank items in a list of factors that prevent homeowners from adopting or investing in measures to mitigate flood damages. Each respondent was asked to provide a rank for three items in the list provided. The results are displayed in Table 11.

Cost was ranked as the top barrier for almost two-thirds of the 315 respondents. The next highest ranked barrier was the effectiveness of the measure. Both of these factors dominated all others provided in the list (see Table 11). Cost was further explored in a question that asked respondents if they would be "willing to protect their home from flooding if the

municipality helped pay the cost of doing so. Only 21.6% of the 315 respondents suggested that municipal financial assistance would not affect their decision. Almost half of the respondents suggested they would be more willing if at least half of the cost of the investments were paid by the municipality, and about 30% would if the full cost of the investment was paid.

Table 11. Edmonton homeowners' reported ranking of barriers that prevent them from undertaking actions to reduce stormwater flooding.

Barrier	Percent total respondents (N=315)		
	Ranked first	Ranked second	Ranked third
Cost	64.4	19.0	6.7
Effectiveness	20.6	22.5	15.2
Time requirements	3.8	13.3	15.2
Maintenance	3.5	20.3	28.6
Construction issues (noise/debris/waste/odours)	3.2	11.4	14.0
Scheduling contractors	2.9	10.8	14.9
Privacy	1.0	2.5	3.5
Cultural/Religious reasons	0.6	1.9	2.5

DISCUSSION

Perceptions of Future Risk of Events and Previous Experience with Stormwater Flooding

Our research set out to explore homeowners risk perception of flooding. One way to understand homeowners' risk perception was to examine previous experience with stormwater flooding. The findings indicate that the perception of flood risk by Edmonton homeowners seems to have decreased since 2007. Since most of the homeowners in the 2021 survey had no experience with stormwater flooding in the past, this makes sense that risk

perception of flood events has declined. The other factor influencing flood risk perception was how recent the experience was, with more recent stormwater flooding impacting the perceived likelihood of future flooding. Our findings align with the literature especially Lechowska (2018) who identified the association between flood risk perception and experience. We also found that objective risk of flooding events and perceived risk were related as well.

Age, being female and first language not being English explained respondents' risk perception; however, education levels had no effect on risk. This study yields results similar to Waite et al.'s (2017) comparative study between social factors and flood risk perception (with the exception of age). Considering most of the valid participants in this present study are 40 years old or older, the filter for housing ownership might have led to the results. While this component of the data set is too small to draw definitive answers, further research may find that younger people have a higher propensity to perceive flood risk. However, the data does not include a suitable number of young homeowners and any observations require further study. It may also be of interest to measure changes in risk perception among young homeowners as they age.

Flood mitigation

Another aspect of this study was to investigate how aware homeowners were of mitigation options they could take to protect their homes from stormwater flood damage. Homeowners were, in general, not very aware of mitigations actions. Homeowners were also unaware of financial programs to help with mitigative actions. Over 25 percent of respondents identified

with the lowest category (1= not very informed) on how informed they were about financial assistance measures. The scores at the opposite end of the scale (very informed) were all very low. While most homeowners were generally uniformed about mitigation efforts they could undertake, some homeowners had taken actions. The most popular mitigative actions taken were installing a sump pump, adding home insurance, and rain collection.

A lack of experience with stormwater flooding has impacted respondents' risk perception of flooding. It is quite likely that this low-risk perception of flooding may explain how aware homeowners are of mitigation options. If people's perception is that there is a low risk to them, it is unlikely they will seek out information on how to mitigate damages as they do not feel they will be impacted. Past flood experience also explained people's investment in more expensive methods of flood mitigation such as sump pumps and backflow devices. Cost is also the biggest barrier to flood mitigation and was mentioned as the top reason for respondents to not actively mitigate flood risk. The other top two barriers were effectiveness of measures and time requirements.

Comparison to 2007

As expected, there is a significant difference in risk perception between those with and without flood experience, which was supported by Sandink (2007) and Waite et al. (2017). Having experienced flooding can increase participant risk perception, especially when it comes to potential property damage, health or emotional impacts. The general perception toward future floods has decreased, while mitigation increased compared to respondents in Sandink (2007).

In contrast to Sandink's (2007) study, this survey focused on general storm flooding

perceptions and mitigation rather than sewer backup, which is a more specific topic yielding slightly different results. Overall, these results seem to be similar and suggest there is great value in increasing the frequency of public meetings and flood mitigation workshops soon after a flood event. The survey's results support Sandink's (2007) conclusions, which find that Edmonton homeowners are more knowledgeable about implementing flood mitigation measures. This is evident in our results, which shows most homeowners implementing at least one active mitigation measure on their property.

As indicated in other responses, barriers to mitigation include costs, capabilities, and expertise. Such reasons also align with Waite et al. (2017), where the research team comments that a majority of the participants were only willing to use up to $1000 CAD to implement flood mitigation measures. This tends to be an insignificant amount to prevent flood damage compared to more expensive measures, such as installing sump pumps in basements. The noticeable decline in the natural distribution of homeowner income, among those who are earning $75,000-$99,999 per year and not mitigating flood risk, while insignificant here, is supported by other research. This indicates that there may be an income range where people can afford to mitigate but cannot afford to replace the property if it is damaged.

Limitation and Disclosure

This study is subject to many limitations. Statistical results are influenced for certain demographics (age, education, first language, and housing type) due to small sample sizes. The participants comprise less than one percent of the population of the City of Edmonton (City of Edmonton, 2019). The survey questions lacked open-ended responses, which limited the nature of responses meaning that many potential barriers could have been overlooked.

Future direction

Based on these findings, a follow-up study with a greater representation of Edmontonians would be of use to demonstrate influential variables. Future research may also seek a balanced study group of those with differing risk perceptions and mitigation approaches. Public meetings are preferred by citizens and have proven to be effective in changing behaviours. Previous research (Eanes & Zhou 2020; Gordon & Yiannakoulias 2020; McKenzie-Mohr 2000) finds education most effective soon after a flood event has taken place. It is likely vital to center the lived experiences of people recovering from flooding to help others gain indirect experience. Given that the greatest effects on behaviour are observed in relation to experience, face-to-face engagement can serve as a means of sharing direct experience with others through stories. When someone is given new information through another person they are likely to increase a desired behaviour, while those who receive mailed information are more likely not to notice and change behaviour (McKenzie-Mohr 2000). McKenzie-Mohr (2000) recommends education strategies focused on desirable social norms (e.g., mitigation rates in Edmonton) and exploring barriers to desired behaviours. Subsidy programs covering at least half the cost of upgrades will likely increase willingness to proactively mitigate flooding.

CONCLUSION

Understanding the dynamics of flood risk perception in Edmonton is an essential tool for the future of the city's flood and insurance planning. The goal of the survey was to determine if there is a significant difference in flood perception and preparedness spanning socio-demographic (contextual and personal) variables. Age has a limited impact on flood

risk perception and mitigation and, while several other socio-demographic variables were found to have effects, which are considered at risk of bias until additional data is collected. A critical finding of the study is that residents have higher risk perceptions after a recent flood event. After a flood event, there is a short window to capitalize on heightened risk perceptions and instigate mitigation behaviours among residents. As for the homeowners, the cost of installing certain flood mitigation technologies is one of the greatest concerns. Though the study determined most respondents have implemented flood mitigation techniques.

Edmontonian flood risk perceptions have changed since Sandlink's (2007) survey. For individuals to feel responsible for their own mitigation, the City of Edmonton will need to clarify the importance of changes in behaviours at the lot level. Door-to-door services from the City of Edmonton could help educate Edmontonians in this manner, but it is not recommended that insurance companies attempt this work, as homeowners surveyed do not prefer information from insurers as much as from other sources.

A logical second research step to this survey would be thorough engagement of current and future homeowners regarding ideas on flooding and other risks posed by the climate crisis. Implementing an education program that is suitable for different demographics may help increase flood mitigation over the next decade. A continuation of such studies could be done to observe changing perceptions and behaviours as younger generations age.

Edmonton is likely to see an increase in flood events in the future. Public perception of flood risk and individual behaviours will influence the city's preparedness. Future studies will be necessary to look at the emerging generations' understanding of flood events and how people can help the city maintain and thrive through extreme weather events and the damages.

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APPENDIX I. SURVEY QUESTIONS.

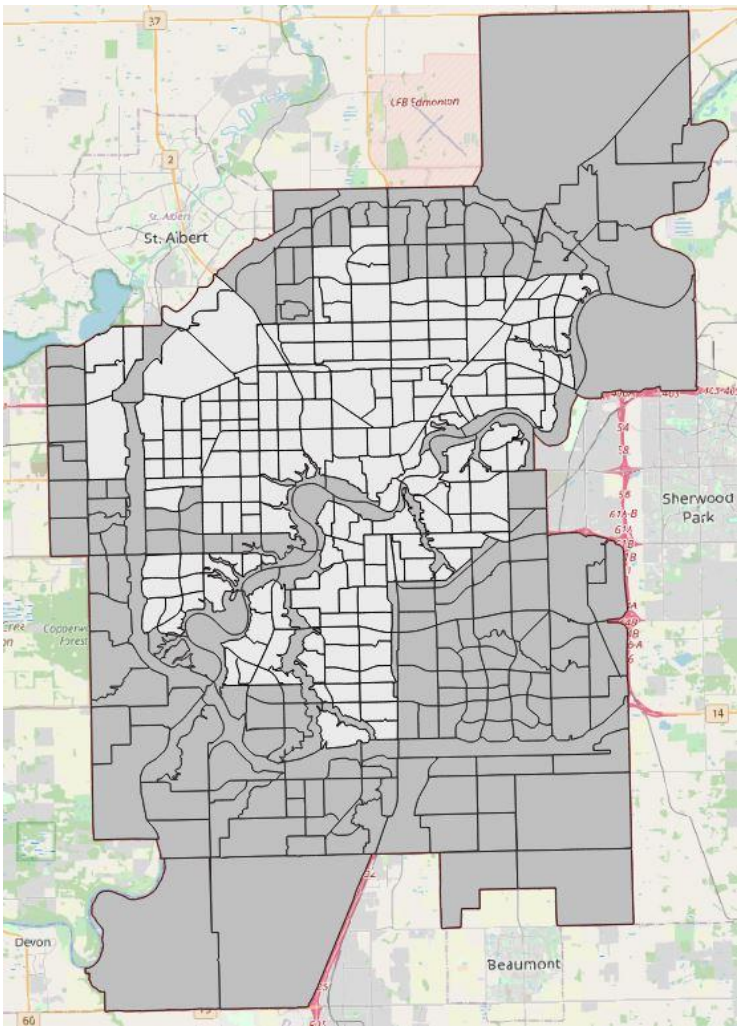
Screening Questions:

S1. Do you currently live in any of the metropolitan cities below? [Show in alphabetical order]

1. Edmonton
2. Toronto [Terminate survey]
3. Vancouver [Terminate survey]
4. Montreal [Terminate survey]
5. Ottawa [Terminate survey]
6. Calgary [Terminate survey]

98. Other [Terminate survey]

S2. Please select which area you currently live in [Random ordered]



1. Dark grey [Not in flood zone]
2. Light grey [In flood zone]

3. Neither [Not in flood zone]

S3. What best describes your living situation?

1. Own
2. Rent [Terminate survey]
3. Live with family [Terminate survey]
98. Other [Terminate survey]

S4. What type of resident do you currently own and live in?

1. Apartment/Flat [Terminate survey]
2. Condominium [Terminate survey]
3. Town house
4. Semi-detached home
5. Detached home
98. Other [Terminate survey]

Experience/Knowledge Questions:

Please keep the following definitions in mind for the following questions. [Infonode]

Definitions:

Stormwater flooding: Occurs when there is an excess of water from rain or snowfall that collects in residential sewer or drainage systems, which can result in basement and road flooding.

Sewage Backup: One major consequence of stormwater flooding. When sewage is unable to flow into the existing sewage system due to over-capacity, it will either flow back up from the input source such as toilet or shower.

River flooding: Occurs when rainfall or snowfall causes rivers to rise beyond the normal level and can lead to land and house flooding. This survey **is not** focusing on this type of flooding.

Q1. Have you ever had any damage caused by any kind of stormwater flooding such as sewer backup?

1. ___Yes, once
2. ___Yes, multiple times
3. ___No, never [Go to Q4]
97. ___Don't know [Go to Q4]

Q2. When was the most recent stormwater flooding incident you experienced in the City of Edmonton?

_____month _____[Range: 1900-2021] (year)

99. I have not experienced storm flooding in Edmonton.

Q3. What was the severity of this recent stormwater flood you experienced?

1. ___ Minor (minimal or no property damage)
2. ___ Moderate (moderate property damage, disturbance to basement and contents)
3. ___ Severe (severe property damage, possible health risks, possible evacuation)
99. ___ Not applicable

Q4. Are you aware of anyone in your neighbourhood who has had stormwater flood damages on their residential property?

1. ___ YES
2. ___ NO
97. ___ Don't Know

Q5. On a scale from 1-7 (1= not very informed, 7= very informed), how informed are you about the following: [Random order]

1. Actions I could take as a homeowner to reduce the potential for stormwater flood damage to my property
2. The availability of financial assistance to undertake actions on my property to reduce stormwater flood damages.

Risk Perception Questions:

Please keep the following definitions in mind for the following questions. [Infonode]

Definitions:

Stormwater Flood Mitigation Actions: Methods or techniques to prevent or reduce the impacts of stormwater flood damage on my property

Environmental Impacts: Immediate or long-term negative impact towards the environment.

Q6. How likely is it that you will have stormwater flood damages in the next 10 years??

1. ___ Very likely
2. ___Somewhat Likely
3. ___ Somewhat Unlikely
4. ___ Not very likely
97. ___ Uncertain

Q7. Rank from most important to least important the benefits of undertaking stormwater flood mitigation actions on your property (e.g., personal safety, community safety, environmental factors, health factors, financial factors) (1-most; 4-least) [Random order]

1. ___ Public Health and safety
2. ___ Environmental Impact
3. ___ Property damage and repair cost
4. ___ Mental health (well-being) and social impact

Q8. Have you taken any actions to protect your property from stormwater flooding? (check all that apply) [Random order]

1. ___ Installation of backflow prevention device or valve to prevent backflow of sewage
2. ___ Water alarm installation/access (remote software or notification)
3. ___ Removal of important belongings in the basement/lower level of home
4. ___ Installed a sump pump
5. ___ Disconnected eavestrough downspouts from the sewer system
6. ___ Rain collection (e.g., rain barrels, rain gardens, low density paving)
7. ___ Leaving basement unfinished
8. ___ Moved away from stormwater flood prone areas
9. ___ Added coverage to my home insurance to pay for sewer backup damages
98. ___ Unsure/Not listed above
99. ___ None

Q9. Please rank the following barriers that prevent you from undertaking actions to reduce stormwater flooding on your property from most concern to least concern. (1- most concern; 8-least concern) [Random order]

1. ___ Cost
2. ___ Privacy
3. ___ Scheduling contractors
4. ___ Time requirements
5. ___ Construction (noise/debris/waste/odors)
6. ___ Maintenance
7. ___ Effectiveness
8. ___ Cultural or religious reasons
97. Unsure what to do/how to begin

Who Is Responsible for Reducing or Mitigating Stormwater Flood Damages?

Q10. On a scale of 1 to 7 how much do you agree or disagree with the following statements (1 = strongly disagree and 7 = strongly agree): [Random order]

1. Some stormwater flooding mitigation projects should be mandatory for property owners to undertake.

2. The City of Edmonton/EPCOR (*A power & water utility company in Edmonton*) should be solely responsible for mitigating and/or compensating stormwater flood damage.
3. Private property owners should be solely responsible for mitigating stormwater flood damage to their property.
4. Mitigation of stormwater flood damage should be a shared private and public responsibility.
5. Home builders should be responsible for including stormwater damage infrastructure in homes they build and sell

[QC Flag_Q10 – Flag if straight line Q10]

'What would you do if 'Questions

Q11. Would you be willing to contact EPCOR for a free home flood protection inspection?

1. ___ Yes
2. ___ No

Q12. On a scale from 1-7, rate how likely are the following to influence your decision to undertake mitigation measures on your property to prevent stormwater flooding (1= very unlikely and 7 = very likely). [Random order]

1. Finding out that the majority of Albertans have done various flood mitigation measures on their properties.
2. The City of Edmonton emphasizes the importance of implementing flood mitigation actions on your property as stormwater flood events happen more often.
3. Stormwater flood mitigation may help reduce the total amount of damage in a flooding event. This is only fair because it ensures disaster relief funds are left for those who cannot afford to implement mitigation measures
4. Implementing stormwater flood mitigation measures protects people who cannot afford to perform these flood mitigation measures by reducing the number of people needing emergency disaster relief funds.
5. Finding out that keepsakes and mementos might become damaged permanently or lost once a flooding event has occurred. You may be able to avoid this by implementing proper mitigation procedures.
6. Your private home insurance company encourages you to implement flood mitigation to save you from possible damages in the future.
7. You could prevent stress for your household/family by undertaking stormwater flood mitigation actions on your property.
8. Your neighbours have conducted flood mitigation measures
9. Performing flood mitigation measures will reduce the risk of living in an unsanitary or dirty environment in the case of a flooding event.
10. It is only fair that people who can afford it do their own stormwater flood mitigation so that insurance premiums do not increase.
11. Please select 3 here [QC Flag_Q12]

Q13. Please rank in the order of your preference the following methods of receiving information about stormwater flood mitigation actions: (1=least preferred and 7= most preferred) [Random order]

1. Researching on your own.
2. Web marketing or a telephone call from EPCOR explaining mitigation options.
3. A mitigation action is recommended by trusted relatives and/or friends.
4. Receiving incentives to take part in surveys that inform you of the benefits of mitigation actions.
5. Information packets delivered to your mailbox
6. Participating in a town hall meeting in your neighborhood that outlines the risks of stormwater flooding in your neighborhood and informs residents of mitigation measures.
7. Having an expert assess your property.

Q14. Would you be more willing to protect your home from flooding if the municipality helped pay the cost of doing so? If so, how much would they have to pay?

1. ___ Yes; half the cost
2. ___ Yes; all the cost
3. ___ No; this would not affect my decision to protect my property from flooding

Demographics: (*Select one for each question***)**

Q15. What is your annual household income before taxes?

1. Under $15,000
2. $15,00 to $24,999
3. $25,000 to $49,999
4. $50,000 to $74,999
5. $75,000 to $99,999
6. $100,000 to $149,999
7. $150,000 to $199,999
8. $200,000 to $249,999
9. $250,000 or more
96. ___ Prefer not to say/ do not know

Q16. What is your age?

1. ___ 18-24
2. ___ 25-34
3. ___ 35-44
4. ___ 45-54
5. ___ 55-64
6. ___ 65 and over

Q17. What is your highest level of education?

1. ___ Grade 1-9
2. ___ High school
3. ___ College/University
4. ___ Trade school

Q18. What best describes you?

1. ___ Female
2. ___ Male
3. ___ Non-binary, gender fluid, or other

Q19. On a scale of 1 to 7 how would you rate your political identity? (1= Liberal and 7= Conservative)?

Q20. Is your first language something other than English or French?

1. ___ Yes
2. ___ No

Chapter 5: Is stormwater flood mitigation a moral conundrum? An analysis of the effectiveness of moral framing and nudges on the likelihood of liberals and conservatives implementing flood mitigation

Chantel Van Kessel, Jacob Bilodeau, Tessa McQuaid, and Yongjia Shan

INTRODUCTION

The purpose of this study is to determine whether moral nudging can be applied to influence homeowners to engage in flood mitigation behaviours. Nudging, or a nudge, originates in behavioural economics and is about intervening in people's behaviour, through public or private institutions. This intervention still allows for people's choices (Jesse & Jannach 2021; Sunstein 2020). One type of nudge is moral suasion (Jesse & Jannach 2021). Moral foundations theory suggests that people do not only make decisions based on personal benefit but instead people make decisions that coincide with their moral beliefs (Graham, Haidt, & Nosek 2009). These moral beliefs can determine their political stances and dictate what individuals deem important and influential (Graham, Haidt, & Nosek 2009).

Our study investigates how effective nudging statements combined with moral frameworks are in influencing people of different political ideologies to implement flood mitigation measures on their property. Our findings have the potential to be used to inform governments and insurance companies on the efficacy and potential of moral nudging techniques for promoting flood risk mitigation measures (Graham, Haidt, & Nosek 2009).

LITERATURE REVIEW

We surveyed people to investigate the efficacy of various communication strategies, with a focus on studying moral framing techniques to nudge liberals and conservatives. In this literature review we explore research on the following topics that are relevant to informing our survey development: communication strategies, flood experience, attitudes towards flood risk and mitigation, nudging and surveys from the public perception, liberal and conservative moral framing, and survey methodologies.

Flood Experience, Communication Strategies, and Attitudes towards Flood Risk & Mitigation

In the case of flood risk mitigation, willingness to mitigate is linked to flood exposure and beliefs regarding the efficiency of public flood risk reduction measures (Grahn and Jaldell 2019). Expanding on this, it is possible that homeowners' willingness to mitigate may also be related to their beliefs about government. Trust in the local government has also been found to be a factor in flood risk perception and attitudes in a study of Austrian communities (Seebauer & Babcicky 2017).

A study done by Thistlethwaite et. al (2017) argues that Canadians are unwilling to accept more responsibility for risk mitigation, and that their perception of flood risk does not reflect actual levels of risk. An effort to increase accessibility of flood risk data could promote public willingness to accept responsibility. Improving access to flood risk information is necessary to better prepare residents and increase their willingness to engage in proactive mitigation behaviours (Heidenreich, Masson & Bamberg 2020). Additionally, this supports the importance of research that explores the most effective methods of communicating flood risk and mitigation information to different demographics.

Previous experience with floods is also relevant to preparedness of residents (Barendrecht et al. 2021). Barendrecht et al.'s (2021) study of flood risk regions in England showed an increased trend of preparedness when there is greater experience with floods. The severity of previous floods and whether or not English is the first language of most residents may influence differences in preparedness in the communities studied (Barendrecht et.al 2021). This indicates that considering the language that communication is available in, compared to the primary languages of communities, may be important to improving flood risk mitigation. These

factors may have implications for how influential various communication and moral nudging strategies are on different demographics, and people within the same demographic but with different past experiences with flooding.

Nudging and Surveys, from the Public Perspective

Nudging is the idea that decision making behaviour can be influenced. A common example of a nudge in the literature is the setup of a cafeteria. The way that the cafeteria is organized can influence people to make healthier food choices, thus creating a change in behaviour without limiting choices (Jesse & Jannach 2021). Utilizing the findings of Jesse and Jannach's (2021) paper, which looked at different nudging mechanisms, our survey is either a Decision Information or Decision Assistance mechanism, as it makes information visible about flood risk and mitigation incentives and acts as a reminder about flood risk. Sunstein, Reisch, and Kaiser (2019), noted in a multi-national study that there is a broad acceptance of nudges, often because they maintain individual choice. Additionally, Hurst and Stern (2020) relate how conservative leaning individuals are more likely to accept environmental action originating from a conservative source (such as a right-leaning organization), rather than government imposed; however, they also found that this did not dissuade liberals from supporting the action. Furthermore, nudging is attractive to the policy makers because it is highly efficient and inexpensive while still affecting behavior (Sunstein 2020).

Liberal and Conservative Moral Framing

Research has suggested that moral foundations underlying an individual's political stance can impact their perceptions and decision making regarding various issues (Day et al. 2014; Emir et al. 2021; Graham, Haidt, & Nosek 2009; Haidt & Graham 2007, Hurst & Stern 2020). Moral foundations theory proposes that individuals may not make decisions based solely on increasing

benefit to themselves, but instead will also consider decisions as they relate to the moral foundations underlying their ideological perspectives (Graham, Haidt, & Nosek 2009). These foundations can be summarized as either "individualizing foundations" or as "binding foundations" (Graham, Haidt, & Nosek 2009).

Individualizing foundations are based on the moral framework of placing value on the individual as the center point of morality; individuals should take actions to respect the rights of other individuals (Graham, Haidt, & Nosek 2009). Whereas binding foundations center group morality through binding roles, institutions, and duties (Graham, Haidt, & Nosek 2009). Within this theory there are 5 categories of moral foundations: 3 binding foundations (Loyalty/Ingroup, Authority/Respect, and Purity/Sanctity), and 2 individualizing foundations (Harm/Care and Fairness/Reciprocity) (Day et al. 2014; Emir et al. 2021; Graham, Haidt, & Nosek 2009; Haidt & Graham 2007).

The Harm/Care foundation focuses on caring for others and preventing harm (Hurst & Stern 2020; Graham, Haidt, & Nosek 2009). The Fairness/Reciprocity foundation is concerned with justice, fairness to all, honesty, and reciprocation (Hurst & Stern 2020; Graham, Haidt, & Nosek 2009). The Loyalty/Ingroup foundation criticizes betrayal, dishonest behaviours and prioritizes loyalty to and trust in one's friends, family, social network or identity group (Hurst and Stern 2020; Graham, Haidt, & Nosek 2009). The Authority/Respect foundation focuses on respecting authority and social hierarchies while also favouring traditions (Hurst & Stern, 2020; Graham, Haidt, & Nosek, 2009). The Purity/Sanctity foundation places value on ensuring the purity and cleanliness of both people and objects (Hurst & Stern 2020; Graham, Haidt, & Nosek, 2009). Liberals prioritize individualizing foundations; whereas conservatives usually make

decisions based on all 5 of the foundations and typically rate binding foundations as more important than liberals do (Haidt & Graham 2007; Graham, Haidt, & Nosek 2009).

Discourse strategies have been found to be useful in swaying an individual's attitudes or behaviour if moral framing is used to relate an issue to a moral foundation that aligns with their political stance (Day et al. 2014; Emir et al. 2021). Survey research on how to apply these strategies to flood risk communication has the potential to reduce flood damage to communities through potentially influencing proactive mitigation behaviors. Informed by our review of literature, our research aims to explore if moral nudging communication strategies can influence Edmontonian homeowners' willingness to engage in flood risk mitigation behaviour.

In investigating moral nudging, we hypothesize that conservatives will be more likely to be influenced to undertake flood mitigation measures by all five moral frameworks; however, they will be most likely to be strongly influenced by Authority/Respect, Loyalty/Ingroup, and Purity/Sanctity framing. For liberals, we hypothesize that they will be more likely to be strongly influenced to undertake flood mitigation measures by Harm/Care framing and Fairness/Reciprocity framing, and are not likely to be influenced by the other three frameworks.

METHODS

The methods employed were the same as those in chapter five. These two chapters, five and six, utilized the same questionnaire. For more detailed methods and data cleaning please refer to chapter five. The questions in the moral nudging study regarding liberal and conservative framing were based on the moral framing theory as outlined in the Hurst & Stern (2020) and the Graham, Haidt, & Nosek (2009) papers. There are five foundations that used to describe liberal

versus conservative framing: Harm/Care, Fairness/Reciprocity, Loyalty/Ingroup, Authority/Respect, and Purity/Sanctity.

To test our research question on the efficacy of utilizing moral nudging to influence flood mitigation behaviour we used the previously mentioned frameworks to create morally framed statements. The following is an example of a Harm/Care statement: "*implementing stormwater flood mitigation measures protects people who cannot afford to perform these flood mitigation measures by reducing the number of people needing emergency disaster relief funds*". The respondents were asked to rate, on a scale from 1-7, how likely the statement would be to influence them to implement mitigation measures, with 1 equating to "very unlikely" and 7 equating to "very likely". This method of testing moral nudging through rating agreement or (un)willingness regarding morally framed statements was based on research by Day et al. (2004) and Haidt & Graham (2007) as described in the literature review.

RESULTS

Our findings show the midpoint options were chosen for many of the rating scale questions in the survey, as most means were one standard deviation away from the center. To identify political affiliation we asked respondents, on a scale of 1 to 7 how would you rate your political identity (1= Liberal and 7= Conservative)? The largest group was "centrist" (4 on our 1-7 scale) with a count of 85, and the next largest group being "very conservative" (7 on our 1-7 scale) with a count of 49. The political group which had the lowest number of respondents was the "very liberal" group with a count of 26 (1 on our 1-7 scale). When divided into three political identities the study group had 88 respondents identify as liberal (1-3 on the scale), 136 as conservative (5-7 on the scale), and 85 centrists (4 on the scale).

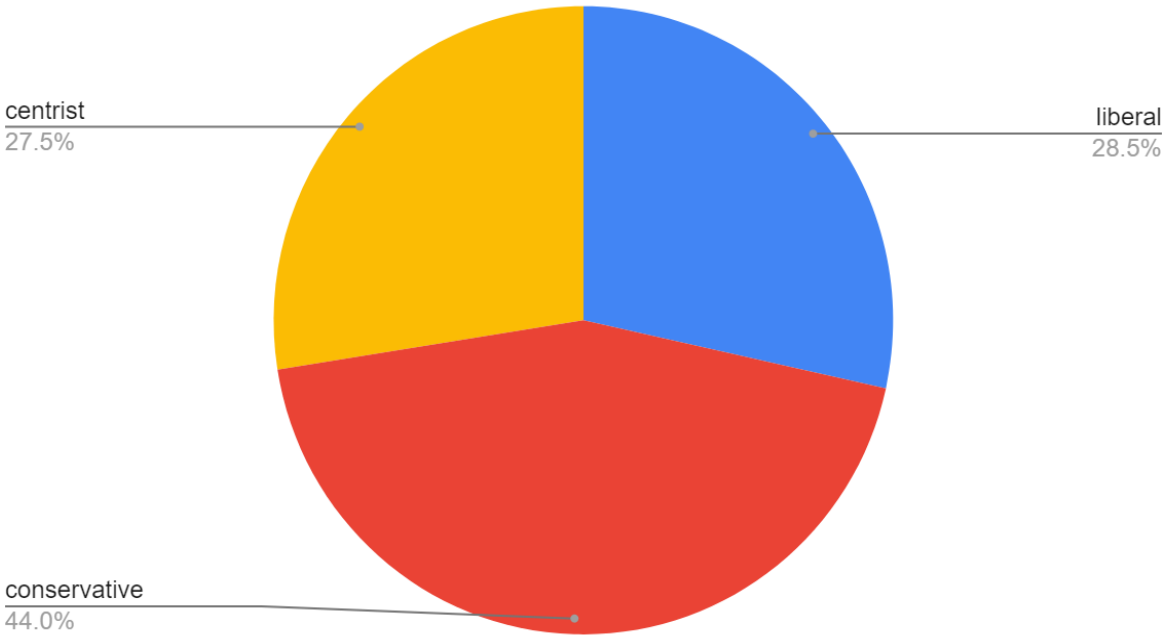


Figure 14. Pie Chart showing the % distribution of liberals, conservatives, and centrists (n=309).

To identify differences in responses based on political orientation, t-tests were performed to compare the average answers of liberals and conservatives. In response to the morally framed statements there was no statistically significant differences between liberal and conservative respondents (Table 12). Every statement had roughly the same mean for conservatives and liberals within one number. Table 12 shows the results of the morally framed statements on influencing decisions to undertake flood mitigation measures to prevent stormwater flooding. Table 12 also indicates no moral frameworks were better than the others. Each statement had a mean between a 4 and 5 (on a scale of 1-7) except for the statement, "*your neighbours have conducted flood mitigation measures"*. This statement had a 3.97 for conservative respondents and corresponds with Harm/Care moral framework. The lowest mean for liberal respondents was also on this question with a 4.02. The highest mean for liberal respondents was 5.52 on the statement, "p*erforming flood mitigation measures will reduce the risk of living in an unsanitary or dirty environment in case of a flooding event*" which has a moral framework of

Purity/Sanctity. The highest mean for conservative respondents was 5.31 on the same moral framework statement.

Table 12. Likelihood that moral framework statements influence decisions to undertake mitigation measures to prevent stormwater flooding (1=very unlikely and 7 = very likely).

Statement	Moral Framework	Liberal (n = 88)	Conservative (n = 136)	t test (p value)
Finding out that the majority of Albertans have done various flood mitigation measures on their properties.	Loyalty/Ingroup	4.49*	4.38	.579 (.563)
The City Edmonton emphasizes the importance of implementing flood mitigation actions on your property as stormwater flood events happen more often.	Authority/Respect	4.56	4.58	-.139 (.889)
Stormwater flood mitigation may help reduce the total amount of damage in a flooding event. This is only fair because it ensures disaster relief funds are left for those who cannot afford to implement mitigation measures.	Fairness/Reciprocity	4.86	4.67	1.080 (.281)
Implementing stormwater flood mitigation measures protects people who cannot afford to perform these mitigation measures by reducing the number of people needing emergency disaster relief funds.	Harm/Care	4.98	4.59	2.171 (.031)
Finding out that keepsakes and mementos might become damaged permanently or lost once a flooding event has occurred. You may be able to avoid this by implementing proper mitigation procedures.	Purity/Sanctity	5.38	5.21	.970 (.333)
Your private home insurance company encourages you to implement flood mitigation to save you from possible damages in the future.	Authority/Respect	4.95	5.03	-.425 (.671)

You could prevent stress for your household/family by undertaking stormwater flood mitigation actions on your property.	Authority/Respect	5.09	5.03	.350 (.727)
Your neighbours have conducted flood mitigation measures.	Harm/Care	4.02	3.97	.251 (.802)
Performing flood mitigation measures will reduce the risk of living in an unsanitary or dirty environment in case of a flooding event.	Purity/Sanctity	5.52	5.31	1.284 (.200)
It is only fair that people who can afford it do their own stormwater flood mitigation so that insurance premiums do not increase.	Fairness/Reciprocity	4.16	4.07	.407 (.685)

* Mean value on a scale from 1 to 7.

We also compared the responses of liberal and conservatives to understand their beliefs about who is responsible for reducing or mitigating stormwater flood damage. A t-test was conducted to determine if there was a statistically significant difference between liberals and conservatives and the attribution of responsibility. The test showed that overall, there was no significant difference between liberals and conservatives for any of those survey questions. For three out of five questions the mean answer for both liberals and conservatives was ~4 based on a 1-7 rating scale, making four the middle answer (Table 13). This included: responsibility on the homeowners for mandatory installation of mitigation measures, water utility companies and/or the city needing to bear a majority of the responsibility, and that it should be a shared private and public responsibility. The statement that had the highest agreement between both liberals and conservatives was "*home builders should be responsible for including stormwater damage infrastructure in homes they build and sell*". The statement that had the lowest agreement

between both liberals and conservatives was "*private property owners should be solely responsible for mitigating stormwater flood damage to their property*".

Table 13. Responsibility for reducing or mitigating stormwater flood damage (1 = strongly disagree and 7 = strongly agree).

Statement	Liberal (n=88)	Conservative (n=136)	t test (p value)
Some stormwater flooding mitigation projects should be mandatory for property owners to undertake.	4.63*	4.43	.991 (.323)
The City of Edmonton/EPCOR (*A power & water utility company in Edmonton*) should be solely responsible for mitigating and/or compensating stormwater flood damage to their property.	4.77	4.71	.281 (.779)
Private property owners should be solely responsible for mitigating stormwater flood damage to their property.	3.02	3.26	-1.119 (.264)
Mitigation of stormwater flood damage should be a shared private and public responsibility.	4.94	4.76	.821 (.413)
Home builders should be responsible for including stormwater damage infrastructure in homes they build and sell.	5.92	5.69	1.162 (.246)

* Mean value on a scale of 1 to 7.

Another metric we measured was the preferences of methods of receiving information about stormwater flood mitigation actions. This question showed no statistically different results between conservative and liberal respondents. Table 14 shows the highest rated method for conservatives was "*participating in a town hall meeting in your neighborhood that outlines the risks of stormwater flooding in your neighborhood and informs residents of mitigation measures*", with mean of 4.49. For liberals, the highest rated information method was "*web*

marketing or a telephone call from EPCOR explaining mitigation options" with a mean of 4.59 (Table 14). The lowest ranked methods for both conservatives and liberals was "i*nformation packets delivered to your mailbox*". All methods were ranked as either a 4 or a 3 (scale of 1-7).

Table 14. Preference for methods of receiving information about stormwater flood mitigation actions (1=least preferred and 7 = most preferred).

Statement	**Liberal (n=88)**	**Conservative (n=136)**	**t test (p value)**
Researching on your own.	4.40*	4.02	1.362 (.174)
Web marketing or a telephone call from EPCOR explaining mitigation options.	4.59	4.38	.767 (.444)
A mitigation action is recommended by trusted relatives and/or friends.	4.26	4.60	-1.431 (.154)
Receiving incentives to take part in surveys that inform you of the benefits of mitigation actions.	3.41	3.63	-.909 (.364)
Information packets delivered to your mailbox.	3.30	3.10	.742 (.459)
Participating in a town hall meeting in your neighborhood that outlines the risks of stormwater flooding in your neighborhood and informs residents of mitigation measures.	4.48	4.49	-.053 (.957)
Having an expert assess your property.	3.57	3.77	-.715

			(.476)

*Mean value on a scale from 1 to 7.

The last comparison between liberal and conservatives that was regarding how informed respondents were about mitigative actions and financial assistance for stormwater damages. Table 15 shows conservative respondents were slightly more informed in both categories. Both liberal and conservatives responded that they were not very aware about the financial assistance for actions to reduce stormwater flood damages (Table 15).

Table 15. How informed respondents were about mitigative actions and financial assistance for stormwater damages. (1= not very informed, 7 = very informed).

Statement	**Liberal (n = 88)**	**Conservative (n = 136)**	**t test (p value)**
Actions I could take as a homeowner to reduce the potential for stormwater flood damage to my property	3.8*	4.16	-1.501 (.135)
The availability of financial assistance to undertake actions on my property to reduce stormwater flood damages	2.72	3.08	-1.554 (.122)

* Mean value on a scale from 1 to 7.

DISCUSSION

Our study set out to investigate the effectiveness of nudging statements combined with moral frameworks in influencing people along the political spectrum to implement flood mitigation measures on their property. We hypothesized that conservatives would be more likely to undertake flood mitigation efforts when influenced by Authority/Respect, Ingroup/Loyalty, and Purity/Sanctity framing than liberals. We expected liberals to be more influenced than conservatives by Harm/Care and Fairness/Reciprocity framing. The results of the study showed that morally framed statements did not produce statistically significant differences between liberal and conservative respondents. What is interesting to note is that all the statements seemed

to perform roughly the same for both liberal and conservative respondents. Therefore, the political differences between people may not matter when it comes to nudges. Even though our study did not find any statistically significant results between conservative and liberals, this does not mean moral frameworks have no usefulness in nudging. In fact, there were some statements that produced a higher level of likelihood to undertake mitigation measures.

As noted in the results of Table 12, the moral framework of Purity/Sanctity resonated the best both conservative and liberal respondents. The second best performing moral framework was Authority/Respect. The moral framework that was the least likely to influence decision to undertake mitigation measures was Harm/Care. In future research it would be worth creating more statements for each category to examine if Purity/Sanctity and Authority/Respect act as the best moral frameworks to influence behaviour.

Table 13 indicates that both liberals and conservatives agree that home builders should bear most of the responsibility for flood mitigation measures. This may be related to the idea that it is less expensive to implement many mitigation measures during a home building process compared to an older, already built home. The statement of the lowest agreement, "*private property owners should be solely responsible for mitigating stormwater flood damage to their property*", may represent hesitancy of people to implement mitigation measures (Table 13). These results indicate that both ends of the political spectrum may see stormwater mitigation as a joint responsibility, but not as purely a homeowners responsibility.

Political orientation did not have a statistically significant result on preference for communication strategies for nudging flood mitigation (Table 14). Our findings indicate that information delivered via mailbox was the least preferred option for both groups of people.

Townhall participation and web marketing or a telephone call were the highest ranked options. This information can be used to best focus messaging when there are limited funds for outreach.

Table 15 shows a t-test to compare the mean value in responses between those who self-identified as liberals and conservative. There is no significant difference between the two groups on how they self-reported their awareness of possible mitigation actions which can be taken by a homeowner to reduce the potential for stormwater flood damage to their property. The same can be stated for the availability of financial assistance to undertake actions on their property to reduce stormwater flood damages. The response for this question, awareness of financial assistance, was significantly lower than the midpoint of 4 (Table 15). This indicates that the general populace is unaware of the options available for financial assistance, regardless of political affiliation.

CONCLUSION

Overall, our study did not find there to be a significant difference between the moral framing for liberals and conservatives, as they both answered similarly to each question. While we did not see much separation between viewpoints of political ideologies, it is worth noting that statements of agreement could be utilized to understand how similar messaging and nudging may work across the political spectrum.

Some of the limitations of our data could be attributed to a small sample size and using an internet panel approach. The internet approach was likely not a random sample of households and presents some selection bias. With only 309 usable respondents, there is a large portion of the Edmonton population that is not represented, especially with the large proportion of respondents being over 55. In the future opening up the sample size to other large cities, where the data would be applicable to our sponsors may help gather statistically significant results.

Time duration of the survey may have also played a part in the results, as we were limited to a semester at a time of year when flooding is not often on people's minds. A longer period of the survey being released to the public may have gathered more results and consequently could have aided in more significant results. Invalid or rushed responses is another limitation when there is a benefit for respondents to finish a mass number of surveys, without complete consideration for each question.

For a future research project, it would be worth considering applying a variable benefit to respondents regarding their decisions after a nudge has occurred. This will further entice respondents to put more effort and thoughtfulness into their responses and also allow us to see how the same framing we applied here can alter decisions being made. Future research could also focus on creating more statements for each moral framework to further test which communication strategies are most effective.

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Chapter 6: Analyzing differences between perceived, objective risk and flood mitigation outcomes

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INTRODUCTION

With the onset of more frequent and severe rainfall events due to man-made climate change, it is increasingly important for homeowners to guard themselves, both financially and physically, against the effects that these events can have on their property. An increased incidence of urban flooding events due to extreme rainfall has put pressure on homeowners to take such protection seriously, and yet, there remains a gap among homeowners between the perception of risk and actually acting to protect themselves (Price et al., 2019). This report is primarily concerned with filling in a gap in the understanding of this issue. Similarly to the students in Chapter 4, who conducted a survey on a large sample of Edmonton homeowners and found a link between perceived risk and objective risk.

Previous research on this gap between perception and behaviour, while ultimately limited in its scope, demonstrates that this gap indeed exists in certain communities (Agrawal et al., 2020). The primary purpose of this report is to further identify and understand what contributes to the phenomenon. We wanted to develop an understanding of risk to help fill this gap and, increase our understanding of the evaluation methods used to estimate risk and protection against risk. To start, we reviewed previous methods to understand where past research on risk and evaluation has failed and to also see what has worked. Building on that foundation, our focus will shift to current methods concerned with risk and evaluation. Finally, we will look at the development of new programs aimed at reducing risk and their efficacy.

In this study, we explore factors that affect perceived risk in addition to factors that perceived risk influences concerning flooding events across Canada. How these different factors both affect and are affected by perceived risk is important to understand as we believe an

understanding will help identify why mitigation measures (including uptake of insurance) are or are not adopted by homeowners.

Previous studies reveal conflicting evidence as to whether there is a statistically significant correlation between perceived risk and objective risk of stormwater flooding and property damage. Literature suggests that people will learn from previous destructive events and that when given information about objective risk, their perceived risk will increase. However, other studies show that past experience causes people to believe these events will not happen again (Dickie et al. 2020; Scolobig et al. 2012; Harries 2012). We want to investigate whether there is a disconnect between the perceived risk of basement flooding and the objective risk of basement flooding. For our data, we hypothesize that the objective risk of flooding will be significantly different from the perceived risk of flooding.

To understand why people make the decisions that they do, it is imperative to understand the reasoning behind their perceived risk. Previous papers have highlighted many demographic factors as well as how previous experience will affect people's perceived risk. There is also some conflicting evidence as to whether personal demographics are a statistically significant demographic determinant that affects perceived risks (Wachinger et al. 2013; Kuligowski et al. 2021). It is generally concluded that further analysis must be done to determine if these factors truly affect perceived risk, so we wanted to examine this by asking: do gender, household income, level of education received, and language spoken at home have a significant impact on the perceived risk of basement flooding? Research conducted by Wachinger et al. (2013) found that most demographic factors are not statistically significant on their own, but only when combined with other factors; we hypothesize that these factors will be statistically significant when they are combined.

To further understand reasons behind decision making and perceived risk, it is necessary to understand what factors influence perceived risk. Two factors that we expect to influence perceived risk of flooding are the likelihood of buying insurance and willingness to pay (WTP) for installing flood mitigation techniques on properties. We hypothesize that a household's perceived risk would have a positive correlation with the household's likelihood of buying insurance. We also hypothesize that having a higher perceived risk of residential flooding will increase a household's willingness to pay for various flood mitigation techniques. Data suggests demand for insurance is relatively inelastic and therefore the willingness to pay for insurance may have a large range (Shively 2017). This would mean that while perceived risk may have an impact on willingness to pay, the price would not matter as much.

Understanding the gap between perceived risk and actions taken to manage said risk involves understanding the methods used to evaluate and therefore manage risk. As anthropogenic climate change increases the frequency and severity of rainfall events, the importance of proactively adopting risk mitigation strategies increases as well. Bridging gaps between perceived and objective risk is imperative in protecting communities against the effects of natural disasters. In addition to closing the gap, getting people to invest in flood mitigation measures to protect their homes from flooding has been challenging and understanding why is another important issue.

LITERATURE REVIEW

To understand the factors affecting household demand for risk reduction, it is important to examine historical methods and their effectiveness. Risk reduction, specifically for flooding, has been a concern throughout the historical record. The first documented civilization, Sumer, used floodplains as a form of agricultural irrigation, similar to what was done in ancient Egypt

(Crawford 1988; Mays 2010). Since humans have been dealing with flooding for millennia, many management strategies have been attempted and analyzed. When examining more recent methods, the majority of these strategies can be categorized as land-use regulations, construction specifications, structural flood protection, and encouragement of behavioural changes (Chang et al. 2020). We examine factors affecting demand for risk reduction across these strategies.

Two major factors which have historically increased demand for risk reduction are household size and recent experience with a major flood event (Kreibich et al. 2005). The increase in demand is augmented by informational programs and financial incentives (Kreibich et al. 2005). This is especially true if these are implemented during the immediate aftermath of a flood at the same time as reconstruction (Kreibich et al. 2005). A study, conducted across the Canadian prairie provinces found that while risk reduction preferences vary by province, management was most likely to be valued at the highest willingness to pay when residents mitigated a perceived risk to health and human life (Morrison et al. 2019).

Current methods for flood risk management and prevention in Canada can vary by province and city and are reliant on the perceived risk by homeowners and overall risks of flooding among neighbourhoods (Nastev & Todorov 2013). Previous literature on flood risk management analyzed how effective tools and programs implemented by governments are; how other natural disasters, such as wildfires, affect decisions homeowners make; and how the risk is perceived based on area and knowledge of flooding events. Communication of risk is also explored as not all residents may be aware of procedures governments employ to reduce risk, and there is a lack of communication between residents, authorities, and government which leads to a skewed perception of risk by residents (Stewart & Rashid 2011). The methods governments are currently using are centralized on reacting - there is little focus on preventing floods from

happening at the outset, which may explain skewed risk perceptions of residents (Raikes et al., 2019).

There is also debate about whether to make risk management services delivered by the public or private sectors. While there is currently a mix of both public and private, having some services designated as private goods can interfere with residents being able to access the service (Geaves & Penning-Rowsell 2016; Thistlethwaite & Henstra 2017). While many new buildings are built with flood risk in mind and are up to code with government policy, a big problem will be getting residents owning older buildings to update their homes to prevent flooding (Chang et al. 2019). Homeowners might not realize that their home is at risk. Other natural disasters, such as wildfires, might be a bigger concern for them, or there is confusion about government policy and the increasing frequency of natural disasters (Agrawal et al. 2020). Residents need to be more aware of the risk to their homes; for example, the Hazus program operated by the United States government, allows communities to educate themselves about the risks and the consequences of those risks (Nastev & Todorov 2013).

To help residents reduce damages from floods and, by extension, dependence on insurance as a primary management practice, there are several risk reduction practices and strategies that have been adopted in different parts of North America. These flood risk reduction methods often emulate existing methods and strategies in place for other natural disasters such as wildfires. For wildfires, risk reduction methods are often done by private homeowners and landowners and include using fire-resistant materials and creating “defensible space around their homes and businesses” (Talberth et al. 2006). This is primarily to compensate for shortfalls in insurance coverage (Talberth et al. 2006).

With risk reduction for floods, the aim is typically the same. There are differences in methods for commercial buildings, residential and multi-use areas, and farmland as the functions and purposes of these areas differ. For commercial areas and buildings, contingency plans and funds for critical equipment and retrofitting are the primary risk reduction strategies (Moudrak & Feltmate 2019). The retrofits typically include elevating and flood-proofing critical equipment and supplies, protecting server rooms and other critical areas, and upgrading electrical panels to allow for remote shut-off (Moudrak & Feltmate 2019). Some of the critical equipment includes sump pumps, air moisture sensors, portable generators and battery-operated lighting. These combined are intended to reduce the expected damage from floods, while also accounting for increased risk due to climate change (Moudrak & Feltmate 2019).

For residential buildings and areas, efforts could be made by individuals or by communities. Individual methods are typically influenced by an individual's perception of risk, both perceived probability and perceived severity of an event (Mann & Wolfe 2016). The methods include adopting public flood prevention methods and floodproofing through retrofitting (Mann & Wolfe 2016). Community methods often include following the protect/accommodate/retreat/avoid framework (PARA) and vary from place to place within Canada (Doberstein et al. 2019). In the BC Lower Mainland, which is located along the Fraser River Valley Delta, a system of dikes and pumping stations is in place to protect the area from major destruction from floods (Doberstein et al. 2019). This uses the 'protect' approach. Other communities such as the Red River Valley of Winnipeg, used the 'accommodate' approach, through the use of a ring dike, (e.g. the 2011 flood); while others have used 'retreat' methods such as in 1954 with flooding from Hurricane Hazel in Toronto (Doberstein et al. 2019). Yet

others have used 'avoid' approaches such as in the Calgary flood of 2013 (Doberstein et al. 2019).

Understanding the gap between perceived flood risk and preventative measures taken involves understanding historical and current methods of risk reduction, management, and analysis. Since the dawn of human civilization, floods have posed risks to settlements and infrastructure, giving rise to preventative and reactive measures. Flood risk management strategies encompass many types of mitigation, including land-use regulations, construction specifications, structural flood protection, and communication strategies to influence behaviour (Chang et al. 2020). In more recent times, communication strategies include government communication of procedures. Residents' perception of risk can be altered by a lack of communication between themselves and authorities and government (Stewart & Rashid 2011). Retrofitting older homes is of great concern as new homes are built with risk reduction measures already in place (Chang et al. 2019). Perceived risk, concerns about other types of disasters, and understanding of government policy, play a role in the acceptance of retrofitting (Agrawal et al. 2020). Flood mitigation strategies tend to be related to gaps in insurance, which relates to property type (Talberth et al. 2006; Moudrak & Feltmate 2019). Therefore, residential, commercial, and farm areas have differing risk reduction strategies.

METHODS

A study from 2016 analyzes perceived and objective risk measures with Canadians that were 18 years and older all over Canada (Price et al. 2019). The questionnaire included the household income, level of education, gender, language spoken at home, the perceived risk of flooding, and questions on if they have various methods for dealing with flooding (mitigations or insurance). Comparing these variables with each other and the objective risk of basement

flooding allows us to examine potential correlations in regards to why people are not investing in mitigation methods or why they believe they do not need them.

To examine the potential gap between perceived and objective risk, the following procedures were executed. Firstly, the survey dataset was revised to omit responses from participants who spent less than ten minutes completing their questionnaires, as it was felt that this was too short of a time to give meaningful responses to all questions. Objective risk was measured using a method established by Elshorbagy et al. (2017). The authors created a flood risk map of Canada, map utilizing topography and nightline data (Elshorbagy et al. 2017). The parameters that were used in the construction of this map were elevation above the nearest drainage, distance from the nearest drainage, and nightlights (which are used as an indicator of human activity) (Elshorbagy et al. 2017). Using the revised dataset, statistical tests were performed on the values for perceived risk and objective risk, looking at the comparisons of objective risk and perceived risk of basement flooding. The statistical tests performed were comparison of means, frequency analysis, and bivariate correlations. The objective of these tests was to examine the relationship between objective and perceived risk, identifying potential correlations and trends.

From there, a multivariate linear regression was conducted to analyze the relationship between perceived risk of basement flooding and gender, household income, the language spoken at home and the level of education. The objective risk of basement flooding was also included in this analysis to see how it explained perceived risk while holding our chosen demographic variables constant. To run this linear regression, we re-coded gender and language spoken at home so that they became dummy variables; gender was converted to a binary scale with female having a value of 1 and male having a value of 0. For language spoken at home,

English, being the primary language spoken in Canada, was given a value of 1 and all others were given a value of 0 (Statistics Canada 2017). The perceived risk of basement flooding was used as the dependent variable and was tested against the independent variables. The objective of the linear regressions was to compare the effects of objective risk of basement flooding, gender, income, language, and education level on the perceived risk of basement flooding. We hypothesized that together, these factors would have a significant impact on people's perceived risk of flooding, with objective risk, gender, and level of education have the greatest effect, based on the literature we had read.

To determine the relationship between the perceived risk of basement flooding and adoption of various flood damage mitigation methods and the cost associated with said methods, bivariate correlation tests were carried out. Utilizing the results from the correlations, multivariate regressions for different combinations of the mitigation methods and associated costs were performed to identify any significant combination of mitigation methods. For the correlation tests, we hypothesized that we would see a significant positive correlation (i.e. above 0.500) between the perceived risk of basement flooding and mitigation methods. We also expected to see a significant positive correlation between perceived risk and the willingness to pay for mitigation techniques as well as between perceived risk and insurance-related methods. For the regressions, we expected to see high R-values and high significance among complementary mitigation methods based on the correlation results.

Additionally, two cases were identified in the dataset that showed vast differences between the discussed variables to exemplify situations where the objective risk index is much greater than perceived risk and vice versa.

RESULTS

Figure 15 shows the frequency of responses for objective and perceived risk. The frequency distribution of perceived risk estimates shows that 33% of responses were of 0% risk, 50% of responses were under 10% and 70% of responses were under 15%. The majority of objective risk indices were in the 12-20 range, as 66% of scores fell into this range. The bivariate correlation test revealed that there is a -0.014 correlation between objective risk and perceived risk of basement flooding. This result was not statistically significant.

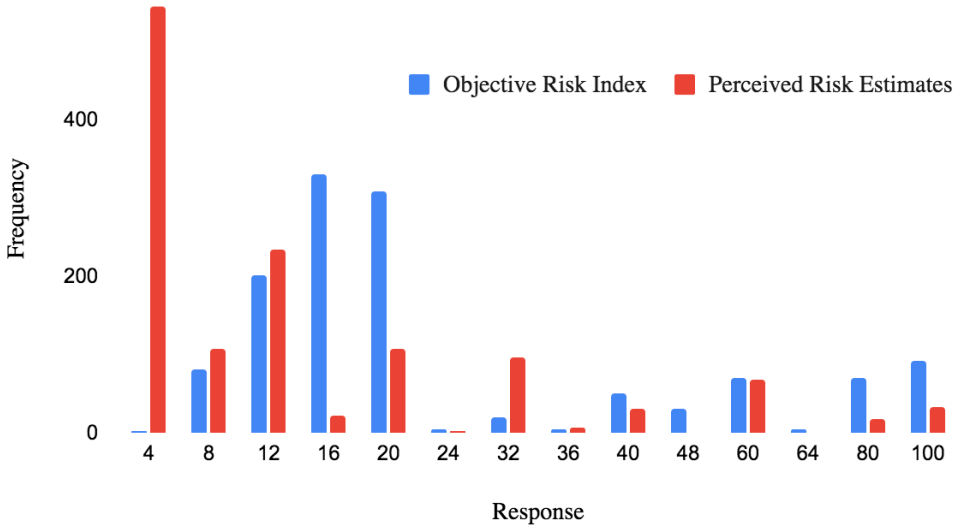

Figure 15. This figure shows the number of responses for each level of perceived and objective risk.

When examining the results of our multivariate regression analysis regarding demographic factors as well as the objective risk of basement flooding, we see an R squared value of 0.019, indicating that 1.9% of the variation of the perceived risk of basement flooding can be explained by our independent variables (level of education, gender, objective risk of basement flooding, language spoken at home, and household income) (Table 16). The ANOVA analysis gave an F value of 4.830 and ($p<0.000$), indicating that there is a significant relationship, allowing us to reject the null hypothesis that there is no correlation between our

independent variables and the perceived risk of basement flooding (Table 16). This supports our hypothesis that level of education, gender, objective risk of basement flooding, language spoken at home, and household income will interact and have a significant impact on a person's perception of risk. When referring to the coefficients of each of the variables, we see that gender and language spoken at home are the only two statistically significant factors (at the 90% level) with t-values of 3.041 and 1.886 and ($p<0.002$), ($p<0.060$) (Table 16). This indicates that people who identify as female and people who live in households where English is the primary language spoken are more likely to have higher levels of perceived risk than those who identify as male or speak other languages at home. The objective risk of basement flooding had a t-value of 0.137 and ($p=0.891$) household income had a t-value of -0.065 and ($p=0.948$) and level of education had a t-value of 0.769 and a p-value of 0.442 (Table 16).

Table 16. Multivariate Regression of Perceived Risk of Basement Flooding vs Objective Risk of Basement Flooding, Education, Income, Language, and Gender (n=1309).

Variables	**Coefficent**	**SE**	***t*-stat**	**Prob.**
Constant	7.299	2.400	3.041	.002
Gender	2.221	1.177	1.886	.060
Language	6.035	1.398	4.316	.000
Objective Hazard Level	.003	.022	.137	.948
Household income	-.013	.204	-.065	.390
Level of education	.243	.316	.769	.442
R^2		0.019		

It is interesting to note that language spoken at home is the best predictor of perceived risk, with other predictors not having a significant impact.

Correlation coefficients of basement flooding and flood mitigation action taken are shown in Table 17. Perceived risk of basement flooding did not correlate well with the mitigation methods themselves nor with the cost associated with the mitigation methods. Several mitigation methods did produce statistically significant correlations with perceived risk. These included making architectural adjustments (.100), installing anti-backflow valves (.077), and use of sump pumps or power generators (.172) (Table 17). Although these correlations are significant, they are extremely low and would likely indicate that these variables have no real impact on perceived risk of basement flooding.

Table 17. Pearson Correlation Coefficients of Perceived Risk of Basement Flooding vs. Flood Mitigation Action Taken (n=1309).

Flood Mitigation Actions Taken	**Perceived Risk of Basement Flooding**
Architectural Adjustments	.100**
Raising electric components	.036
Backflow valves	.077**
Sandbags/Protective Barriers	.054
Sump Pump/ Power Gen.	.172**
Emergency Kit	.125**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 18 shows the correlation between perceived risk of flooding and insurance policy type. There was not significant relationship between insurance decisions and perceived risk.

Table 18. Pearson Correlation Coefficients of Perceived Risk of Basement Flooding vs. Insurance Policy Type(n=1309).

Insurance Policy Type	**Perceived Risk of Basement Flooding**
Sewer backup in home insurance policy	0.055
Overland flooding damage in home insurance policy	-.076*
Consulted provider about purchasing overland flood insurance	-0.035

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

Further regression analysis was carried out regarding the WTP. Table 19 shows the regression of sump pumps, anti-backflow valves, and architectural adjustments as variables and resulted in a R squared value of (0.267).

Table 19. Multivariate Regression of Perceived Risk of Basement Flooding vs Money Spent on Sump Pumps/Power Generators & Architectural Adjustments (n=1309).

Variables	**Coefficient**	**SE**	***t*-stat**	**Prob**
Constant	9.384	4.327	2.169	.036
Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?	0.001	0.000	2.666	.011
Sump pump and power generator: Approximately how much money has your household spent on the following items?	0.007	0.003	1.939	.060
R^2		0.267		

DISCUSSION AND CONCLUSION

We hypothesized that the objective risk of flooding would be significantly different from the perceived risk of flooding. While the correlation between these variables was not statistically significant, it was noted that the means differed and that there was a notable difference in the distribution of the perceived and objective risk measures (Figure 15). We hypothesized that gender, household income, level of education received, language spoken at home, and objective risk of flooding would be statistically significant when they are combined as a predictor of perceived risk of flooding. This hypothesis was confirmed, the aforementioned factors were significant when combined in a regression. However, language spoken at home and gender were the only significant predictors. Lastly, we hypothesized that a household's perceived risk would have a positive correlation with the household's likelihood of buying insurance and that having a higher perceived risk of residential flooding would increase a household's willingness to pay for various flood mitigation techniques. These hypotheses were not supported by the results. There was no correlation between insurance decisions and perceived risk. Out of the mitigation methods examined, willingness to pay for architectural adjustments and sump pumps/power generators were the only significant results. The willingness to pay regression did align with the hypothesis, though the statistical significance of the results should be noted.

To highlight the complexity of the gap between perceived risk and objective risk, two respondents from the survey were identified for having large discrepancies between their perceived risk that vastly differed from their objective risk index.

Respondent 1085 was selected because they greatly overestimated their risk. This Albertan woman claimed that she was confident in her perceived risk of 100% odds of basement flooding, though her objective risk index was only 12. This person had not been inconvenienced

by flooding and had not made any architectural adjustments to their home, which they own, but did report that their insurance covered sewer backup. Other demographic information received from the respondent was that she grew up in an urban area, spoke English at home, and that the highest level of education she had obtained was high school.

Respondent 884 was selected because they greatly underestimated their risk. This woman, located in Newfoundland and Labrador, claimed that she was confident in her perceived risk of 15% odds of basement flooding, though her objective risk index was 100, the maximum possible hazard score. This person had been significantly inconvenienced by flooding and had made architectural adjustments to their home, which they own, but did not specify what adjustments had been made. They reported that their insurance covered both sewer backup and overland flooding. Other demographic information received from the respondent was that she grew up in a rural area, spoke English at home, and that the highest level of education obtained was a college/technical school degree.

These two cases exemplify the complex nature of the issue at hand: the difference between perceived and objective risk is not always in the same direction. Some overestimate their risk while others underestimate their risk. Both of these respondents spent an average of 20 to 25 minutes on their survey, and both were females who owned their homes, so these factors were controlled for in this comparison. These observations lead to more questions than answers, most importantly considering what factors these respondents used to formulate their estimates of perceived risk, as they both felt that they were confident in their answers. It is counterintuitive that someone who had not been inconvenienced by a flood would think that they were at 100% risk of one occurring. A potential explanation for respondent 884's underestimation of their risk could be that they have made architectural adjustments to their property that they feel are

adequate to protect their basement from flooding, and that their insurance would cover damages. However, since they did not specify what adjustments had been made, we cannot confidently assume that they have made adequate adjustments to reduce their risk of flooding from the objective index of 100 to the perceived score of 15%. Further, the age of the house itself may play a role in how the perception of risk is formed. A newer house may have flood mitigation methods built into it, while older homes might not, and therefore perceptions of risk could vary depending on the age of the home. This survey did not ask participants to specify the age of their home, something that could contribute to flood risk perceptions greatly. Further research could explore how this overlooked factor contributes to the formation of perceived risk among homeowners. However, despite the age of the home or architectural adjustments made, given the severity of the risk that respondent 884 faces, their low estimates of perceived risk are still concerning.

Thus, further research is required to provide more conclusive answers for the reasons behind this disconnect between perceived and objective risk. While the existence of the disconnect has been observed, the reasons for it, scale, and direction were not clearly identified as these factors varied throughout the sample. As exemplified in the case studies of respondents 1085 and 884, some people confidently over and underestimate their risk. This complex relationship could be part of the reason why the objective risk was also not statistically significant in our multivariate regression analysis. While most of the results were statistically insignificant, the finding that language spoken at home and gender are significant is notable. This leads to questioning if factors such as cultural norms or gender roles affect perceived risk. However, because the multivariate regression only accounted for 1.9% of the variance, other factors are affecting perceived risk that were not identified in this study. If it were known why

people perceived certain levels of risk, one could suggest methods for closing the gap between perceived and objective risk. Surveys such as the one used for this report could be used, though asking different questions that relate more closely to the factors that people use to determine the risk they face. For example, Kuligowski et al. (2021) found that receiving warnings from a trusted official source had a significant impact on the risk perception of a nearby wildfire (Kuligowski et al., 2021). Avenues such as how and where people obtain risk information, information on the age and features of homes, and relationships between language and cultural norms could be explored in further research. If the results of this analysis indicate anything, it is that the factors that determine a person's perceived risk as it relates to flooding are complex. Therefore, there is ample room for further research in this area to understand the gap between perceived and objective risk and to examine the uptake of risk mitigation measures.

While future research into why people implement risk mitigation measures may be valuable, it is also important to discuss external factors which may have influenced our results. Regarding WTP for mitigation measures, money spent on architectural adjustments and sump pumps or power generators had significance, the lack of significance of uptake of insurance with perceived risk could be because flooding insurance is relatively recent in Canada. Flood insurance only started to become available after stakeholders started to pressure insurance companies on the need for it after large Canadian flooding events in 2013 (Thistlewaite 2016). By 2016, when the survey was conducted, most agencies were still in the process of developing policies (Price et al. 2019). It is likely that so early in the introduction of flood insurance, it had not become a societal norm to purchase insurance, nor was awareness of it that common. Additionally, the low uptake of insurance is an interesting finding in that it possibly is telling of the perceived risk individuals have concerning floods. If they already have a low perception of

risk, which is what the majority of survey participants indicated, then it is likely they would not purchase insurance or other forms of mitigation measures anyway. On the other hand, what our results possibly indicate is what those who adequately assess their perceived risk are already doing to protect themselves from floods; making architectural adjustments and using sump pumps and/or power generators. It would be interesting to compare our findings to nations that have had flooding insurance for decades, as well as to do Canadian studies in the future to see if having a long history of flood insurance popularized it and creates a significant correlation where people who have a high perceived risk invest in flood insurance to mitigate it.

Subsequently, further research can be done to determine the reasoning behind why people take certain risk mitigation measures and what sort of factors affect their willingness to pay for these measures. Developing a questionnaire asking people why they have certain levels of perceived risk and why they take certain risk mitigation measures could help us further develop answers to our research questions.

We had developed three separate research questions prior to conducting our analysis;

1) Is there a disconnect between the perceived risk of basement flooding and the objective risk of basement flooding?
2) Do gender, household income, level of education received, and language spoken at home have a significant impact on the perceived risk of basement flooding?
3) What factors influenced one's perceived risk of flooding?

For our first question, we did not find a simplistic yes or no answer. Comparing the means did not give us a significant result, which would have allowed us to reject the null hypothesis, however, there were clear differences. The objective risk measure and perceived risk measure had essentially zero correlation, indicating that there is a lack of connection between the

two measures. Having an open-ended survey might help us understand if there is truly a disconnect between the two, as learning the reasoning behind the way people think might bring up new ways that we could quantitatively analyze it. We learned that this question was a lot more complex than originally thought.

As for our second question, we were able to find a significant answer. Together all of these factors affected the perceived risk of basement flooding; however as stated above, they only accounted for 1.9% of its variance. This means that there are other factors that need to be examined as to why people have certain levels of perceived risk. Further research into the interrelationship between various demographic and cultural factors is suggested to further define the relationship between said factors and perceived risk.

A few interesting topics presented in our results include the fact that language spoken at home was the most closely correlated factor to the perceived risk that we found. From previous literature, we did not come across anything discussing this, and there could be many potential reasons supporting this finding. One likely explanation could be cultural norms which tend to be closely associated with the language spoken at home. For example, perhaps households located in Quebec, who are a lot more likely to speak French, may have certain cultural factors that cause them to have relatively lower levels of perceived risk. Another interesting result was that although it was not significant, there was a negative trend presented between household income and the perceived risk of basement flooding. It would be interesting to look into if this is because households have already invested in mitigation measures, or if they are generally less worried about basement flooding because they know they can afford it, or if they have a less accurate idea of risk compared to their objective risk. Lastly, we expected the level of education to be one of the most influential factors, however, it was not significant. There could be many reasons for

this, but it could lead to some interesting research about if there is a difference in where people get information about risk based on their level of education.

Lastly, we split up our third question asking what factors influence one's perceived risk of flooding, into how perceived risk is affected by one's likelihood of buying insurance and their willingness to pay for mitigation techniques. The only significant result of the willingness to pay estimates determined that architectural adjustments inform perceived risk better than other mitigation methods. Insurance uptake, surprisingly, was not a good determining factor for perceived risk. Again, this seems to indicate a lack of information as to why people make the decisions they do. The perceived risk seems to be the most obvious explanation for having mitigation measures, but it should be examined as previous experience, advertising, and several other factors may have a more significant effect. Further research should focus more directly on adjustments made to the house itself as well the age of the house itself.

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