UNDERSTANDING PSYCHOLOGICAL DRIVERS OF ATTITUDES TOWARDS COASTAL CLIMATE ADAPTATIONS IN THE MINAS BASIN, NOVA SCOTIA

by

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Dalhousie University is located in Mi'kma'ki,

The ancestral and unceded territory of the Mi'kmaq.

We are all Treaty People.

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Abstract

Coastal climate adaptations are changes in human behaviour that tackle the social and ecological challenges arising from sea level rise. Such adaptations are used in Nova Scotia, but have been met with some degree of public resistance. In this study, we sought to explore the drivers of resistance to two specific coastal climate adaptation strategies: flood risk mapping and managed dyke realignment. Using a survey administered to residents of the Minas Basin region, we found that while an overall majority of residents supported both strategies, 30% expressed resistance to flood risk mapping on the basis of real estate value concerns, and 20% expressed resistance to managed dyke realignment that would involve retreating homes or businesses. These results highlight that while the psychological drivers of resistance for each adaptation strategy vary, being self concerned is a common underlying driver of resistance in both cases.

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Land Acknowledgement

The Minas Basin region of the Bay of Fundy is located in the Sɨpekne'katik district, one of the seven districts of Mi’kma’ki. The Mi’kmaq have been stewards of this land since time immemorial, and did not cede their rights during the signing of the Peace and Friendship treaties. As a settler, I recognize my responsibility to work towards Truth and Reconciliation. I am grateful for the lessons the land has taught me here, and I will continue to work towards embodying the values of Truth and Reconciliation as I progress in my career.

Chapter 1: Introduction

1.1 Statement of the Problem

Recent flooding events on both Canadian coasts have devastated infrastructure, communities, and lives (MacDonald & Smellie, 2021; Schmunk, 2021). In many affected regions flooding has isolated communities from essential goods and services and compromised the safety of thousands of Canadians. Flooding is a natural process, however anthropogenic activities are accelerating the occurrence and increasing the severity of flooding events across the planet (Hirabayashi et al., 2013). Flooding is worsened by greenhouse gas emissions, and human development patterns are pushing people to live in areas of increased flood risk (Retallack & Conde, 2020). In 2019, the Canadian government declared a climate emergency in recognition of the need for mobilization regarding climate mitigation and adaptation (Jackson, 2019). As the global climate emergency continues to unfold, flood events are predicted to increase significantly in both frequency and severity, highlighting the need for effective preventative adaptation measures (IPCC, 2023). Effective adaptation strategies are important to identify, especially for already vulnerable regions with elevated flood risk, as they are more likely to be facing worsening flooding and associated challenges (IPCC, 2023).

Coastal climate adaptation strategies encompass a variety of interventions which seek to protect coastal areas and their residents from the impending threats of climate change and sea level rise. These can include psychological, economic, physical, technical, and nature-based adaptations (Glavovic et al., 2022). Psychological interventions include information-based techniques in awareness raising, such as the

adoption of publicly available flood risk mapping used to inform planners, developers, landowners, and other decision makers about flood risk within a specified area (Henstra et al., 2019). Nature-based coastal adaptations simultaneously address social and ecological challenges (International Union for Conservation of Nature, 2020). The goal of nature-based solutions is to facilitate a natural coastal ecosystem through adaptation strategies which leverage, and thus prioritize space for, and restoration of, the natural environment (Vouk et al., 2021). Nature-based coastal adaptations sometimes employ the use of soft or green infrastructure, which refers to natural systems such as wetlands, soils, and plants, as opposed to hard or grey infrastructure, which refers to built structures including seawalls or dams (US EPA, 2022). Managed realignment is a nature-based adaptation which involves retreating hard infrastructure inland, for instance pulling dykes further inlandand facilitating some former dykeland areas to return to naturally occurring tidal wetlands or to be converted to managed living shorelines (Williams, 2017).

While both coastal adaptation strategies of publicly available flood risk mapping and managed realignment are currently underway in many jurisdictions including Nova Scotia, they have both also been met with resistance from the public (Bax et al., 2023; Bradley, 2016; Goodchild et al., 2018; Kellens et al., 2013; Roca & Villares, 2012).

Resistance to coastal adaptation strategies is a well-documented phenomenon, but the reasons for resistance are not well understood. Generally, resistance to adaptation strategies are strongest in retreat-based situations such as dyke realignment, as there is significant cultural attachment not only to the coastal areas themselves, but also to the landscapes and associated infrastructure in these areas (Mallette et al., 2021). Additionally, landowners are often resistant to flood-risk mapping, as they are concerned

that the public availability of flood risk maps may impact the value of their property (Howard & Sherren, 2023). Canadians living in high flood-risk areas have also expressed a lack of willingness to pay for flood protections and recovery out of pocket (Thistlethwaite et al., 2018).

Previous research exploring the implementation of coastal climate adaptations has found that there is resistance associated with the implementation of these measures, including lack of public awareness of adaptation strategies, resistance to change, silo mentality, lack of standards and frameworks for implementation, lack of knowledge and skills needed for implementation, actual or perceived costs, and zoning or property ownership challenges (Sarabi et al., 2020). While policy makers have attempted to address these concerns through the implementation of policies and programming including funding strategies and educational campaigns, resistance still occurs. Understanding the psychological influences which drive resistance can help ensure that programs aimed at protecting coastal residents and ecosystems are effective.

1.2 Purpose and Research Questions

The purpose of this study is to understand how residents of the Minas Basin region of Nova Scotia perceive the implementation of two coastal adaptation strategies: managed dyke realignment and publicly available flood risk mapping. Specifically, we sought to explore the role of demographic and psychological factors in driving resistance to these two nature-based adaptation strategies being implemented in the region. The Minas Basin region of the Bay of Fundy is an important site for understanding drivers to resistance to adaptation as it is at significant risk of flooding, and the current dyke infrastructure in the region is eroding and/or of inadequate height for climate projections

(van Proosdij et al., 2018). Flooding in the region is increasingly resulting in personal and material losses for individuals and communities, and dyke failure could expedite saltwater intrusion, rendering agricultural land no longer fertile. In addition to providing agricultural production, dykelands provide a diverse set of benefits including tourism, recreation, identity, and cultural amenities (Sherren et al., 2021). In order to implement effective climate adaptations, it is critical to first understand how people in the region perceive them, as resistance to both flood risk mapping and managed dyke realignment has historically affected projects (Sherren et al., 2019). An understanding of what drives resistance to adaptation will allow policy makers and governments to implement effective communication and participation strategies that work to reduce resistance.

Dykes (elsewhere in the world typically spelled dikes) and dykelands (also known as polders) were originally implemented in various places across the globe to drain tidal wetland so as to be able to farm the land and/or protect low-lying land from tidal fluctuations. Within the Bay of Fundy, previous research found that the hard infrastructure of dykelands has become an important aspect of both the natural and cultural landscape, and that the dykes themselves are important for sense of place, along with social and recreational activities for the local communities (Chen et al., 2020; Sherren et al., 2016). This community importance has resulted in opposition to the implementation of nature based climate adaptations which would impact the dyke infrastructure (Sherren et al., 2019)

In this region, dykes currently protect areas from coastal flooding, but also can exacerbate flooding upland by narrowing the floodplain for rainfall, storm surges or extreme high tides. The drainage system in dykes operates by the opening and closing of

aboiteaux, which are a one-way hinged gate or door which open at low tide to allow for drainage of freshwater but close at high tide to prevent saltwater intrusion. During a storm, fresh water can be trapped behind the dyke, causing flooding if rainfall comes at high tide or the aboiteaux is kept closed due to a storm surge.

This study sought to understand how residents of the Minas Basin region perceive the implementation of publicly available flood-risk mapping and managed dyke realignment strategies, and to identify factors driving resistance to the adaptations. To do so, this study sought to answer the following questions:

1. What perspectives exist among residents of the Minas Basin Region regarding the coastal climate adaptation strategies of dyke realignment and publicly available flood risk mapping?
2. How do psychological concepts related to temporal and spatial scales of thinking and decision making influence resistance to coastal climate adaptations?

1.3 Context: The Bay of Fundy Dykelands

This research took place in the Bay of Fundy coastal region, specifically within Minas Basin located in the upper southern region of the Bay (Figure 1). This region is home to the dykelands, which are fertile agricultural lands dating back to early Acadian settlers who first arrived in the region in 1604 and began dyking in the 17th century (Bleakney, 2004; Rudin, 2021). Dykelands are converted tidal wetlands that are protected from the ocean by earthen dykes and drained through ditches and one-way drains (called aboiteau(x)) that only open at low tide. Prior to the construction of dykes, salt marshes dominated in the tidal estuaries, and acted as natural flood buffers in coastal areas

(Sherren et al., 2016). It has been estimated that 69% of coastal tidal wetlands in the Bay of Fundy region have been lost due to dyking and associated activities (Sherren et al., 2021). Today's dyke system is inadequate for the sea level rise the region faces, with 70% of current dykes at risk of being overtopped by a storm surge (van Proosdij et al., 2018). Maintaining the 240km of dykes that are on the Nova Scotian side of the Bay of Fundy, shown below in Figure 1, is both technically and economically unrealistic, as the Nova Scotia Department of Agriculture, who is responsible for dyke maintenance, has inadequate resources, and technically there are locations where there is not enough room to widen the dykes enough to support raising them (van Proosdij et al., 2018).

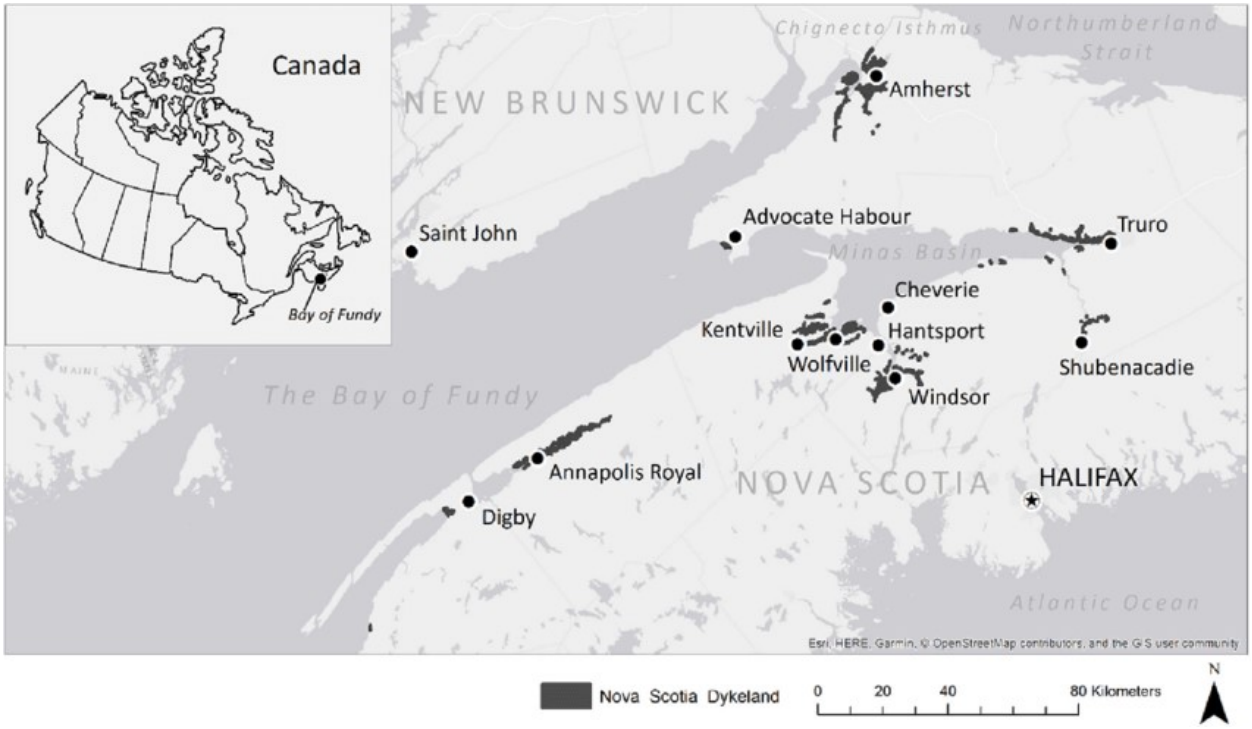

Figure 1: Bay of Fundy Dykelands Region, highlighting dykeland area on the Nova Scotia side and population centres. *Map from Sherren et al., 2021 (created by Yan Chen).*

In addition to risks in the region faced by dykeland management in the Bay of Fundy, the region is also at extreme flood risk. The Bay of Fundy is projected to

experience some of the greatest relative sea level rise of Canadian coastlines, with an expected average increase of 77-120 cm by the year 2100 (James et al., 2015). This is because, in conjunction with rising sea levels, the region is experiencing glacial-isostatic adjustment, causing the land to subside (Bush et al., 2019). The Bay of Fundy region is known for the largest tides in the world, with the average tidal range being 13 meters in the Minas Basin (NOAA, 2023). The region experiences significant annual flooding, most of which is coastal or pluvial in nature. Coastal flooding, mainly from storm actions and surges from hurricanes, has damaged infrastructure across the region in many recent events, including Hurricane Fiona in 2022 and Hurricane Dorian in 2019. Pluvial flooding, which is a result of rainfall or snowmelt, occurs annually during the springtime throughout the Bay of Fundy watershed region, and occasionally throughout other times of the year, washing out roads, damaging infrastructure and isolating people in their homes (Starratt, 2022). Pluvial flooding can also lead to fluvial flooding, which occurs when rivers or other water bodies in the region overflow beyond their banks or shores due to excess rainfall or significant snowmelt. Flooding is particularly challenging in dykeland areas if the rainfall occurs at high tide when the aboiteaux are closed.

1.4 Introduction to Conceptual Theoretical Framework

As described, resistance to the implementation of nature-based solutions may be driven by a variety of factors. In a study conducted by Sarabi et al. (2020), who interviewed urban or environmental planning experts from various municipalities across the globe, but concentrated in Europe, it was found that there can be a public lack of awareness, apathy toward adaptation needs, and resistance to change. There may also be resistance to implementation from governments related to a silo mentality causing lack of

collaboration across required departments, lack of standards and frameworks for implementation, lack of knowledge and skills for implementation, actual or perceived cost, and zoning and property ownership challenges (Sarabi et al., 2020). In this study, we sought to specifically explore public awareness of coastal climate adaptations including nature-based solutions, resistance to change and its drivers, and how resistance to change impacts perceptions of the implementation of nature-based solutions.

In a literature review exploring public coastal adaption options and preferences across the globe, Mallette et al. (2021) identified place attachment as an important driver of resistance, as well as a general preference to retain the current landscape and its associated affordances including rights to build on it and profit from it. While place attachment has been previously employed within the study of resistance to coastal climate adaptations (Agyeman et al., 2009), a better understanding of a wider set of psychological dimensions can provide more insight into factors that motivate resistance to coastal climate adaptations.

Previous research exploring perceptions of land-use changes in climate adaptation situations have used Climax Thinking theory to guide understanding of these perceptions (Chappell et al., 2020; Howard & Sherren, 2023; Sherren et al., 2022). Climax Thinking is a theory in development which seeks to understand why people resist public good landscape changes. Climax theory posits that individuals with high Climax Thinking may perceive the current landscape is in its final and ideal state, and have difficulty conceptualizing future or other landscapes. Climax Thinking was conceptualized with two dimensions that serve as potential axes. Spatially, on the axis from self to other, climax thinkers are oriented toward the self. A climax thinker would not recognize, for

instance, that rejecting change locally has implications for those more distant, e.g., those putting up sea walls worsening erosion for neighbours, or on a broader scale, rejecting wind turbines perpetuating coal production elsewhere. Temporally, on the axis of past to future, climax thinkers are oriented towards the present and past. A climax thinker would not recognize, for instance, that rejecting change now may have an impact on the future, e.g., those neglecting to protect their homes from flooding now needing to rebuild or repair post-flooding in the future (Sherren, 2021). Two drivers are also hypothesized in Climax Thinking, ignorance and exceptionalism. When hypothesized to be driven by ignorance, the climax thinker is unaware of the impact of their landscape-based decisions on others. When hypothesized to be driven by exceptionalism, the climax thinker may be aware of impacts, but places their own landscape-based needs and desires over the potential negative impacts on others.

Climax Thinking has previously been employed to study perceptions of various public good landscape changes, including renewable energy and coastal climate adaptations. Chappell et al. (2020), for example, discovered that within the context of wind farm development, there is significant attachment to both past and present utilitarian landscape features. This work suggests that people who show attachments to past landscapes are also capable of forming attachments to new landscape features like wind farms once they are present (although they may have opposed them before construction). Howard & Sherren (2023) examined the influence of Climax Thinking on resistance to flood risk mapping in Southwest Nova Scotia. Their results suggested that while resistance to flood risk mapping was low overall, the self/other ignorance variables were the best predictors of resistance to publicly available flood mapping, and were far more

predictive than more conventional measures such as risk perception (Howard & Sherren, 2023). Relatedly, Sherren et al. (2022) found that in experimental focus groups around Nova Scotia about nature-based coastal adaptation the use of priming devices about altruism and future generations significantly reduced measures of self-orientation among participants in pre-post tests.

Previous attempts to measure Climax Thinking has shown that it is not a single phenomenon, but influenced by a variety of factors (Chappell et al., 2020; Howard & Sherren, 2023; Sherren et al., 2022). When Howard & Sherren (2023) attempted to measure Climax Thinking, each dimension (self, other, past, future) and driver (ignorance and exceptionalism) combination of Climax Thinking was tested only as a single statement on a novel Likert scale. Similar dimensions and drivers can be found in established social psychological theories and question sets, but have not yet been evaluated in the context of Climax Thinking and coastal adaptation.

In this research we have chosen established theories and measurement instruments which might contribute to a more robust understanding of the spatial and temporal dimensions of Climax Thinking. Figure 2 below describes the dimensions of each of the four theories (Value Belief Norm theory, Basic Values theory, Time Perspective theory, and Futures Consciousness theory) in a conceptual map, using the same spatial and temporal dimensions of the Climax Thinking framework (and adding *biospherism*). The concepts taken from each theory were chosen because we hypothesized that they fit in the conceptual figure along either spatial or temporal dimensions. We can thus use Figure 2 to conceptualize the impacts of each social-psychological measure on perceptions of

nature-based coastal climate adaptations as per the Climax Thinking framework. These are briefly introduced below but explored more fulsomely in the following chapter.

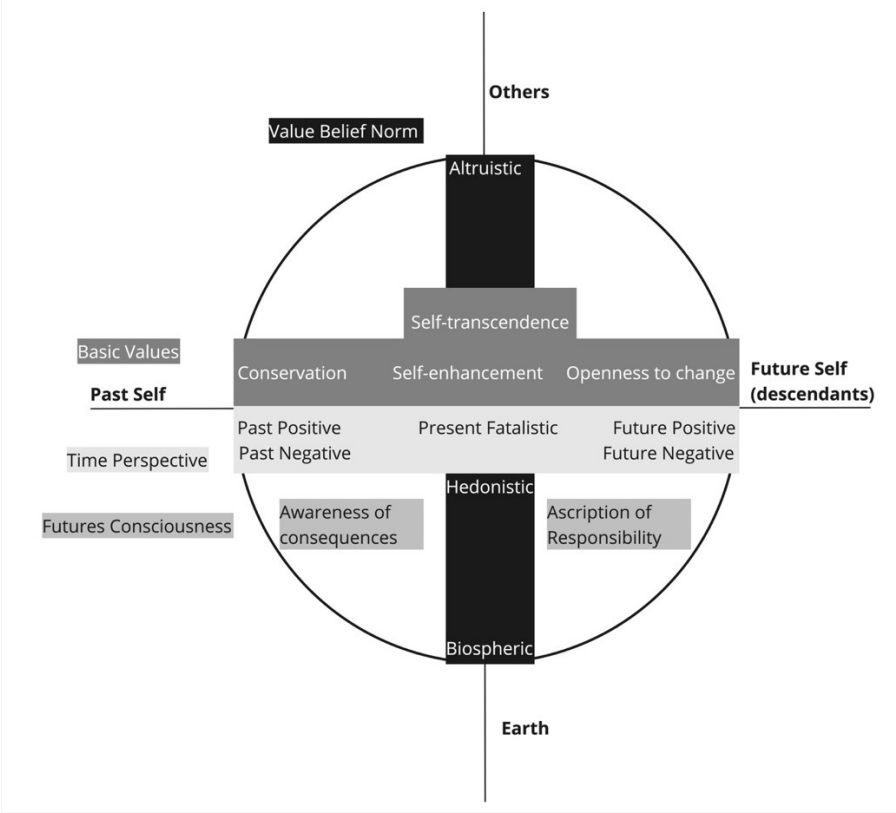

Figure 2: Theoretical Conceptual Framework*, including key constructs from each of the four theories placed along the spatio-temporal axes of the Climax Thinking framework.*

Time perspective is a theory which seeks to explain the process by which we subconsciously assign time frames to events and experiences, in order to help assign meaning to them (Zimbardo & Boyd, 1999). An understanding of where individuals place value with respect to time through time orientation theory can be used to untangle attachment to historical coastal features, such as dykes, or perceptions of future climate change, fitting into the temporal axis of the Climax Thinking framework. The Value Belief Norm theory of Environmentalism, introduced by Stern et al. (1999), explores how personal values and beliefs impact understanding of environmental norms, and resultant

level of support for environment-related actions including climate adaptations. Within the context of our research, understanding individuals' values, beliefs, and norms such as altruism or biospherism helps shape our understanding of what they value most in their environment, and the impacts of their beliefs on support for implementation of flood risk mapping and dyke realignment, fitting into the spatial axis of the Climax Thinking framework. The Theory of Basic Values explores how individuals see themselves, and can help us understand what and who they prioritize in decision making, such as openness to change, including decisions relating to climate adaptations, fitting into both the spatial and temporal dimensions of the Climax Thinking framework (Schwartz, 2012). Finally, Futures Consciousness theory explores individuals' ability and capacity for understanding the future, and subsequently preparing for it, fitting into the temporal dimension of the Climax Thinking framework (Lalot et al., 2020). Futures consciousness can allow us to explore how individuals interpret the future, for instance if they have the capacity to comprehend future potential threats of climate change on dyke infrastructure and flooding in their region.

As an alternative explanation to the Climax Thinking framework explored above, risk perception theory can help us understand how future environmental conditions are perceived, and whether a presence or a lack of risk perception may contribute to an individual's lack of ability to adapt (Hügel & Davies, 2020; Wachinger et al., 2013). While there remains debate in the literature about the link between cognition and action in terms of preparedness for events with heightened risk perception, within the context of flooding it has been found that those who live in higher risk areas are generally more accepting of climate adaptations (Jhong et al., 2020; Wachinger et al., 2013).

Through the use of these theories explored above, we are able to operationalize the Climax Thinking framework using established, tested scales. A thorough exploration into the theories chosen, how they relate to the Climax Thinking framework, and what they can indicate regarding psychological constructs relating to resistance to nature-based coastal climate adaptations is explored in Chapter 2.

1.5 Methodological Overview

In order to gain a population-level understanding of how residents of the Minas Basin region perceive coastal climate change adaptations, we engaged in a hybrid multiple-reminder mail-out survey methodology. This was completed through simple random sampling using residential addresses from the Nova Scotia Residential Dwellings Characteristics Dataset (version published January 10th 2022), excluding all addresses with more than one living unit, only 0 bathroom, and/or those currently under construction (datazONE, 2022). This dataset was spatially joined with the Nova Scotia Enhanced Postal Code Dataset (version 2021.3) obtained from the Dalhousie University GIS centre to obtain mailing addresses.

A multiple-reminder mail-out survey, based on the Dillman (1978) methodology, was utilized to collect the data. Throughout a four-month recruitment period from June to September 2022, three mailouts were dispatched. The survey was sent to a random sample of 1350 addresses within the Minas Basin area, encompassing the counties of Hants, Kings, Colchester, and Cumberland (see Figure 4). Each of the three survey invitations sent to participants included a QR code and a link for survey access, which was hosted online using Qualtrics software, as well as a unique number so we could track

completion. Prior to distribution, the content and collection of the survey received approval from the Dalhousie University Research Ethics Board (REB# 2022-6088).

The survey contained a total of 45 questions, comprised mostly of multiple choice or multi-select, along with five short answer questions. On average, it took participants 25 minutes to complete the survey. The survey contained three sections--attitudes towards flood risk mapping and managed dyke realignment, theoretical variables, and demographic characteristics--as well as a section which explored ecosystem services and uses of dykelands for research by affiliated scholars.

Analysis of results was conducted through descriptive statistical analyses using R software, as well as partial least squared structural equation modeling (PLS-SEM) using STATA software. Descriptive statistics were generated and analyzed to explore the demographic composition and distribution of the surveyed sample, and check for representativeness. Following this, further descriptive statistics explored general attitudes towards, and experiences with, flood risk mapping and managed realignment. Structural equation modelling (SEM) is a theory-driven multivariate data analysis method that is used to analyze relationships between measured and latent variables or between multiple latent variables (Hair et al., 2021; Lee et al., 2011). Within SEM modelling two approaches are possible, covariance-based SEM (CB-SEM) and partial least squared SEM (PLS-SEM). CB-SEM is predominantly used in confirmatory work, while PLS-SEM is better suited for conducting exploratory theoretical research, which is why we chose to employ this type of SEM (Fan et al., 2016). PLS-SEM consists of four main steps – building the model, estimating the model, evaluating the measurement model, and evaluating the structural model. PLS-SEM was used to explore relationships between

underlying concepts described in the theoretical model, and resistance towards both flood risk mapping and managed realignment.

1.6 Limitations

There were several limitations of this research. We engaged in a hybrid multiple-reminder mail-out survey, where participants were recruited with letters and postcards in the mail and invited to complete the survey online through a link or QR code. This required all respondents to have access to the internet and a computer, mobile phone, or tablet to be able to fill out the survey online. This excluded those without internet connection or devices which connected to the internet. While we did offer the option to contact us via mail or email to request a paper copy of the survey to complete and return to us in the mail, only one participant engaged with this option. Furthermore, the representativeness of our sample was impacted by the data availability of addresses to recruit from within this region. As we were denied access to the provincial residential addresses dataset for privacy reasons, we were only able to confidently address mail to single-unit homes within the residential dwellings dataset, as there was no way to figure out how many units were in multi-unit homes and address them individually. As this is a rural region, this only resulted in the elimination of a minority of addresses, but those eliminated this way are likely to be different in age and/or income levels than those in single-unit homes (see Chapter 2). This introduced systematic bias, which we can see reflected when we compare with Census population data for the region.

When implementing a survey-based methodology, there are always limitations related to response rate. This leads to a self-selection bias, where those who are more inclined to respond to the survey are likely more familiar with and engaged with the issue

(Whitehead, 1991). As a result, the conclusions drawn from this research may not be representative of the Minas Basin region as a whole, but may over represent the opinionated or those with more leisure time to complete the survey. The representativeness of our sample was explored by comparing demographic factors of gender, income, and education to the 2021 Canadian census of the counties of Hants, Kings, Cumberland, and Colchester. A majority of our respondents were between the ages of 50 and 70 and female, and generally had higher income and more post-secondary education than the average population of the area. Those with an income under $50,000, younger than 40 and older than 70, males, and those with a high school or lower education were underrepresented within our sample. Additional data regarding representativeness of the sample can be found in Appendix A.

In addition to considerations of representativeness within our sample, the results from this research are specific to the Minas Basin region and cannot be generalized to flood risk mapping and managed dyke realignment projects in other regions. Even across Nova Scotia, previous research exploring flood risk mapping acceptance in the South Shore showed differing perspectives, with less resistance than those in the Minas Basin region (Howard & Sherren, 2023). Results of this study should only be used to understand general, population-level perspectives and attitudes towards managed dyke realignment and flood risk mapping within the Minas Basin region.

1.7 Thesis Structure

This thesis is presented as five chapters, including two separate but related substantive papers. Chapter 2 describes the theoretical background and methods, which are the same for both papers. It explores the operationalization of Climax Thinking

theory, which guides both substantive papers, into a theoretical framework to understand resistance to managed dyke realignment and publicly available flood risk mapping. This chapter also discusses the study area of the Minas Basin, and more detailed methods used for data collection and analysis throughout both papers. Chapter 3, which is the first paper, discusses the historical and cultural attachment to the dykeland landscape, as well as management options present for dykelands within this region. This chapter also explores which demographic and psychological dimensions contribute to resistance towards managed realignment within the Minas Basin region. Chapter 4, which is the second paper, discusses perspectives surrounding publicly available flood risk mapping for the Minas Basin region. This chapter further explores which demographic and psychological dimensions contribute to resistance towards publicly available flood risk mapping in the Minas Basin region, adding the variable of risk perception. Finally, chapter 5 summarizes key findings of the study, as well as implications for both policy and theory, and directions for future research.

The work presented in this thesis represents the culmination of my Masters degree at Dalhousie University. Although this thesis is the culmination of this learning journey, I could not have developed the research and analytical skills required to accomplish this study as a responsible researcher without the support and contributions of my supervisors and committee members. This thesis is structured in a two-paper (chapters 3 and 4) format, as it is intended for publication as two separate, substantive academic journal articles. I chose to use the term ‘we’ throughout this thesis in recognition of the critical contributions of my supervisors, Dr. Kate Sherren and Dr. Brooke McWherter, as well as

my committee member Dr. Karen Akerlof, whom are all going to be co-authors on the papers that arise from this work.

Chapter 2: Theoretical Background and Methods

2.1 Theoretical Framework

2.1.1 Climax Thinking

Within the scope of this thesis, Climax Thinking serves as an organizational framework, operationalized through the implementation of existing measures in social psychology, with the goal to improve the rigour of the theory. Previous attempts to measure Climax Thinking in Howard & Sherren (2023) and Sherren et al., (2022) were able to validate the utility of the framework as well as face and content validity, however lacked the ability to explore construct and criterion validity in its measures. Throughout this study, we sought to improve construct validity, which describes how well constructs measure the desired phenomenon, through creating constructs from well-established theoretical measures.

Climax Thinking is a working theory which was originally developed to present hypotheses for psychological dimensions of resistance to landscape-based changes. The climax thinker believes they live in a climax landscape state, one almost fated for the area, and faces psychological barriers to comprehension of past or possible future land uses (Sherren, 2021). Climax Thinking is hypothesized to be caused by either exceptionalism or ignorance drivers (Sherren, 2021). When caused by ignorance, it suggests a person lacks awareness in considering alternative past or future land uses or the way that their own land use decisions (including resistance to nearby changes) impact others. For instance, resistance in one place can cause land use changes to be forced on those less politically powerful. When caused by exceptionalism, Climax Thinking

suggests that people might set themselves above the need to consider other alternative land uses or other people on equal terms to themselves.

This working theory posits that both spatial and temporal dimensions might influence climax thinkers. Spatially, Climax Thinking describes our lack of ability to accept change, based on lack of understanding of impacts on others elsewhere whose landscapes are changed as a direct impact of our decisions to hold ours static (Sherren, 2021). Temporally, Climax Thinking explores our lack of understanding and acceptance of different previous or future landscapes existing where our 'ideal' one is today (Sherren, 2021). The 'climax thinker' considers themselves and the preservation of the status quo to be the most important aspects in landscape-based decision making, potentially also looking backward to the source of that status quo. The dimensions of Climax Thinking stem from the intersections between the drivers and the spatio-temporal dimensions framework, resulting in eight dimensions defined in Table 1.

Table 1: Dimensions of Climax Thinking Theory

Climax Thinking Dimension	**Climax Thinking Pathology** (informed by Howard & Sherren, 2023; Sherren, 2021; Sherren et al., 2022)
Past-ignorance	Someone who is unaware of previous land uses.
Self-ignorance	Someone who perceives themselves as unable to adapt to landscape change.
Other-ignorance	Someone who cannot comprehend impacts of local landscape decisions on others in their community or elsewhere.
Future-ignorance	Someone who believes current solutions will hold up in future landscape conditions.
Past-exceptionalism	Someone who perceives previous land uses as building up to the current, ideal one.
Self-exceptionalism	Someone who perceives themselves as above the need to accept landscape change.
Other-exceptionalism	Someone who perceives others as needing to accept landscape change before they do.
Future-exceptionalism	Someone who perceives future generations as less important in landscape-based considerations than this current one.

Climax Thinking theory has previously been used to explore resistance to both climate change mitigation and adaptation strategies. Chappell et al. (2020) studied attachment to utilitarian landscape features, specifically wind turbines for renewable energy generation, and found there is significant attachment to past utilitarian landscape features, including dykes. Moreover, attachment to such utilitarian features predicted a capacity to support more wind turbines only if turbines were already visible from the person's home. This demonstrated that wind turbines had become part of the climax

landscape for these people. Chappell's survey research took place in the Chignecto region spanning the Nova Scotia and New Brunswick border, which overlaps the Minas Basin region, and found that within that region there is significant attachment to the dykes (Chappell et al., 2020). Howard & Sherren (2023) applied Climax Thinking to understand opposition to publicly available flood-risk mapping in Nova Scotia's South Shore region using a survey. Using eightnovel statements designed to test the dimensions and drivers of Climax Thinking, they discovered that self-ignorance and other-ignorance are significant drivers of real-estate-related resistance to the implementation of publicly available flood risk mapping. This raises questions about whether self-ignorance and other-ignorance may be drivers of climax-thinking behaviour across adaptation contexts. Howard & Sherren (2023) further found that Climax Thinking theory suggests that ignorance, rather than exceptionalism, may be the leading cause of the phenomenon.

Previous research exploring Climax Thinking has uncovered that this is not a single characteristic, but it is influenced by a variety of underlying spatial and temporal drivers. Factor analysis has indicated independence of the causes (exceptionalism and ignorance) of Climax Thinking (Sherren et al., 2022),. In order to explore which specific spatial and temporal drivers contribute to a resistance to coastal climate change adaptations, we chose to explore pre-existing theories with validated question sets within the literature that measure these same spatial and temporal dimensions.

2.1.2 Theoretical Conceptual Model

To operationalize each of the spatiotemporal dimensions of the Climax Thinking framework, we drew from four overlapping well-established theories in the social science literature, each of which engage with specific dimensions of Climax Thinking, however

were not specifically landscape-focused in the constructs they assess. Dimensions within these theories were used to measure each of the seven constructs we tested in this study, found below in Table 2.

Table 2: Creation of constructs. *Creation of the constructs used to test the Climax Thinking framework, including their original sources.*

Climax Thinking Dimension	**Construct**	**Source**
Other	Other focused	Basic values (Schwartz, 1994)
Self	Self concerned	VBN (Gärling et al., 2003)
Past	Past focused	Time perspective (Zimbardo & Boyd, 1999)
Future	Future focused	Futures consciousness (Lalot et al., 2020)
Present	Present focused	Time perspective (Zimbardo & Boyd, 1999)
New, not in original Climax Thinking framework	Concerned for nature	VBN (Gärling et al., 2003)
New, not in original Climax Thinking framework	Biospherism	Basic values (Schwartz, 1994); Futures consciousness (Lalot et al., 2020)

The temporal dimensions of Climax Thinking capture which timeframes are valued and prioritized in landscape-based decision making. Understanding how individuals use and interpret time as an underlying factor in decision making also informs responses to coastal climate adaptations. Time perspective is the process through which we subconsciously assign time frames to events to help assign them order and meaning, and our personal time perspectives have a significant influence on our future actions and decisions (Zimbardo & Boyd, 1999). Many of our key psychological processes are influenced by time perspective, including memory, routine, and cognition (Zimbardo & Boyd, 1999). Time perspective theory, which is used to understand where an individual's time focus lies, can be measured with the Zimbardo Time Perspective Inventory (ZTPI),

which places an individual's time perspective within the parameters of past-negative, past-positive, present-hedonistic, present-fatalistic, future-negative, or future-positive (Zimbardo & Boyd, 1999). Time perspective has been explored in relation to risk-taking behaviours, specifically finding that those exhibiting present-hedonistic time perspective are more likely to take risks with regards to risky driving, smoking, substance abuse, health decisions (i.e. safe sex), and financial decisions (i.e. investing and gambling) (Apostolidis et al., 2006; Jochemczyk et al., 2017; Keough et al., 1999; Protogerou & Turner-Cobb, 2011; Zimbardo et al., 1997). Work on renewable energy landscapes using Climax Thinking suggested that an orientation to past and present landscapes might influence resistance to proposed land use change (Chappell et al., 2020), and experimental focus groups suggested that an orientation to future generations might support coastal adaptation (Sherren et al., 2022). Understanding time perspective allows us to establish innate temporal values such as if individuals are concerned predominantly with the past, present, or future.

The Value Belief Norm Theory of Environmentalism (VBN) was developed by Stern et al. (1999) to explore social-psychological measures of support for environmental movements. It explores the links between personal values, beliefs, and personal norms, and how these impact pro-environmental action (Stern et al., 1999). This theory is influenced by prior work in personal values, beliefs, and norms. In terms of values, VBN theory explores core values relating to environmental concern: egoistic values (self-interest), altruistic values (concern for others), and biospheric values (altruism towards the natural environment). The norms in VBN are informed significantly by Schwartz's understanding of moral norm activation (1973, 1977), which explains how pro-

environmental actions occur in response to norms about these actions, and are activated in response to beliefs that current environmental conditions threaten the natural environment (awareness of consequences), and that actions they personally take could impact outcomes for the natural environment (ascription of responsibility to self) (Schwartz, 1973, 1977). This is further explored in the New Ecological Paradigm (NEP), which is founded on the belief that some anthropogenic actions have an adverse impact on the natural environment (Dunlap & Van Liere, 1978). In the VBN, personal values and beliefs impact understanding of environmental norms, which in turn influence an individual's levels of support and associated actions such as environmental activism, environmental citizenship (support individual responsibility and actions), policy support, and private-sphere behaviours (Stern et al., 1999). Gärling et al. (2003) created a revised questionnaire based on VBN, which has since been replicated (Hansla et al., 2008), that assesses these personal values, beliefs, and norms in decision making contexts. We employed statements from this questionnaire assessing concern for oneself—in terms of the values of hedonism and egoism—as well as priority for the natural environment in decision making. Acceptance of managed realignment, which restores previously human modified landscapes back to the original natural state, as well as flood risk mapping, which can act as an awareness raising tool for environmental phenomena, could be influenced by understanding and prioritization of the natural environment in decision making.

Somewhat overlapping Value Belief Norm Theory is the Theory of Basic Values, first introduced by Schwartz (1994), which explores differing core values and the impacts of our core values on our actions and decision making. Through extensive

implementation and refinement of this theory, it was found that the ten basic values identified are generally culturally universal (Schwartz, 1994, 2012). The Portrait Value Questionnaire (PVC) is an established psychometric instrument which facilitates the identification of personal value orientations, and can be used to explain individual beliefs and behaviours (Bouman et al., 2018; Schwartz, 2012). These values are characterized along four broad categories: openness to change, conservation, self-transcendence, and self-enhancement (Schwartz, 1994). Individuals expressing conservation (which in this context means conservatism) and self-enhancement may be less likely to be open to pro-environmental actions, whereas those expressing openness to change and self-transcendence may be more likely to accept pro-environmental actions (Bouman et al., 2018). Understanding these values will allow for a more nuanced understanding of why individuals are resistant to coastal climate adaptations.

Futures Consciousness is a new way of understanding an individual's capacity for understanding and preparing for the future (Lalot et al., 2020). It encompasses five dimensions: time perspective, agency beliefs, openness to alternatives, systems perception, and concern for others (Ahvenharju et al., 2018). Time perspective in this context is based upon work from Zimbardo & Boyd (1999), discussed above, focusing expressly on our understanding of the future with respect to decision making. Agency beliefs are an individual's perception of their ability to influence future events. Openness to alternatives describes an individual's adaptability and willingness to accept changes that may come in the future, overlapping with Schwartz's Theory of Basic Values, discussed above. Systems perception is an individual's understanding of the interconnectedness of all systems, including biological and social, and the consequences

of actions across these systems, which overlaps with the theoretical basis of NEP in terms of the interconnectedness of biological systems, discussed above. Finally, concern for others is how individuals value others in their understanding of the future, which is also explored adjacently through Schwartz's Theory of Basic Values, discussed above. The scale that measures future consciousness has been empirically tested across populations, and there is a strong relationship between each of these individual factors (Lalot et al., 2020). The future-conscious individual is extroverted, conscientious, and open to change, characteristics opposite to the climax thinker who is stuck in the past and present and unable to consider others on equal terms. An understanding of the presence of future consciousness within our sample helps us explore the temporal axis of Climax Thinking, specifically with relation to the future, and provides insight into which characteristics climax thinkers may lack.

The interactions between each of these theories help us to operationalize all the spatiotemporal dimensions of Climax Thinking theory, which is shown below in Figure 3. Exploring the relationships between basic value theory, value belief norm theory, time orientation, and future consciousness, and their respective predictive powers with respect to resistance to nature based coastal adaptations, allows us to gain a holistic understanding of this issue. Furthermore, interactions between these psychological dimensions helps to uncover who is likely to be resistant to coastal climate adaptations within the Minas Basin region, and what can be done to minimize this resistance.

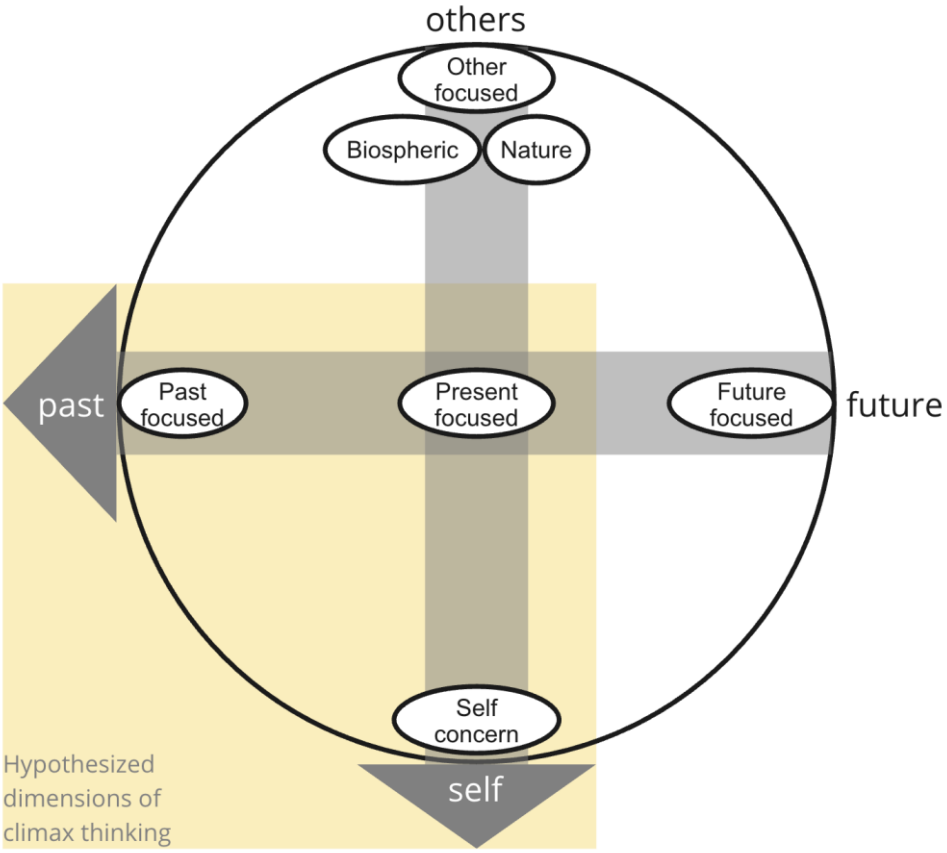

Figure 3: Conceptual Map of Theoretical Framework. *Seven constructs created from the hypothesized spatiotemporal dimensions of Climax Thinking and grounded in supporting theories places across these spatiotemporal dimensions. Time dimensions explore the importance of the past, present, and future in decision making, while space dimensions explore the importance of self, others, and the natural world.*

In addition to the theoretical variables exploring dimensions of Climax Thinking, risk perception theories were employed in order to explore how risk is perceived in the face of landscape changes and natural disasters (Hügel & Davies, 2020; Keller et al., 2012; Wachinger et al., 2013). Across a variety of environmental risks, including floods, landslides, droughts, and earthquakes, researchers have found that risk perception is heavily influenced by both personal experience with a previous environmental hazard, and level of trust in decision making authorities who act to mediate environmental risks

(Wachinger et al., 2013). There is a notable paradox within environmental risk perception literature, as it is unclear if increased risk perception leads to increased preparedness for future environmental disasters. Generally, increased preparedness is related to trust in authorities and ability to recall severe damages from past events, items we do not explore here, but not necessarily to increased risk perception (Wachinger et al., 2013). Through operationalization of this theory in surveys, it has been demonstrated that those who live in areas with heightened environmental risk are generally more accepting of incoming climate adaptations (Hügel & Davies, 2020; Jhong et al., 2020), however, this remains dependent on what individuals attribute the causes of climate change impacts to (Myers et al., 2013). In our context, understanding of risk perception can help us understand how respondents perceive future environmental conditions and their potential personal implications. This could provide an alternative explanation to the Climax Thinking framework if resistance comes from individuals not being able to appropriately perceive their own risk and the resulting need to adapt.

2.2 Study Area: The Minas Basin, Upper Bay of Fundy

The Bay of Fundy dykeland region spans two provinces and includes 373 km of dykes protecting 33,000 hectares of drained land, approximately 70% of which continues to be actively farmed in Nova Scotia (Sherren et al., 2021; van Proosdij et al., 2018). The Minas Basin is located on the Nova Scotia side of the inner Bay of Fundy. Although much of the high tidal wetland areas of this region have been drained by dyking, there remains about 1,330 hectares of low tidal wetlands in the intertidal zones of the basin (Bay of Fundy Ecosystem Partnership, 2001). The watershed area of the Minas Basin covers about 20 per cent of mainland Nova Scotia, and is roughly 5 times larger in

surface area than the basin itself, making the region susceptible both to flooding from the outer Bay of Fundy, and overland from the watershed (Bay of Fundy Ecosystem Partnership, 2001). Much of the dyke infrastructure is threatened due to sea level rise and larger storm surges resulting from climate change (van Proosdij et al., 2018). Some foreshore tidal wetland areas, which once protected the dykes through wave attenuation, have become engulfed by the bay through coastal squeeze (Sherren et al., 2021). Although the dykelands in the Minas Basin were originally intended for agricultural production, it is estimated that within the Nova Scotian coasts of the Bay of Fundy, only 70% of the area remains agriculturally active (Sherren et al., 2021). With an estimated 77-120cm of expected sea level rise by 2100, as well as a projected significant increase in frequency and severity of storm surges, dyke management decisions within this region are critical to make before the infrastructure fails (James et al., 2015; Sherren et al., 2021).

The Minas Basin was chosen purposively due to the high flood risk of the region. As it is located at the head of the Bay of Fundy, it experiences the most dramatic tidal ranges of the bay, with water level fluctuating up to a maximum of 16 meters every 12 hours (NOAA, 2023). Towns within the region suffer regular flooding not only due to tidal flooding, but also experience significant coastal flooding due to storm surges, pluvial flooding as a result of excessive precipitation, and fluvial flooding caused by rivers overflowing from excessive precipitation or snowmelt.

Research was conducted within the counties of Hants, Kings, Cumberland, and Colchester, outlined below in Figure 4. These counties were chosen as they fully encompass the Minas Basin region, and they are also inclusive of the most densely

populated regions of the Bay of Fundy on the Nova Scotia side. This provided an opportunity to engage with people who had varied flood and dykeland related experiences, all of whom are impacted by coastal and dykeland management decisions. As a result, we were able to garner a more population-level perspective on these issues, engaging with people who live both along the dykelands, in low lying areas, and those who live further inland.

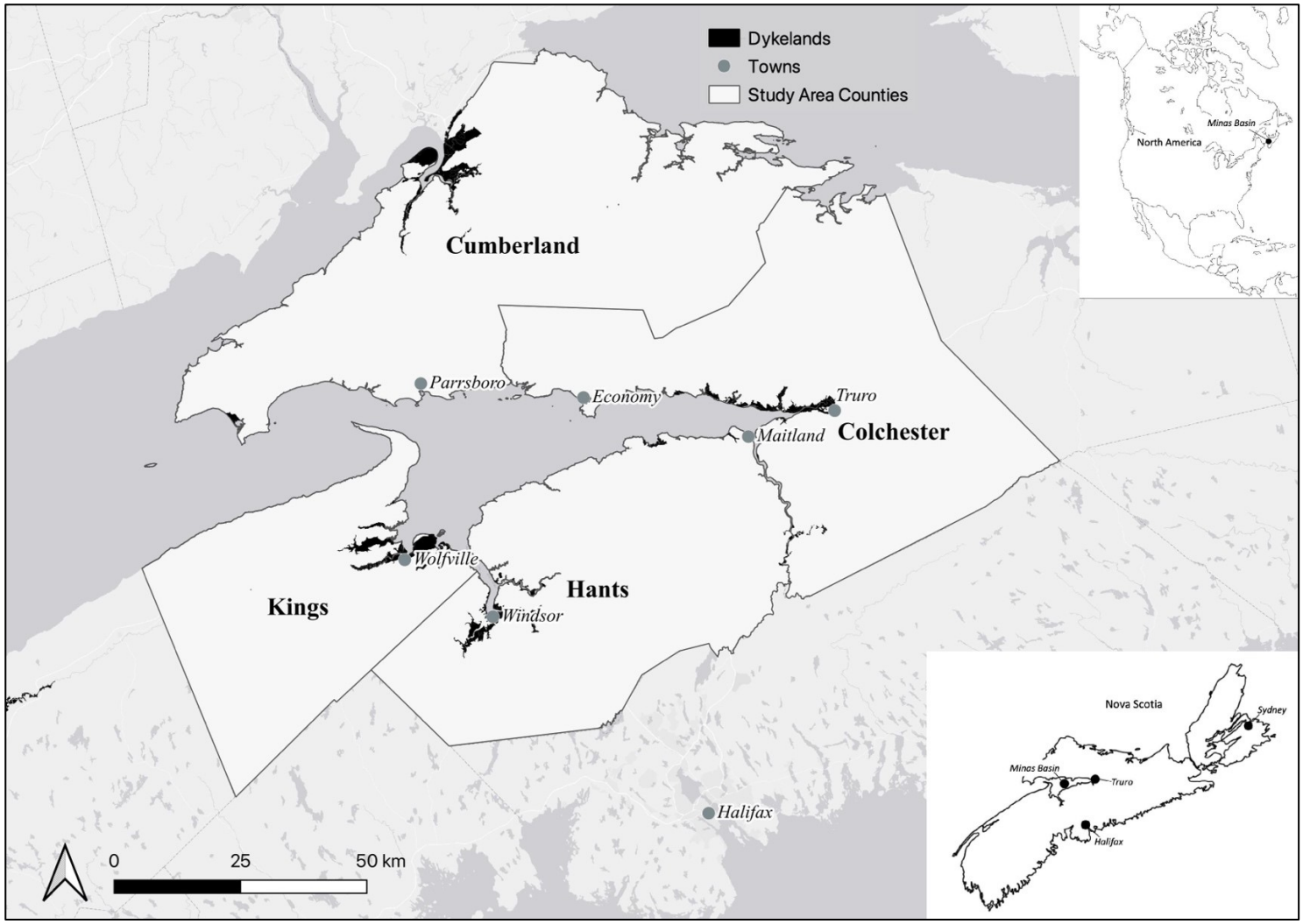

Figure 4: Study Area Overview. *Created by Samantha Howard, 2023.*

2.3 Data Collection

2.3.1 Survey Implementation

Simple random sampling was used to obtain a sample of residential addresses located within the Minas Basin study area, specified above in Figure 4. This sample was selected from addresses on the Residential Dwellings Characteristics dataset on January 10th, 2022 (datazONE, 2022). This dataset provides civic addresses and map coordinates, as well as information regarding each residential dwelling in the province. To maximize the chances of the survey being received by currently inhabited single-family residences, all dwellings with more than 1 living unit, only 0 bathrooms, and/or currently under construction were eliminated. There were 79,501 addresses in the initial dataset. After eliminations, there remained 69,929 addresses. Our final random sample included 1,350 addresses, which represents approximately 2% of eligible addresses, and was estimated to be able to provide a representative sample using this multiple mail-out methodology based upon a similar methodology implemented in a partially overlapping region by Chappell (2019).

As this dataset does not contain postal code information, the NS postal code dataset was obtained from the Dalhousie University GIS Centre, using version 2019.3 from DMTI Spatial. Postal code data was spatially joined to the addresses using the intersect function in QGIS. All mail was addressed to “the residents of” each address, as we were unable to gain access to data which indicated names of occupants at each address. Use of this strategy with this dataset in previous research resulted in a significant amount of mail being returned to sender (Chappell, 2019). Despite this limitation, we chose to use this strategy, as it was the most accurate list we were permitted to access of dwellings in the

region. Canadian privacy regulations left us without other alternatives, as we were denied our access request for the property ownership dataset for survey purposes.

Data was distributed using a hybrid multiple mail-out survey method, adapted from Dillman (1978). A total of three mailouts were sent over the course of a four-month recruitment period. The first mailout sent on June 6th, 2022, was a letter, the second mailout sent on July 8th, 2022, was a postcard, and the final mailout sent on September 2nd 2022 was a letter. The survey was hosted online, using Qualtrics software. All three survey invitations received by participants included both a QR code and a link to access the survey. Addresses were only sent a reminder if they did not complete the survey, although slow turnaround at Canada Post in relation to undeliverable mail was a significant challenge. Completion was identified by necessitating participants to enter a unique code printed on their mailed-out invitation.

The contents and collection of the survey were approved by the Dalhousie University Research Ethics Board prior to distribution (REB# 2022-6088). The first 100 participants who responded to the survey had the option to enter a drawing for 1 of 10 $50 Irving Gas or Tim Hortons gift cards, and all remaining participants had the option to enter a draw for 1 of 10 $25 Irving Gas or Tim Hortons gift cards (choice of retailer was left to the participant).

2.3.2 Survey Design

In order to understand how residents perceive coastal climate adaptations, the survey contained three sections: attitudes towards flood risk mapping and managed dyke realignment, theoretical variables, and demographic variables. The survey also included a section which explored ecosystem services and uses of dykelands, which was used to

inform a different research project. The survey contained a total of 45 questions, comprised mostly of multiple choice and multi-select questions, and five short answer questions. The complete survey can be found in Appendix 2. On average, it took participants 25 minutes to complete the survey. Of the 266 people who began the survey, 35 did not complete the survey in its entirety. 233 responses were complete enough to include in analysis.

Demographic variables collected included age, gender, highest level of education, average annual household income, if participants had children or grandchildren, number of years lived in the region, and personal identification with ethno-cultural groups associated with wetlands or dykelands within the region including Acadian, New England Planters, African Nova Scotian, or Mi'kmaq. This section provided us with a range of quantitative information to understand the representativeness of our participants, as well as whether these demographic variables influenced attitudes towards managed realignment and flood risk mapping.

Theoretical variables included questions from the Zimbardo Time Perspective Inventory (ZTPI), Schwartz's Portrait Value Questionnaire (PVC), Futures Consciousness scale, and questions exploring VBN and risk perception theories. Questions within this section were all taken from pre-validated scales to explore the Climax Thinking framework. Statement choices were carefully made to manage the length of the survey, such that the entire scales were not able to be included. All questions in this section were Likert-scale based.

Attitudes about and experiences with flood risk mapping and managed dyke realignment were explored through both qualitative and quantitative questions on the

survey. Attitudes towards the outcomes, both positive and negative, of flood risk mapping and managed realignment were explored through Likert-based scales, where participants agreed or disagreed with statements. Details about these scales are described in the following chapters. Experiences surrounding flooding and managed realignment were also explored qualitatively through open-ended short answer questions, where participants were asked to share their personal experiences, as well as opinions regarding management options for the future.

2.4 Analysis

We examined results collected from respondents to the survey quantitatively using descriptive statistics and analyzed using a partial least-squared structural equation modelling (PLS-SEM), and through exploratory qualitative analysis. We first generated descriptive statistics to understand the demographic composition of the surveyed sample. We further assessed attitudes towards managed dyke realignment and publicly available flood risk mapping through descriptive statistics. Following this, we used PLS-SEM to explore relationships between latent constructs represented within the theoretical model (Figure 3) and resistence towards both flood risk mapping and managed realignment. We built two separate models, one exploring resistance to flood risk mapping and another exploring resistance to managed realignment. In order to understand and discuss our results, we explored the responses from short-answer sections of the survey, however we did not complete qualitative analysis.

Structural equation modelling (SEM) is a statistical analysis technique which enables the development and evaluation of multivariate relationships, and allows for the exploration of relationships between multiple dependent and independent variables

simultaneously (Hair et al., 2021). The aim of SEM is to estimate, test, and ultimately represent a theoretical model in a way which explains as much of the variance as possible (Ramlall, 2017). SEM was chosen as the most appropriate statistical analysis approach for this research, because it allowed for the development and exploration of constructs (i.e., underlying concepts informed by measured indicators/variables) and accounted for the inherent error created in developing said constructs. Furthermore SEM was selected over a multivariate regression because it allowed for more variance to be explained and accounts for both indirect and direct effects, while regression only accounts for direct effects (Lee et al., 2011). Through SEM, we were able to explore both direct and indirect psychosocial drivers of resistance to flood risk mapping and managed realignment, allowing for a deeper understanding of what truly underlies these behaviours, even indirectly. Indirect drivers have the potential to impact direct drivers, and these relationships are important to understand in order to truly implement solutions that aim to reduce resistance to coastal climate change adaptations. Constructs in SEM can either be reflective, which are constructs that cause their indicators, or formative, which are constructs that are caused by their indicators (Sarstedt et al., 2016). The reflective constructs include our theoretical constructs, as their presence can only be measured or approximated indirectly through the use of psychometric evaluation tools, such as questionnaires. The formative constructs include our demographic variables as well as risk perception, which we can directly assess through our survey; our models use both.

SEM can be conducted either by a covariance-based SEM (CB-SEM) or a partial least squared SEM (PLS-SEM). CB-SEM is based upon covariance, and focuses on the theoretical covariance matrix, as opposed to the explained variance which is what PLS-

SEM aims to maximize (Amaro et al., 2015; Dash & Paul, 2021). We selected the PLS-SEM approach as it is best suited for exploratory work, allows for the use of non-metric data (i.e. ordinal and nominal), and does not require a specific distribution of data nor a large sample size (Hair et al., 2017). The PLS-SEM allowed us to explore the application of the Climax Thinking framework, as well as look at the underlying relationship between constructs taken from other potentially compatible theories. The PLS-SEM consists of four main steps; building the model based off of our constructs, estimating the model, evaluating the latent variable measurement models for both formative and reflexive constructs, and evaluating the structural model to determine relationships between latent variables. All PLS-SEM analyses were conducted using *plssem* command in STATA SE17.

Chapter 3: Understanding psychological drivers of resistance to managed realignment in the Minas Basin, Bay of Fundy

3.1 Introduction

Coastal climate adaptations are purposeful human interventions in coastal areas to protect people and the coast from impending threats to the landscape (Mallette et al., 2021; Vouk et al., 2021). This includes both structural adaptation (i.e., hard line) approaches as well as nature-based adaptation (i.e., soft line or retreat) approaches (US EPA, 2022). In the face of the climate crisis, nature-based solutions have the potential to sustainably protect—and restore previously modified—coastal ecosystems in ways that simultaneously address social and ecological challenges (International Union for Conservation of Nature, 2020).

Nature-based solutions aim to encourage management which mimics or facilitates a natural coastal ecosystem (Vouk et al., 2021). Nature-based coastal climate adaptation can employ a diversity of strategies including adapting the coastal land uses and ecosystems for new conditions, and restoring natural coastal features to decrease erosion (Temmerman et al., 2013). The solutions are often site specific, as certain coastal environments, including dykelands, have been heavily influenced by centuries of anthropogenic activities, and require different management strategies than unaltered coasts. Compared to hard-infrastructure solutions, nature-based coastal adaptations typically require a significant adjustment period before effects are achieved, which means

that local coastal residents need to accept changes to the coastline or what they can do there before they fully realize the risks or the benefits (Sherren et al., 2022).

Globally, dyke systems are facing significant challenges. Although in Atlantic Canada they are mostly limited to the Bay of Fundy region, dykelands exist globally, including in the Netherlands, United Kingdom, Greece, and Bangladesh. Currently, dykeland systems globally are faced with critical management decisions in light of climate change, as many are at risk of overtopping, flooding or salt water intrusion (Ebersole et al., 2010; Islam et al., 2019; Sherren et al., 2021). With such infrastructure at risk of failing, there are three key management options for dykes: raising, removing, and realigning. Raising dykes involves building current dykes higher so that they can withstand sea level rise and storm surges in the region. This is expensive and not always physically feasible, as building higher requires a wider base and there is not always space due to coastal squeeze (Sherren et al., 2021). Removing dykes involves completely breaching and/or removing a dyke and allowing for the ecosystem to naturally restore tidal wetland, sometimes with human assistance such as planting or earthworks. Managed realignment is a solution which offers a compromise of keeping some actively farmed dykelands protected by building new and higher dykes landward around them, while restoring some of the land previously protected by dykes to wetlands (Figure 5). This technique is also called depolderisation across the globe, and has been implemented throughout North America, Europe, and the Middle East (Goeldner-Gianella et al., 2015). Through the restoration of tidal wetlands in managed realignment, flood risk is further reduced in coastal communities protected by the dykes as the floodplains become wider

and vegetated, increasing their ability to hold water and absorb wave energy (van Proosdij et al., 2018).

Figure 5: Managed Dyke Realignment project at Belcher Street Marsh in Kentville, Nova Scotia along the Jijuktu'kwejk (Cornwallis) river*. The old dyke which followed the coastline when it was built was realigned to a more linear dyke protecting only active agricultural land and allowing restoration of foreshore tidal wetlands. Created by Kate Sherren using Google Maps imagery.*

The overall goals of this study were to understand how residents in communities within the Minas Basin region perceive the implementation of managed realignment in the region, and how psychological constructs relating to the spatial and temporal scales of Climax Thinking impact these perceptions. This understanding aims to inform the successful implementation of managed realignment projects within this region, as they offer a sustainable way of managing flood risk while protecting remaining active agricultural lands and the cultural importance of dyke structures.

3.2 Background

3.2.1 Dykeland Management in the Bay of Fundy

Prior to the 1600s, the Mi'kmaq occupied Nova Scotia's coastal areas, including in the Bay of Fundy, where they relied on the dynamic coastlines for livelihood and culture (Wells, 2023). When French settlers arrived in the Bay of Fundy in the 1600s, they constructed dykes and aboiteaux to drain coastal wetlands for agriculture, as Nova Scotia's shallow and acidic soils did not offer an agriculturally friendly landscape (Butzer, 2002). These were managed collectively by the farmers whose land was protected by them. After the English expelled the French settlers (Acadians) starting in 1755, they signed Treaties of Peace and Friendship with the Mi'kmaq, in which land rights were never ceded. Despite this, they forced the Mi'kmaq into 13 small reservations, most of which did not have coastal access (Sherren et al., 2021). In 1948, after dykeland infrastructure had fallen somewhat into disrepair, the Federal government passed the Maritime Marshland Rehabilitation Act, with the goal to manage the dykelands under the broader post-World War II infrastructure management plan. The act created the Maritime Marshland Rehabilitation Administration (MMRA) to manage the repair and upkeep of dykes in the Canadian Maritimes (Milligan, 1987). The act legislated the creation of 'Marsh Bodies', which were a consolidated collective of dykeland owners who could request assistance with repairs of infrastructure, with two thirds of the marsh body collective needing to agree on these or other land use change decisions (Milligan, 1987). In 1968, management of the dykelands was transferred from a federal responsibility to a provincial responsibility, where it was taken over by the Nova Scotia Department of Agriculture (Milligan, 1987).

Currently, dykeland infrastructure management is the responsibility of the Nova Scotia Department of Agriculture and the Minister of Agriculture, under the Nova Scotia Agricultural Marshland Conservation Act *2000, c. 22, s.1* (Agricultural Marshland Conservation Act, 2000). Dyke management is a complicated issue in the Bay of Fundy region, as a diversity of stakeholders are involved in and implicated by dykeland management decisions. Dykes hold cultural value to Acadian communities and recreational value to birdwatchers and hikers within this region (Sherren et al., 2016, 2021). Within our study area (Figure 4), the major population centres of Truro, Windsor, Wolfville, and Amherst are all at least partially protected from tidal flooding by dykes, including residential, commercial, and industrial land uses.

Dykes have resulted in the loss of an estimated 69% of Nova Scotia's coastal tidal wetlands, which are some of the most biodiverse and ecologically important ecosystems for human benefit, and also act as natural flood barriers (de Groot et al., 2012; Nova Scotia Environment, 2009). Previous research has indicated that despite the strong attachments to dykelands, there is generally a lack of knowledge regarding climate change impacts and the importance of tidal wetlands and maintained living shorelines in climate change adaptation (Sherren et al., 2016, 2021).

3.2.2 Managed Realignment

Managed realignment is a dykeland management strategy in which a pre-existing dyke is moved back and restored, to simultaneously allow for the restoration of foreshore tidal wetlands and maintain protection of active agricultural land protected by the dykes. Figure 5 above illustrates a managed realignment project in Belcher Street Marsh along the Jijuktu'kwejk (Cornwallis) river in Kentville, Nova Scotia, which is located within

our study area (Figure 4). Across many managed realignment projects, including the one in Belcher Street Marsh, the old dyke followed the curve of the river when it was originally installed. As rivers change shape with annual fluctuations in flow as well as storm events, dykes often constrain the shape of the river over time, and prevent it from expanding or eroding. Managed realignment allows for the restoration of tidal wetlands within the floodplain and thus room for the river to meander, and the realignment of the dyke landward (and usually straighter) to protect only a prescribed perimeter of land. Across the study area, there are numerous managed realignment projects which have been completed or are in progress (Bowron et al., 2012). In the Bay of Fundy region, examples include Walton River, Green Creek, and St. Croix River (Bowron et al., 2012).

Despite its benefits, managed realignment is not feasible nor successful in all contexts. In many instances, dykes are located very close to critical infrastructure, and protect homes, businesses, and towns, allowing for no space to realign existing dykes (Roca & Villares, 2012). However, in agricultural areas managed realignment is generally the most environmentally and economically feasible dyke management option (Turner et al., 2007).

3.3 Methodological overview

This research sought to discover the underlying drivers of resistance to change, using managed dyke realignment in the Minas Basin region of the Bay of Fundy region as a study area and issue to explore this phenomenon (Figure 4). The study area chosen, discussed in section 2.2, includes the towns of Truro, Windsor, and Wolfville, which are at least partially protected from tidal flooding by dykes. We used a mail-out survey to understand perceptions of nature based coastal adaptations within the Minas Basin

Region, and drivers of resistance found. Complete information regarding survey design and implementation is discussed above in section 2.3.

Results collected from respondents to the survey were explored using descriptive statistics and analyzed using a partial least-squared structural equation modelling (PLS-SEM). Descriptive statistics were first generated to understand the demographic composition of the surveyed sample, which was compared to the 2021 Canadian census to assess representativeness compared to the region in general. Descriptive statistics were further used to establish levels of support or opposition to managed realignment. The PLS-SEM was then used to test drivers of MR resistance. Resistance was defined based on the level of agreement with the following statement "*In some cases, it would be acceptable to relocate homes or businesses to allow for dyke realignment".* This statement was chosen as it elicited the greatest diversity of opinions among respondents among the five tested, and the five statements were found to be not cohesive enough to form a single index. This is discussed further in section 3.4.2.

3.3.1 PLS-SEM

For the PLS-SEM, we built seven reflexive constructs, to represent the theoretical variables hypothesized to impact resistance to managed realignment. These constructs were *other focused*, *future focused*, *past focused*, *present focused*, *biospheric*, *concerned for nature*, and *self concerned*. We included a formative construct in the PLS-SEM of whether someone has descendants to explore the impact of having descendants on resistance to managed realignment, as an alternative to being *future focused*. The statements included in the formation of each of the constructs are included in Table 3 below.

3.3.2 Operationalization of Constructs

Each construct was built from either one question measuring a unique variable, or through linearly combining related questions through the PLS-SEM. The spatial dimensions of the conceptual framework are represented by the constructs of *other focused*, *self concerned*, *concerned for nature*, and *biospherism* (see vertical of Figure 3). *Other focused*, developed from values of universalism and benevolence from the Schwartz theory of Basic Values, designates an individual who prioritizes others and thinks about consequences for others in decision making. *Self concerned* was developed from values of hedonism and egoism from Value Belief Norm and Basic Values question sets to capture how an individual focuses on outcomes for themselves as the principal consequence of their actions. *Concerned for nature*, developed from the value of environmental concern from Value Belief Norm theory, discerns whether individuals are concerned for nature within their core values. *Biospherism*, while related to concern, explores more of a feeling of connection and care for nature, beyond concern. *Biospherism* is developed from values of universalism, from Basic Values theory, and systems perception within Futures Consciousness theory.

The temporal dimensions explored within the conceptual framework explore the constructs of *future focused*, *present focused*, and *past focused* (see horizontal axis of Figure 3). *Future focused*, developed from values within Futures Consciousness, captures an individual who considers the future and future consequences of their decisions and actions. *Present focused*, developed from the value of present fatalistic within the Zimbardo time perspective inventory, describes an individual who feels no personal control over the past or the future in their decisions. Finally, *past focused*, also developed

through the Zimbardo time perspective inventory, considers an individual who is immersed in a retrospective mindset, constantly mulling over the past. The creation of each of these constructs are explored below in Table 3, including the specific Likert style agree/disagree questions participants were asked to assess these constructs, which were derived from pre-existing question sets within the literature.

Table 3: Creation of theoretical constructs from Likert survey questions drawn from pre-existing scales.

Construct	**Variable measured**	**Source**	**Statement used for measurement**	**Scale**
Other focused	Universalism	Basic values (Schwartz, 1994)	They think it is important that every person in the world be treated equally. They believe everyone should have equal opportunities in life.	Portrait values *(Not like me at all/ A little like me/ Somewhat like me/ Like me/ Very much like me)*
	Benevolence	Basic values (Schwartz, 1994)	It's very important to them to help the people around them. They want to care for the wellbeing of others.	
Self Concerned	Hedonism	VBN (Gärling et al., 2003)	Protecting the environment will threaten jobs for people like me.	Likert (*Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree*)
	Hedonism	VBN (Gärling et al., 2003)	Laws to protect the environment will limit my choices and personal freedom.	
	Egoism	VBN (Gärling et al., 2003)	A clean environment provides me with better opportunities for recreation. **scale reversed*	
	Egoism	VBN (Gärling et al., 2003)	We don't need to worry much about the environment because future generations will be better	
	Egoism	VBN (Gärling et al., 2003)	Claims that current levels of pollution are changing the earth's climate are exaggerated.	
Concerned for nature	Environmental concern	VBN (Gärling et al., 2003)	Over the next several decades, thousands of species will become extinct.	
	Environmental concern	VBN (Gärling et al., 2003)	The balance of nature is delicate and easily upset.	
Biospherism	Universalism	Basic values (Schwartz, 1994)	They strongly believe that people should care for nature. Looking after the environment is important to them. (Not like me at all/ A little like me/ Somewhat like me/ Like me/ Very much like me)	Portrait values *(Not like me at all/ A little like me/ Somewhat like me/ Like me/ Very much like me*
	Systems perception	Futures consciousness (Lalot et al., 2020)	I have had the experience of feeling 'at one' with nature.	Likert (*Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree*)
Past focused	Past Negative	Time perspective (Zimbardo & Boyd, 1999)	I think about the good things I have missed out on in my life. (Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree)	

Construct	**Variable measured**	**Source**	**Statement used for measurement**	**Scale**
Future focused	Future	Futures consciousness (Lalot et al., 2020)	I think about the consequences before I do something	Likert (*Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree*)
	Future	Futures consciousness (Lalot et al., 2020)	I think about how things might be in the future	
	Future	Futures consciousness (Lalot et al., 2020)	I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future	
	Future	Futures consciousness (Lalot et al., 2020)	I consider how things might be in the future, and try to influence those things with my day to day behavior	
Present focused	Present Fatalistic	Time perspective (Zimbardo & Boyd, 1999)	It doesn't make sense to worry about the future, since there is nothing that I can do about it anyway	

3.3.3 Model Measurement

In order to assess our constructs (Table 3) for validity and reliability, we put them through a series of statistical tests. Factor loadings on each construct were tested to determine if the items measuring the construct were dependable, with a dependable loading being 0.6 or above (Hair et al., 2021). The average variance extracted (AVE) was used to quantify how much variation in the indicators was accounted for by the latent construct, which determined convergent validity, with 0.50 or greater indicating that the constructs are significantly different. Cronbach's alpha was used to evaluate the internal consistency within each of the constructs with more than two variables, with a value of 0.7 or higher generally indicating strong internal consistency. In this study, we used a cut-off value of 0.50 for our constructs, as this was an exploratory study seeking to determine the presence of relationships rather than the strength thereof. Each of the five multi-factor constructs we created were valid based upon AVE, Cronbach's alphas, and the factor loadings for their creation. Table 4 below explores the factor loadings, AVE, and Cronbach's alpha for each of the constructs in our PLS-SEM.

Table 4: Validity tests of PLS-SEM model *(N=217)*

Construct	**AVE**	**Cronbach's alpha** (n>2)	**Variable**	**Factor loadings**
Other focused	0.735	n/a	Universalism	0.897
			Benevolence	0.815
Self Concerned	0.491	0.737	Hedonism (jobs)	0.695
			Hedonism (laws)	0.768
			Egoism (recreation)	0.583
			Egoism (future)	0.711
			Egoism (pollution)	0.733
Concerned for nature	0.722	n/a	Environmental concern (extinction)	0.953
			Environmental concern (balance)	0.731
Biospherism	0.706	n/a	Universalism	0.903
			Systems perception	0.771
Future focused	0.558	0.733	Future (consequences)	0.736
			Future (neutral)	0.784
			Future (sacrifice)	0.639
			Future (influence)	0.816

3.4 Results

The survey was sent to a random sample of 1350 addresses within a defined area of the Minas Basin. 233 responses were received, with 217 of those being complete enough to include in the structural equation modelling analysis, using a cut-off of no more than 12 unanswered questions. As a result of our sampling technique described above, mailouts to 233 addresses were returned to us as undeliverable, indicating that there is no house currently at that address or no residents (e.g. seasonal only). This leads to our

overall response rate being 21%, with a margin of error of +/- 6% at a 95% confidence level.

We determined the representativeness of our sample by comparing demographic factors of gender, income, and education to the 2021 Canadian census of the counties of Hants, Kings, Cumberland, and Colchester, as seen in Table A1. A majority of our respondents (49%) were between the ages of 50 and 70, which represented only 38% of the population. Our sample was overwhelmingly (66%) female, and generally had more post-secondary education than the average population of the area. Our sample was over-representative of those earning a higher income, with 32% of those who responded earning over $100,000 in household income while that only represents 5% of the population. We did, however, have representation within our survey from a diversity of respondents, representing incomes ranging from $10,000 to $19,999 to $150,000 and over and every category of age, gender, and education.

3.4.2 Perceptions of Managed Realignment

Perceptions of managed dyke realignment were evaluated by asking participants to rate their level of agreement to a series of statements regarding the outcomes of managed dyke realignment. Within our sample, explored below in Table 5, participants exhibited overwhelming agreement with all of the positive toned statements, even when they contradicted each other. Notably, there was agreement both that dykes should be raised to counter storm surges and rising sea levels, and that restoring tidal wetlands would help protect against storm surges and sea-level rise. The final statement, which explores the acceptability of moving homes or businesses to allow for dyke realignment, has a significantly wider distribution than all other statements, with no category

(agree/neutral/disagree) under 20%, indicating a diversity of opinions among the surveyed population.

Table 5: Perceptions of Managed Realignment Opinions and Outcomes. *Participants were asked to rate their level of agreement with each statement (N=219).*

Statement	Tone	Agree	Neutral	Disagree
Dykes in Nova Scotia should be raised to counter storm surges and rising sea levels.	Positive	73%	22%	5%
Restoring tidal wetlands would help protect Nova Scotia against storm surges and sea-level rise.	Positive	74%	24%	3%
Moving dykes back will allow us to keep protecting useful dykeland while providing space for flood water.	Positive	69%	26%	5%
Restoring dykelands to tidal wetlands represents more risk than benefits.	Negative	10%	57%	33%
In some cases, it would be acceptable to relocate homes or businesses to allow for dyke realignment.	Neutral	36%	44%	20%

Correlations between each of the statements were assessed to determine if there was a pattern in responses (i.e., the same people responding the same way to all positively toned statements). It was found that there was no significant correlation between responses to any of the statements except “Restoring tidal wetlands would help protect Nova Scotia against storm surges and sea-level rise” and “Moving dykes back will allow us to keep protecting useful dykeland while providing space for flood water”, which had a correlation coefficient of 0.737, as seen below in Table 6.

Table 6: Correlation matrix of perception of managed realignment statements *(Pearson's r) (N=219)*

	Dykes in Nova Scotia should be raised to counter storm surges and rising sea levels.	*Restoring tidal wetlands would help protect Nova Scotia against storm surges and sea-level rise.*	*Moving dykes back will allow us to keep protecting useful dykeland while providing space for flood water.*	*Restoring dykelands to tidal wetlands represents more risk than benefits.*	*In some cases, it would be acceptable to relocate homes or businesses to allow for dyke realignment.*
Dykes in Nova Scotia should be raised to counter storm surges and rising sea levels.	1.000				
Restoring tidal wetlands would help protect Nova Scotia against storm surges and sea-level rise.	0.536	1.000			
Moving dykes back will allow us to keep protecting useful dykeland while providing space for flood water.	0.517	**0.737**	1.000		
Restoring dykelands to tidal wetlands represents more risk than benefits.	0.012	-0.202	-0.202	1.000	
In some cases, it would be acceptable to relocate homes or businesses to allow for dyke realignment.	0.232	0.319	0.312	-0.039	1.000

3.4.3 PLS-SEM

Our PLS-SEM (R^2 0.133), shown below in Figure 6, suggests that a tendency towards being *past focused* (ß 0.183, p <0.05, F^2 0.028) and *other focused* (ß 0.207, p <0.01, F^2 0.022) were found to have a significant positive influence on resistance to managed realignment if homes and businesses are to be affected. An increase in *future focused* (ß -0.181, p <0.05, F^2 0.020) and *concerned for nature* (ß -0.339, p <0.001, F^2 0.083) were found to have a significant negative influence on resistance to managed realignment. While no significant direct effect was discovered, *self concerned* was found to have a significant negative influence on *biospherism* (ß -0.479, p<0.001), *other focused* (ß -0.441, p<0.001), and *future focused* (ß -0.415, p<0.001).

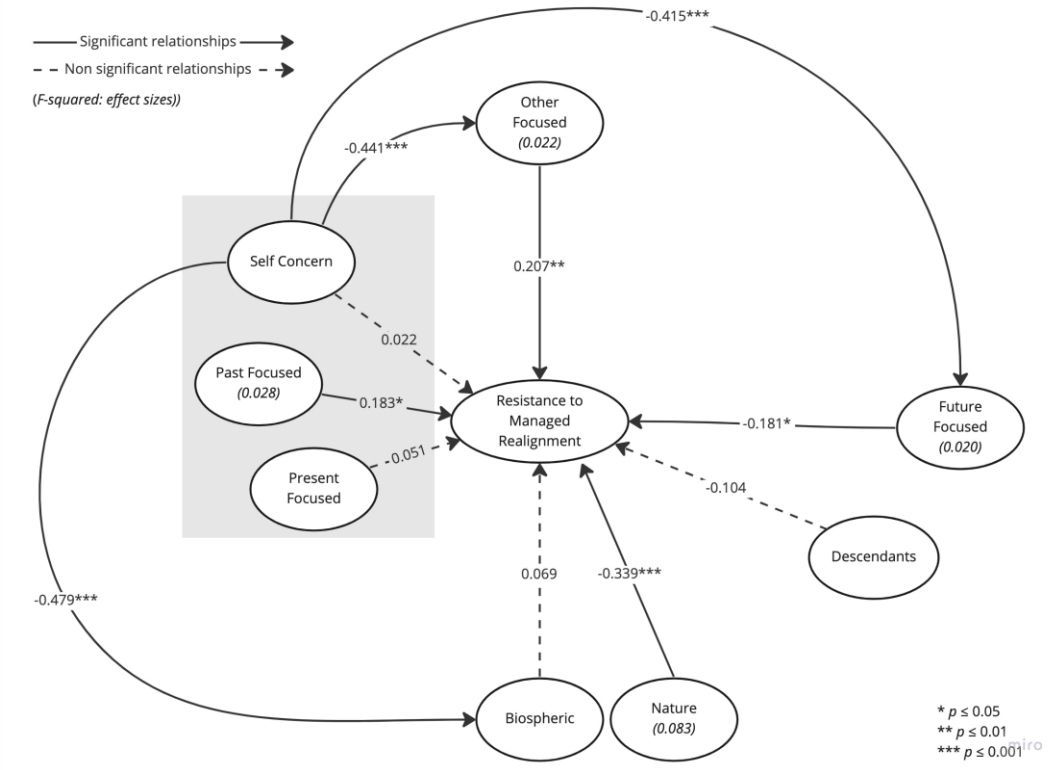

Figure 6: Structural equation model (N=217). *All relationships shown for direct effects, only significant relationships shown for indirect effects.*

3.5 Discussion

3.5.1 Perspectives of Managed Realignment

Managed realignment was overall supported by those in the region, especially when reminded of the potential positive impacts it provides for protections against flooding. Even when asked about support for managed realignment if it required moving houses or businesses, only 20% of respondents disagreed (Notably, there was agreement both that dykes should be raised to counter storm surges and rising sea levels, and that restoring tidal wetlands would help protect against storm surges and sea-level rise. The final statement, which explores the acceptability of moving homes or businesses to allow for dyke realignment, has a significantly wider distribution than all other statements, with no category (agree/neutral/disagree) under 20%, indicating a diversity of opinions among the surveyed population.). When asked to elaborate on their experiences with managed realignment, nobody indicated direct involvement with managed realignment projects. Very few indicated knowledge of managed realignment from involvement in decisions to top up current dykes or mange non-coastal wetland areas. The majority of respondents who answered the open text question (n=27) indicated that they only knew about managed realignment from news media outlets.

Despite broad support for managed realignment, there were somewhat contradictory perspectives regarding its outcomes. Interestingly, the majority of participants agreed both that dykes should be raised in order to help protect against storm surges, and that restored tidal wetlands would help to to protect against storm surges and sea level rise. This may indicate that respondents consider the site-specific nature of coastal climate adaptations, and believe that both managed realignment and reinforcements of current dykes are appropriate, depending on the situation. This is

consistent with findings from Sutton (2020), who found during focus groups in Nova Scotia that respondents were loath to choose a preferred nature-based coastal adaptation, as they felt each site was unique and requiring of a unique adaptation. The mixed responses may also have come from a limited understanding of what managed dyke realignment is, which is consistent with the literature, where a limited understanding of managed realignment is found to be one of the main barriers to acceptance of managed realignment projects (Myatt et al., 2003; Roca & Villares, 2012). Myatt et al. (2003) explored public perceptions of future managed realignment projects in the U.K. and found that public understanding of managed realignment and coastal defence related issues was a barrier to public acceptance of these projects. Roca and Villares (2012) found that in Spain's Metatherian basin limited understanding of managed realignment and its impacts, as well as historical tradition of grey 'hold-the-line' infrastructure in the region, were barriers to managed realignment strategies. Public concern and resistance arises when there is a perception of surrender of land to the sea, even when there are ecological and economic benefits (Myatt et al., 2003). In coastal communities in Wales, researchers found that there is generally a lack of understanding of the benefits provided by foreshore tidal wetlands, in particular their ecological and flood management benefits (McKinley et al., 2020). Overall, the broad support identified in our study may indicate an openness within the population for managed realignment projects, including an openness to recognizing the role and benefits of tidal wetlands. Previous research using interviews has found a general lack of appreciation for tidal wetlands in this region, (Sherren et al., 2016) so this openness may be important to harness for the implementation of future managed realignment projects in the region.

Despite broad support, it is critical to understand why resistance to managed realignment may be present, and why it is related to concern about property. While, so far, no buildings have been moved or damaged during managed realignment within the Maritimes, that may not be the case for future projects. Within our sample, 20% of participants expressed disagreement to managed realignment when outcomes highlighted the potential for relocation of homes or businesses (Notably, there was agreement both that dykes should be raised to counter storm surges and rising sea levels, and that restoring tidal wetlands would help protect against storm surges and sea-level rise. The final statement, which explores the acceptability of moving homes or businesses to allow for dyke realignment, has a significantly wider distribution than all other statements, with no category (agree/neutral/disagree) under 20%, indicating a diversity of opinions among the surveyed population.). While a minority, one-fifth is still a significant proportion of respondents expressing this resistance, which was not seen with regards to other highlighted outcomes such as protection from storm surges and sea level rise. A review of preferences for coastal climate adaptation by Mallette et al. (2021) indicates that across the current literature, there is a desire from the public and governments to retain the current shoreline through the implementation of hard infrastructure methods in order to protect private property. Rulleau et al. (2017) found that in the South of France, compensation criteria based upon market criteria and principles of justice for those whose properties and assets are impacted by managed realignment projects have a significant positive impact on community acceptability of managed realignment projects. Concern for individual property value and associated loss is a well-documented driver of resistance to managed realignment. For there to be public consensus to support nature-

based coastal resiliency and its effects for the common good, there needs to be recognition and compensation of losses and other potential negative impacts for landowners (de la Vega-Leinert et al., 2018; Jones et al., 2014; Ledoux et al., 2005).

3.5.2 Drivers of Resistance to Managed Realignment

This study employed a theoretical framework, guided by Climax Thinking (Sherren, 2021), which sought to explore the relationships between seven spatiotemporal constructs and resistance to managed realignment and associated landscape-based coastal management decisions. Through structural equation modelling, it was found that being *past focused*, *future focused*, *other focused*, and *concerned for nature* all have a significant impact on resistance to managed realignment, but not all in ways predicted by Climax Thinking.

Both *past focused* and *other focused* were found to be associated with higher resistance to managed realignment. While *past focused* increasing resistance to managed realignment is consistent with the Climax Thinking framework, *other focused* increasing resistance to managed realignment is not. Prior research has highlighted the role of being *past focused* in influencing traditional, hard infrastructure management approaches. For example, Roca and Villares (2012) found that when exploring perceptions of managed realignment in Spain's Mediterranean basin, there is public attachment to the status quo and traditional management practices of 'holding-the-line' (dyking). This attachment to past utilitarian landscape features holds true in other tests of Climax Thinking as well, as Chappell et al. (2020) found significant attachment to past utilitarian landscape features led to lack of support for new utilitarian landscape features. The fact that being *past focused* increased resistance to managed realignment within our sample may indicate that

there is a attachment to existing dyke infrastructure among those resistant to managed realignment projects; this would be exacerbated if familial and community historical properties were perceivedto be at risk of relocation. Future research should include a place attachment measure, which we did not use as place attachment had been shown to be previously well understood within the literature exploring perspectives on managed realignment, and researchers suggested that alternative measures be explored (Mallette et al., 2021). A comparison between place attachment and other psychological influences within the Climax Thinking framework may prove fruitful in future research, however.

The discovery that being *other focused* was associated with resistance to managed realignment is contrary to our Climax Thinking framework, but it is important to note that we measured resistance only based on homes and businesses needing to be relocated. This relationship may be associated with the perceived critical importance of appropriate financial compensation for landowners suffering losses (i.e. relocation) as a result of managed realignment, as described across the literature (de la Vega-Leinert et al., 2018; Jones et al., 2014; Ledoux et al., 2005; Rulleau et al., 2017). Those with a focus on others, in this instance as it is related to the acceptability of moving homes or businesses to allow for managed realignment, may be expressing concern for neighbours or community members potentially depreciating property value or facing relocation . This neighbourly concern may be present due to a strong sense of community and history within the Bay of Fundy region, and particularly around its dykeland context (Eger & Courtenay, 2021; Sherren et al., 2021). The respondents to the survey likely are not aware of the fact that dyke realignments typically involve the consent of landowners affected

(the ‘Marsh Body’ members) and generally market-value land purchases (Sherren et al., 2019).

Being *future focused* and *concerned for the natural environment* were found to be significant negative drivers of resistance to managed realignment (i.e., positive drivers of support). Both of these were consistent with Climax Thinking. Previous research has shown that people who are future focused are generally more open and adaptable to change, and have less connection to past and historical landscape features (von Haaren, 2002). Research in the Netherlands and the UK by Većkalov et al. (2021) found that those who are able to perceive future impacts of climate change are more inclined to accept long-term climate solutions that may not have immediate benefit, potentially including managed realignment. Having increased concern for the natural environment in decision making equally tends to engage individuals in support for nature-based climate adaptation projects which have a focus on ecological benefits, such as managed realignment (Marshall et al., 2019).

Contrary to our expectations, being *self concerned* did not have a significant direct impact on resistance to managed realignment, but did have a potentially strong indirect influence. *Self concerned* had a significant negative impact on *biospherism*, *other focused*, and *future focused*. This is consistent with the Climax Thinking hypothesis, as the *self-concerned* ‘climax thinker’ is likely to prioritize preservation of their own current landscape for their own good, and be less able or willing to consider others, the natural world, and the future consequences of their decisions.

Understanding that *past focused*, *other focused*, and *self concerned* all drive resistance to managed realignment informs us that the rollout of managed realignment

projects across Nova Scotia must anticipate and address minority resistance within the community, the impacts of which would depend on the political power of those individuals (Howard & Sherren, 2023). In particular, strategies need to involve the community in decision making, educate the community on the outcomes of managed realignment, and ensure that (everyone knows that) impacted landowners are fairly compensated for potential losses. Much of this is already underway through the Nova Scotia Department of Agriculture's capital campaign to modernize the dyke system, the existing MMRA legislation, and partnerships with groups such as TransCoastal Adaptations Centre for Nature-based Solutions. When working to address psychological barriers to resistance, proponents of MR can deploy communicative framing and priming—the use of messaging designed to help people attach to the most personally salient or favourable aspects of such projects—to encourage the success of these projects (Sherren et al., 2022). Future priming has been shown across the climate literature to be an effective strategy for encouraging openness to adaptation strategies, both at a local scale in Nova Scotia (Sherren et al., 2022) as well as at a national scale across the United States (Stern et al., 2020). Employment of future-focused or altruism-focused priming strategies in communicating managed realignment projects may work to reduce resistance, especially among those who exhibit past and self-focus.

3.5.3 Implications for the Region

Acceptability of managed realignment projects in the Minas Basin region is likely contingent on appropriate design measures implemented into projects which recognize and anticipate concern related to impacts on private property. While managed realignment projects are currently being planned and implemented across the Minas

Basin region, there remain significant management challenges; for instance, it can still be difficult to have a nature-based approach succeed within a bidding program for coastal protection (Ellis, 2023). Public perceptions are critical, in particular within the dykeland management context, as the majority of Nova Scotia's coastline, including within the Minas Basin, is owned by private landowners.

This study highlights that there where concern exists it is around the potential relocation of homes or businesses to allow for managed realignment projects, or potentially a lack of understanding that a managed realignment project could result in relocation of structures. Research across the UK, Netherlands, and Spain has all highlighted that acceptability of managed realignment projects is dependent on appropriate compensation mechanism for property owners impacted by managed realignment projects. As the Minas Basin dykeland region contains significant amounts of individual property owners, policies which encourage managed realignment strategies within the region, and across the Bay of Fundy coastline, should anticipate funding for compensation of individual landowners. Existing legislation provides the requirement for collaboration with landowners and marsh bodies in the development of managed realignment projects in the Minas Basin region (Sherren et al., 2019).

Research from Champagne (2021) who interviewed dykeland owners, and Sherren et al. (2016) who surveyed Nova Scotians, suggest that there is less attachment among both groups to the tidal marsh environment that would expand under a managed realignment scenario. Proponents such as TransCoastal Adaptations Centre for Nature-Based Solutions engage with programming and communication methods to enhance knowledge and understanding of the importance of tidal wetland ecosystems, which may

help to build a sense of value towards these ecosystems. As we found that increased *concern for nature* is likely to reduce resistance to managed realignment, as corroborated by Davis et al. (2011) who found that an increased concern for the natural environment is likely to increase conservation related action.

Public trust in decision makers was a found to be a key influence in the acceptability of managed realignment projects across the UK and Spain (Myatt et al., 2003; Roca & Villares, 2012). While trust was not assessed in our quantitative modelling, three participants indicated mistrust of public officials in open-ended questions, stating that "Environmental idiocy is endemic in the Nova Scotia government.", and "Far too much power being allotted to Government, and it is very excessively oversized." Many more respondents, however, expressed agreement that the issue is pressing, and that decisions and actions must be taken soon, while also recognizing the importance of the dykelands. One respondent stated, "I spent a lot of my childhood enjoying the fruits of the dykelands and feel that is an important tradition for NS but recognize changes may be required to accommodate the greater good". These participants comments suggest that exploring trust toward proponents or governments as it relates to coastal climate adaptations is an important area for future research.

3.6 Conclusion

This study explored the perceptions of, and drivers of resistance to, managed realignment among those living in the Minas Basin region of Nova Scotia. Using a multiple-mail out hybrid survey method, data was collected from a random sample of residents within the region, who broadly expressed support for managed realignment. Although supported overall, responses suggested either that managed realignment was

misunderstood, and/or a proportion of the population believed that the best coastal solutions would be site specific. Resistance to managed realignment was only present in 20% of the population, and only when participants were asked about the acceptability of moving homes or businesses to allow for managed realignment projects. Through partial least squared structural equation modelling, it was found that being past and *other focused* had significant positive effects on resistance to managed realignment, while being *future focused* and *concerned for nature* had significant negative effects. Underlying these was the significant indirect impacts of being *self concerned*, which were negatively driving being *other focused*, *future focused*, and *biospheric*. Understanding the importance of these psychological drivers of resistance will help to design communicative framing devices, along with community involvement and appropriate financing programs, when implementing necessary managed realignment projects in the Minas Basin region.

Chapter 4: Influences of risk perception and psychological drivers of resistance to flood risk mapping in the Minas Basin, Bay of Fundy

4.1 Introduction

Flooding events internationally are continuing to grow in intensity and severity as a result of anthropogenic activities, resulting from increases in extreme weather events, sea level rise, land use and land cover changes, and geologic changes (Hirabayashi et al., 2013; Stocker et al., 2013). Atlantic Canada is particularly vulnerable to this process as it is experiencing glacial-isostatic adjustment in conjunction with sea level rise, resulting in higher rates of relative sea-level rise in the region as compared to the global average as well as elsewhere in Canada (Bush et al., 2019). In addition to sea level rise and erosion, the region is expected to experience significant increases in pluvial and fluvial flooding resulting from projected increases in the frequency of major storms and precipitation (Bonsal et al., 2019). This was most recently evidenced by the over 250mm of rain that fell in Nova Scotia on July 21st and 22nd 2023, causing hundreds to evacuate their homes and many to be cut off from accessing essential services (Sampson, 2023). These climatic impacts are contributing to increasing risks of coastal flooding in the region, which can have widespread negative impacts on coastal communities (Greenan et al., 2019). While the impacts of flooding on communities is well-documented, there has not been consensus on the solution to mitigating these impacts. Climate adaptation requires informed understandings of climatic impacts and risks across all scales of governance,

including the public. Flood maps have the potential to be a useful tool for the public in informing individual adaptation solutions.

Flood maps generally fit into either flood hazard maps or flood risk maps. Flood hazard maps are used by technical experts, such as engineers and planners, and contain detailed technical hydraulic information regarding the flood hazard of a particular area of land, typically using a 1 in 100 year flood (or 1% annual probability) benchmark for flood hazard assessment (Henstra et al., 2019; Porter & Demeritt, 2012). Flood risk maps contain flood hazard information together with supplemental information including the location and presence of assets including houses, buildings, roads, and bridges (Henstra et al., 2019). Unlike flood hazard maps, flood risk maps typically include impacts of flooding on assets, and are used for decision making and policy creation at all levels of government. They are also used to communicate flood risk to the public, however the majority of flood risk maps in Canada are too complex for the lay person to effectively interpret (Henstra et al., 2019). As a result of this difficulty in interpretation, coupled with the lack of standardisation of flood risk maps, experts and the public alike are left to use subjective judgements to make flood risk preparedness decisions (Chowdhury & Haque, 2011).

Resistance to flood risk mapping is a well-documented phenomenon in the media (Bradley, 2016; Chisholm, 2017; Mcclearn, 2019), but the drivers of this resistance have been understudied, particularly within the Canadian context. Within Nova Scotia, for example, residents of the Shubenacadie region protested in 2016 against the rollout of zoning changes based on new flood risk mapping within their municipality, with the principal concern being that their property value would decrease (Bradley, 2016). More

recently in 2022, the Municipality of the District of Lunenburg attempted to publicly release flood risk mapping within the municipality, but was met with resistance from many whose lived experiences had led them to believe these maps may be inaccurate (Municipality of the District of Lunenburg, 2023; R. Shepherd & J. Merill, personal communication, July 12, 2023), As a result, the flood risk maps were rescinded. These examples highlight the importance of understanding what factors might influence resistance, and how a lack of understanding can hinder public policy regarding flood map publication and use.

This study sought to examine perceptions of publicly available flood risk mapping and understand resistance to it. Specifically, we sought to understand why resistance was present and explore potential drivers of resistance. To investigate this, we tested the role of psychological values and beliefs associated with Climax Thinking theory, which is used to understand why individuals perceive their current landscape as its final and ideal form.

4.2 Background

4.2.1 Flood Risk Mapping in Canada

In Canada, flood risk management and preparedness are under provincial jurisdiction, including flood risk mapping and structural interventions, such as dykes, which manage flood risk (Henstra & Thistlethwaite, 2017). Provinces are also responsible for the allocation and management of post disaster relief funds and programs, although federal funds are often provided to support such work. While there are collaborations across all levels of government, the provincial control over flood risk mapping has resulted in significant differences with regards to the state, accessibility, and

efficacy of flood risk maps for the public across the country (Henstra et al., 2019). Henstra et al. (2019) explored the state of flood risk maps for communities in Canada which are at a high risk of flooding based on nine criteria deemed essential for making maps accessible to the public (e.g., legend legibility, flood zone legibility, and explanation of technical terms). It was found that the vast majority of high flood risk communities did have flood risk maps (85%), and when present most of the maps (62%) were of low quality for public use (Henstra et al., 2019). Notably, maps typically lack clear legends, explanation of technical jargon, and are nor easy to find in a centralized location (Henstra et al., 2019).

A key factor influencing the prevalence of ineffective and difficult-to-access flood risk maps is the public-expert gap. This can be understood as the difference in contents of a flood risk map intended for use by an expert and one intended for use by a member of the public. Typically, in creation of flood risk maps, especially with lack of explicit guidelines for public accessibility, maps are riddled with technical jargon and require a university-level understanding of hydrology to understand and interpret (Chowdhury & Haque, 2011; Henstra et al., 2019). As a result, both the public and experts use subjective personal judgements to influence flood risk perception and decision making (Chowdhury & Haque, 2011).

The Municipal Floodline Mapping Project is currently underway in Nova Scotia, as a collaboration between provincial municipalities and the provincial Department of Municipal Affairs and Housing (G. Smith, personal communication, April 13, 2022). This project will, in coming years, result in the publication of flood risk maps evaluating both coastal and riverine floor risk for the entire province. Many regions, including the Minas

Basin, have already been assigned to engineering firms, and work is beginning to create these maps. Certain regions of the province, including the Halifax Regional Municipality (completed in 2016), the LaHave River area (completed in 2013), and the Yarmouth coast (completed in 2012), have been mapped by the NSCC Applied Geomatics Research Group, however these projections are outdated, and they are technical maps which may not be understandable for the general public. Other public maps exist for Annapolis Royal, the Sackville River area, and the Lunenburg coastal area, however these maps are not reliably updated nor comprehensive (Halifax Regional Municipality, 2017; Webster et al., 2014a, 2014b, 2010). While Nova Scotia holds has few good examples of public maps, other Canadian provinces, including Newfoundland and Labrador and Quebec, have completed comprehensive, updated, useful, and easily accessible flood risk mapping (Newfoundland Enironment, Climate Change and Municipalities, 2013; Québec Ministère de la Sécurité publique du Québec, n.d.). Maps in these provinces inform all infrastructure and property-related decision making within those provinces underlining the importance of effective and public flood risk maps (Newfoundland Enironment, Climate Change and Municipalities, 2013; Québec Ministère de la Sécurité publique du Québec, n.d.). However, in Nova Scotia, proposed flood risk maps have been met with resistance including a 2016 protest in the Shubenacadie region where residents felt threatened by potential depreciation of property value leading to its removal (Bradley, 2016).

A common strategy employed by municipalities and private-sector insurance and real estate companies alike is the use of a ‘traffic-light’ system, which transforms detailed maps for internal use into zones of low, medium, and high risk of flooding. The

municipality of Fredericton, New Brunswick is one example of this system, where homeowners can look at risk ratings for fluvial, pluvial, and snowmelt flooding for their own properties (City of Fredericton, 2023). A similar strategy is used by Re-Max, which offers a 'Climate Risk Score' for properties which they list for sale (Warren, 2023). The use of these aggregated strategies allows for the communication of flood risk to the public, while avoiding the need to justify a hard line on a map where the 1-in-100 year flood line is drawn. Services including Climate Central (*Climate Central*, n.d.) and Coastal Action's 3D interactive maps (*Coastal Action's Interactive Flood Mapping Projects*, n.d.) engage in a similar aggregated strategy for sea-level rise projections, however these resources lack the detail required for property-level decision making. NGOs, academics, and some municipalities in Canada are using participatory flood mapping to address gaps in understanding between the public and experts in the flood risk mapping and management field, and to help involve communities in the creation of flood risk maps. This involvement can lead to increased concern and assumption of responsibility in preparation for impending flood risk (Henstra et al., 2019; Khalafzai et al., 2019; Maskrey et al., 2022).

4.2.3 Understanding Flood Risk Perception

Concerns related to flood risk mapping include concerns about property values, impacts on insurance rates, and changes to zoning regulations (Howard & Sherren, 2023; Thistlethwaite et al., 2018). There is also concern that community members may percieve publicly available flood risk maps to be incorrect, based on their own personal flooding experiences, which can be combatted through the implementation of participatory mapping techniques ahead of the release of publicly available flood risk mapping

(Membele et al., 2022; Thapa et al., 2019). This was a principal concern behind the recent retraction of publicly available flood risk mapping in Lunenburg County, Nova Scotia (R. Shepherd & J. Merill, personal communication, 2023). Such concerns relate to an individual's risk perception not just of flooding, but of the impact of public flood risk maps.

Risk perception is commonly understood as an individual's assessment of the perceived probability and severity of a hazard (Bubeck et al., 2012; Grothmann & Patt, 2005; Lechowska, 2018). Understanding how risk is perceived in the face of natural disasters, including flooding, can offer insight into how preparation measures, including publicly available flood risk mapping, are interpreted (Hügel & Davies, 2020; Keller et al., 2012; Wachinger et al., 2013). Several studies have identified potential drivers of risk perception within the context of natural disasters such as flooding and flood risk mapping. Kellens et al. (2013) systematically reviewed 57 studies on flood risk perception and communication, and found that past experiences with natural disasters was strongly affiliated with risk perception. Globally, it was found that people in flood prone areas generally underestimated their risks (Kellens et al., 2013). More recently, a review by Hügel & Davies (2020) and study in Kyoto City, Japan by Jhong et al. (2020) have found that those who live in areas with heightened risks of natural disasters were more open to climate adaptations. Similarly, Wachinger et al. (2013) in their review of risk perception and natural hazards found that personal experience and institutional trust were found to have significant impacts on risk perception. Within the Canadian context, few studies have explored how risk perception influences flood preparedness. Haney & McDonald-Harker (2017) found that residents at high flood risk in High River, Alberta

perceived themselves as having a weak ability to cope with floods, resulting in inaction on risk reduction despite flood risk awareness. Kreutzwiser et al. (1994) found that in three communities in Ontario located on a floodplain, only 28% of those interviewed perceived they had future flood risk, with proximity to the river and length of time residing in the community both significantly increasing perceived future flood risk.

The risk paradox identified by Wachinger et al. (2013), has received increased attention within the natural hazard literature and has been corroborated by other scholars in the field. Bubeck et al. (2012) similarly noted that there is often a strong relationship between risk perception and intention, however the relationship between risk perception and action is significantly weaker. Within the context of climate and natural disaster-related risk, there is a gap in understanding of the differences between collective and individual percieved risk, and how this influences collective and individual climate actions, as risk is predominately assumed to be assessed individually. Thistlethwaite et al. (2018) discuss the role of an 'understanding gap', where individuals' lack of understanding of their flood risks could have a negative impact on their own flood preparedness, as they may not understand how to act or what to do in order to increase their own preparedness. This 'understanding gap' may be addressed by increasing actual flood risk awareness, including through the rollout of publicly available flood risk mapping. Within the Nova Scotian context, Howard & Sherren (2023) found that in the South Shore region, one sixth of survey respondents exhibited resistance to publicly available flood risk mapping related to property value. When exploring what may drive this resistance, it was found that risk perception was not a significant driver of resistance.

While much media and research coverage treat public flood mapping as an assumed public good, as discussed earlier, the public can resist its introduction, and little work has explored why this is. In the United States, flood risk mapping is managed by the Federal Emergency Management Agency (FEMA), who is responsible for creating and updating maps for communities. Wilson and Kousky (2019) discuss how the process of updating county-level maps is lengthy, and delays can be exacerbated by community opposition and revisions, which wealthier communities are more likely to request. As the development of flood risk maps in the United States are created to inform the National Flood Insurance Program (NFIP), the development of maps and associated insurance has been percieved by low-income Americans to be an exploitative exercise which forces them to bail-out wealthy coastal cottagers (Pralle, 2019). It is critical to consider equity and environmental racism which has lead to many low income communities, including historical African Nova Scotian communities, being forced into low-lying areas (e.g., in Truro, NS) when understanding and interpreting perceived flood risk and preparedness.

4.3 Methodological overview

The aim of this study was to understand and explore local perceptions of publicly available flood risk mapping within the Minas Basin region of Nova Scotia. A mail-out survey was sent out to a random sample of 1,350 addresses to the counties of Hants, Kings, Cumberland, and Colchester. Complete information regarding survey design and implementation can be found in section 2.3.

Data collected from respondents to the survey were explored using descriptive statistics and partial least-squared structural equation modelling (PLS-SEM). Descriptive statistics were used to explore the demographic makeup of the sample and assess the

representativeness of our sample. To assesses representativeness, we compared our sample demographics to the 2021 Canadian census for the sampled counties to. Risk perception was assessed through exploring perceived likelihood and severity of consequences of flooding in the near future. PLS-SEM was then employed to explore drivers of resistance to publicly available flood risk mapping. Resistance was proxied through level of agreement with the statement "Publicly available flood risk mapping would have an unacceptable impact on the real estate value of affected landowners.". We selected this statement because it sparked the widest range of opinions among those surveyed from the four options given. Due to a low Cronbach's alpha among the four statements (0.5705), the four statements together were deemed insufficient to form a single index. Additional details can be found in section 4.4.2.

4.3.1 PLS-SEM

For the PLS-SEM, we built six reflective constructs, representing each of the theoretical factors that may influence risk mapping resistance (Table 7). We additionally built two formative constructs, labeled descendants and flood risk perception (Table 7).

4.3.2 Operationalization of Constructs

Using risk perception and climax theories, we selected eight constructs. Six constructs in the PLS-SEM were developed by combining multiple indicators into a single index, and two were single-item indicators with only one variable measuring the construct. Pulling from Climax Theory, we included three spatial dimension constructs including *other focused*, *self concerned*, and *biospherism* (see vertical axis of Figure 3). *Other focused* was developed from Likert scale variable measurements of benevolence and universalism, and captures individuals who consider outcomes on others in decision

making. *Self concerned* was developed from Likert scale variable measurements of egoism and hedonism, and captures an individual who focuses on themselves when considering actions and their consequences. *Biospherism* was developed from Likert scale variable measurements of environmental concern, universalism, and systems perception, and measures whether an individual feels connected to and concerned about the natural environment around them.

The temporal dimensions of the conceptual framework include the constructs of *future focused*, *present focused*, and *past focused* (see horizontal axis of Figure 3). *Future focused* was developed from Likert scale variable measurements of futures consciousness, which measures whether an individual prioritizes and considers the future consequences of their actions. *Present focused* was developed from Likert scale variable measurements of the present fatalistic value established in the Zimbardo time perspective inventory questionnaire, and measures whether an individual lacks a sense of control over their past or future decisions. Finally, *past focused*, also stemming from the Zimbardo time perspective inventory questionnaire Likert scale variable measurements, captures whether an individual has a retrospective mindset, and is overly focused on the past. The creation of each of these constructs is explored below in Table 7.

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Table 7: Creation of theoretical constructs from Likert survey questions drawn from pre-existing scales.

Construct	**Variable measured**	**Source**	**Statement used for measurement**	**Scale**
Other focused	Universalism	Basic values (Schwartz, 1994)	They think it is important that every person in the world be treated equally. They believe everyone should have equal opportunities in life.	Portrait values *(Not like me at all/ A little like me/ Somewhat like me/ Like me/ Very much like me)*
	Benevolence	Basic values (Schwartz, 1994)	It's very important to them to help the people around them. They want to care for the wellbeing of others.	
Self Concerned	Hedonism	VBN (Gärling et al., 2003)	Protecting the environment will threaten jobs for people like me.	Likert (*Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree*)
	Hedonism	VBN (Gärling et al., 2003)	Laws to protect the environment will limit my choices and personal freedom.	
	Egoism	VBN (Gärling et al., 2003)	A clean environment provides me with better opportunities for recreation. **scale reversed*	
	Egoism	VBN (Gärling et al., 2003)	We don't need to worry much about the environment because future generations will be better	
	Egoism	VBN (Gärling et al., 2003)	Claims that current levels of pollution are changing the earth's climate are exaggerated.	
Biospherism	Environmental concern	VBN (Gärling et al., 2003)	Over the next several decades, thousands of species will become extinct.	
	Environmental concern	VBN (Gärling et al., 2003)	The balance of nature is delicate and easily upset.	
	Universalism	Basic values (Schwartz, 1994)	They strongly believe that people should care for nature. Looking after the environment is important to them.	Portrait values *(Not like me at all/ A little like me/ Somewhat like me/ Like me/ Very much like me)*

Construct	Variable measured	Source	Statement used for measurement	Scale
	Systems perception	Futures consciousness (Lalot et al., 2020)	I have had the experience of feeling 'at one' with nature.	Likert (*Strongly disagree/ Disagree/ Neutral/ Agree/ Strongly agree*)
Past focused	Past Negative	Time perspective (Zimbardo & Boyd, 1999)	I think about the good things I have missed out on in my life.	
Future focused	Future	Futures consciousness (Lalot et al., 2020)	I think about the consequences before I do something.	
	Future	Futures consciousness (Lalot et al., 2020)	I think about how things might be in the future.	
	Future	Futures consciousness (Lalot et al., 2020)	I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future.	
	Future	Futures consciousness (Lalot et al., 2020)	I consider how things might be in the future, and try to influence those things with my day to day behavior.	
Present focused	Present Fatalistic	Time perspective (Zimbardo & Boyd, 1999)	It doesn't make sense to worry about the future, since there is nothing that I can do about it anyway.	
Perceived Risk	Likelihood of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How likely do you think it would be that supplies (i.e. electricity, telephone, water) would be interrupted?	Precieved flood likelihood *(Not likely at all/ Unlikely/ Somewhat likely/ Extremely likely)*

Construct	Variable measured	Source	Statement used for measurement	Scale
Perceived Risk	Likelihood of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How likely do you think it would be that some of your assets, not including your home, would be seriously damaged or destroyed?	Precieved flood likelihood *(Not likely at all/ Unlikely/ Somewhat likely/ Extremely likely)*
	Likelihood of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How likely do you think it would be that your home would be seriously damaged or destroyed?	
	Likelihood of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How likely do think you it would be that you or some of your loved ones would be hurt?	
	Severity of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How worried are you that supplies (i.e. electricity, telephone, water) would be interrupted?	Precieved flood severity *(Not worried at all/ Somewhat worried/ Quite worried/ Extremely worried)*
	Severity of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How worried are you that some of your assets, not including your home, would be seriously damaged or destroyed?	
	Severity of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How worried are you that your home would be seriously damaged or destroyed?	

Construct	Variable measured	Source	Statement used for measurement	Scale
Perceived Risk	Severity of flooding impacts	Perceived risk of future flooding events, adapted from (Harlan et al., 2019)	Suppose a flood occurred in your region within the next five years. How worried are you that you or some of your loved ones would be hurt?	Precieved flood severity *(Not worried at all/ Somewhat worried/ Quite worried/ Extremely worried)*
Descendants	Children	N/A	Do you have any children?	N/A
	Grandchildren	N/A	Do you have any grandchildren?	N/A

4.3.3 Model Measurement

We assessed the validity and reliability of our reflective constructs by putting them through a series of standardized statistical assessments, including factor loadings, average variance extracted (AVE), and Cronbach's alpha. Factor loadings for the constructs were used to determine if the individual factors measuring a construct were dependable as an indicator of that construct, with the threshold for a dependable loading being 0.6 or higher (Hair et al., 2021). AVE was used to determine how much variation within the indicators was accounted for by the construct, which determined convergent validity, with a threshold of 0.5 or higher indicating that the constructs were significantly different. If they were not significantly different, they could not be included in the same model. Two variables had AVE scores slightly lower than 0.5, *self concerned* (0.490) and *biospherism* (0.491). Both constructs were ultimately kept as they were considered theoretically important and were close to the cut-off threshold. Cronbach's alpha was used to determine internal consistency within constructs containing more than two variables, with a threshold value of 0.7 or higher generally indicating strong internal consistency. As this was an exploratory study focusing primarily on determining the presence of relationships, rather than the strength of relationships, a threshold value of 0.6 was used as a cut-off for out constructs which is suggested in Hair et al. (2010) as appropriate for novel scales.

The formative constructs measured, including descendants and perceived risk, do not need to meet these statistical standards as they are caused by their indicators, unlike the reflexive constructs which cause the indicators. These formative constructs abide by their own statistical standards, where internal consistency was tested using Cronbach's alpha once again, and factor loadings, which are recommended to be above 0.5, however

if the validity of the instrument is impacted by the removal of a variable within a formative construct it may be retained regardless of the factor loading, which is why the factor loadings for the Perceived Risk construct do not all load (Hair et al., 2021).

Table 8: Validity of PLS-SEM model *(N=217)*

Construct	**AVE**	**Cronbach's alpha** (n>2)	**Variable**	**Factor loadings**
Other focused	0.733	n/a	Universalism	0.899
			Benevolence	0.812
Self Concerned	0.490	0.737	Hedonism (jobs)	0.684
			Hedonism (laws)	0.768
			Egoism (recreation)	0.595
			Egoism (future)	0.710
			Egoism (pollution)	0.731
Biospherism	0.491	0.659	Environmental concern (extinction)	0.724
			Environmental concern (balance)	0.731
			Universalism	0.662
			Systems perception	0.662
Future focused	0.558	0.733	Future (consequences)	0.751
			Future (neutral)	0.774
			Future (sacrifice)	0.633
			Future (influence)	0.817
Perceived Risk	n/a	0.9011	Flood likelihood (supplies)	0.084
			Flood likelihood (home)	0.359
			Flood likelihood (assets)	0.702
			Flood likelihood (loved ones)	-0.071
			Flood severity (supplies)	-0.028
			Flood severity (home)	0.330
			Flood severity (assets)	0.426
			Flood severity (loved ones)	0.054
Descendants	n/a	n/a	Children	0.955
			Grandchildren	0.701

4.4 Results

4.4.1 Overview

Of the 1,350 surveys we mailed out, 233 were returned as undeliverable, and 233 were completed enough to include in analysis (21% response rate, +/-6% at 95% confidence level). Based on our assessment of representativeness, those aged 50-70 were overrepresented within our sample, accounting for 49% of respondents despite being 38% of the population. Females were also overrepresented, accounting for 66% of our sample but 51% of the population. Our sample was over representative of those earning a higher income and those with more post-secondary education that the average for the region. Our sample did have representation from a diversity of individuals, encompassing all categories of income, age, gender, and education. A full comparison can be seen in the Appendices in Table A1.

When asked if participants had seen a flood risk map of their region, 20% indicated that they had. When asked to elaborate on the sources of these maps, respondents indicated they had either seen them online, in town or municipal publications, or on community Facebook groups.

4.4.2 Perceptions of Flood Risk Mapping

Perceptions of flood risk mapping were assessed by agreement with four statements, explored below (Table 9). For each statement, a five-point Likert scale was presented to respondents, however strongly agree and agree were collapsed into one ‘Agree’ column and strongly disagree and disagree were collapsed into one ‘Disagree’ column for analysis. Within our sample, a majority of participants agreed that flood risk mapping was useful for current and future home buyers and renters (93%), and that flood

risk mapping should be publicly available for all to use (85%) (Table 9). Despite this, 31% agreed that flood risk mapping should only be available to specific landowners. The most divisive perspective explored was if publicly available flood risk mapping would have an unacceptable impact on real estate value of affected landowners, where 61% expressed that it would have an unacceptable impact.

Table 9: Perceptions of Flood Risk Mapping Opinions and Outcomes*. Participants were asked to rate their level of agreement with each statement (N=212).*

Statement	**Tone**	**Agree**	**Neutral**	**Disagree**
Flood risk mapping for a given property should only be available to the specific landowner(s).	Negative	31%	12%	57%
Publicly available flood risk mapping would have an unacceptable impact on the real estate value of affected landowners.	Negative	30%	31%	39%
Flood risk mapping for properties in my region should be publicly available for all to use.	Positive	85%	10%	5%
Property-level flood risk mapping provides important information for current and future home buyers and renters.	Positive	93%	5%	2%

Correlations between each of the statements above were calculated to assess patterns in responses “Flood risk mapping for properties in my region should be publicly available for all to use.” and “Property-level flood risk mapping provides important information for current and future home buyers and renters.” were the only statements with a high correlation (alpha= 0.703) (see Table 10 below).

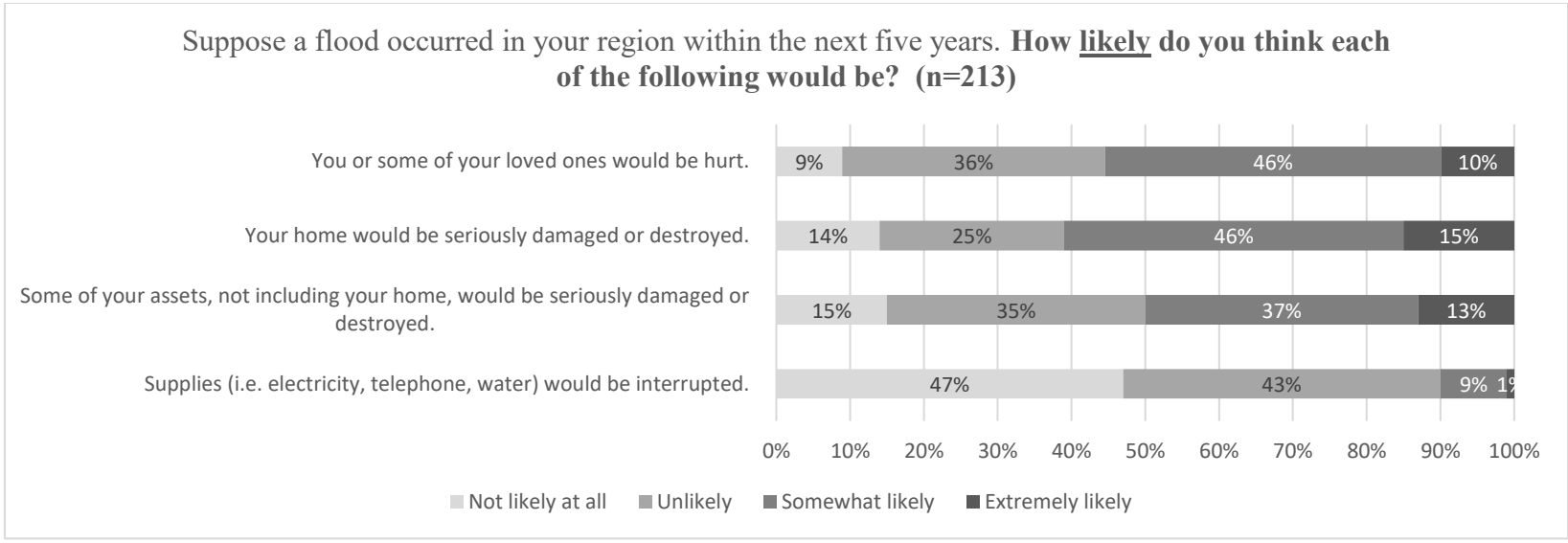
Table 10: Correlation matrix of perceptions of flood risk mapping statements (Pearson's r) *(n=213)*

	Flood risk mapping for a given property should only be available to the specific landowner(s).	*Publicly available flood risk mapping would have an unacceptable impact on the real estate value of affected landowners.*	*Flood risk mapping for properties in my region should be publicly available for all to use.*	*Property-level flood risk mapping provides important information for current and future home buyers and renters.*
Flood risk mapping for a given property should only be available to the specific landowner(s).	1			
Publicly available flood risk mapping would have an unacceptable impact on the real estate value of affected landowners.	0.303	1		
Flood risk mapping for properties in my region should be publicly available for all to use.	-0.171	-0.235	1	
Property-level flood risk mapping provides important information for current and future home buyers and renters.	-0.082	-0.167	**0.703**	1

4.4.3 Risk Perception

Our risk perception variable measured the perceived likelihood and severity of the impacts of a hypothetical flood on respondents within the next five years, assessing

concerns surrounding impacts on supplies, assets (including homes), and safety of themselves or loved ones. 50% of respondents believe that a flood within the next five years would likely damage their assets and 61% believed it would damage their home (Figure 7). The severity of concern was lower, with only 25% being quite or extremely worried about their assets, and 23% being quite or extremely worried about their home (Figure 7). Not all respondents are at risk of flood, of course, but without adequate flood mapping we are unable to establish who is and who is not at higher risk.



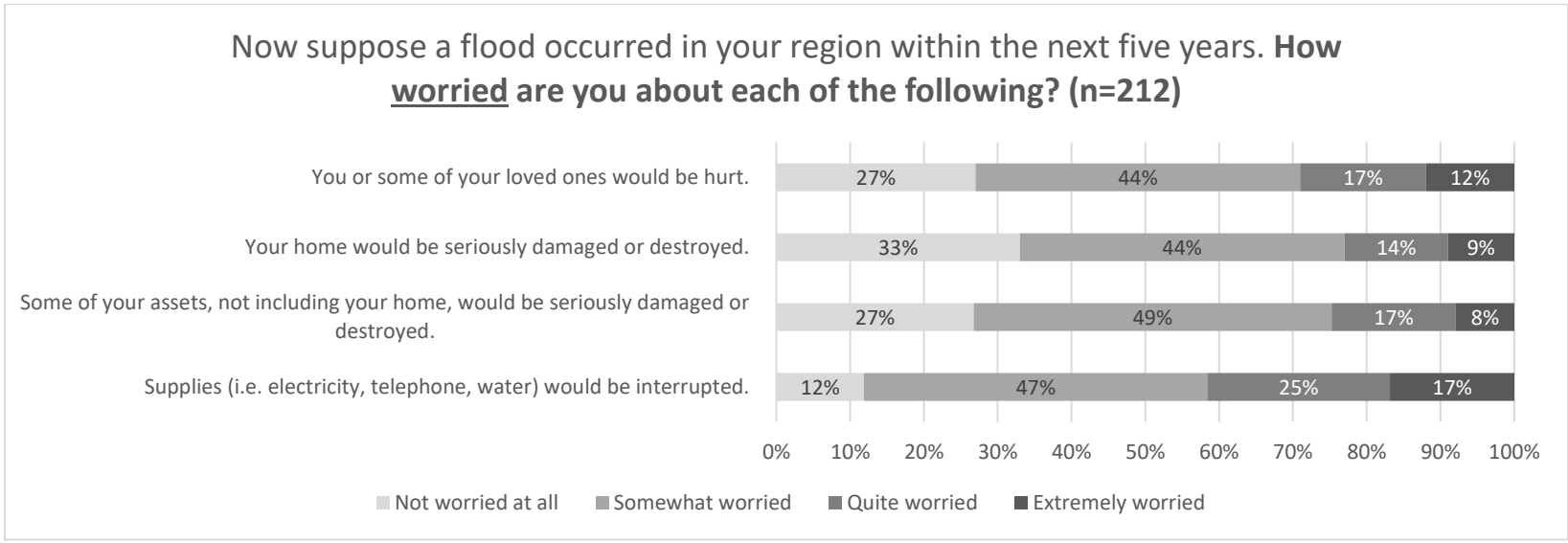


Figure 7: Distribution of perspectives on impacts of flood likelihood and flood severity over the next five years.

Our risk perception variable was calculated by adding together the likelihood values and the severity values for each of the categories of risk, and then multiplying these values together. This scale had high internal consistency, with a Cronbach's alpha value of 0.901. The possible available range of risk perception values using this formula would have a minimum value of 8 and a maximum value of 256, however within our sample these values range from 20 to 196, with an average risk perception value of 115. Based on the distribution, we split respondents into four equal-range categories, representing low perceived risk, mild perceived risk, moderate perceived risk, and severe perceived risk. The proportional distribution (Figure 8) is demonstrated below. The overwhelming majority (88%) of respondents experienced mild or moderate perceived flood risk, and a small number (6% each) experienced low and severe perceived flood risk.

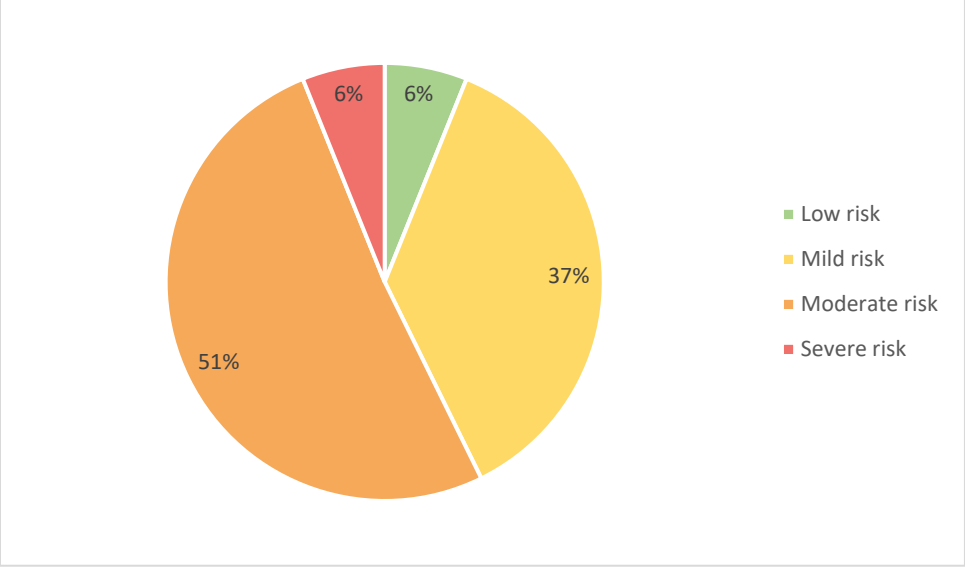


Figure 8: Proportional Distribution of Perceived Risk *(n=213)*

4.4.4 PLS-SEM

Our PLS-SEM (R^2 0.114) examining drivers of resistance towards flood risk mapping (via its impacts on real estate) was completed in STATA (version 17.0). The PLS-SEM suggests several factors may influence resistance to flood risk mapping. An increased perceived flood risk was found to have a significant positive influence on resistance (ß 0.214, p <0.01, F^2 0.014) (Figure 9). An increase in *other focused* (ß -0.169, p <0.05, F^2 0.014), as well as having descendants (ß -0.196, p <0.01, F^2 0.034), were found to have a significant negative influence on resistance to flood risk mapping. While no significant direct effect was present, being *self concerned* was found to have a significant negative influence on *other focused* (ß -0.443, p<0.001), *future focused* (ß -0.415, p<0.001), and *biospheric* (ß -0.562, p<0.001) (Figure 9).

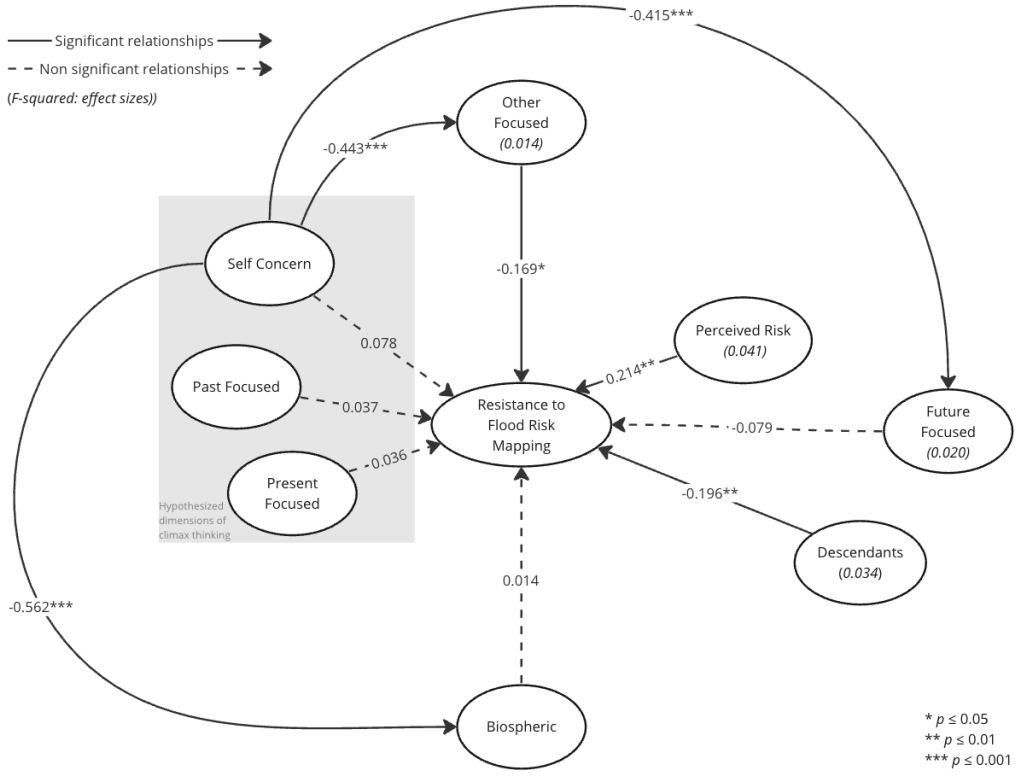


Figure 9: Structural equation model for resistance to flood risk mapping *(N=217). All relationships shown for direct effects, only significant relationships shown for indirect effects.*

4.5 Discussion

4.5.1 Support for Flood Risk Mapping

Overall, there was general support for publicly available flood risk mapping in the region, with 93% of respondents agreeing that it provides important information for current and future home buyers and renters (Table 9). While 85% agreed that publicly available flood risk mapping should be available for all to use, 31% also agreed that flood risk mapping for a given property should only be available to specific landowner(s) which suggests that at least 15% of our respondents held discordant views regarding support for publicly available flood risk mapping. This overlap of contrasting perceptions may be due to a lack of emphasis on the word 'only' within the interpretation of the statement "Flood risk mapping for a given property should *only* be available to the specific landowner(s).", which (if overlooked) would have changed the meaning of the statement. These types of contradictory views have been observed in previous flood mapping studies, as Howard & Sherren (2023), for example, found that while over 90% of respondents agreed that there should be flood mapping available to the public for the region surveyed, but 30% agreed that flood risk mapping for the region surveyed should only be available to affected landowners.

30% of respondents expressed that the potential negative impacts of flood risk mapping on real estate value of affected landowners would be unacceptable. McNamara & Jackson (2019) found that a focus on losses that may result from climate adaptation can lead to feelings of solostalgia or grief, and render people less open to change. This may partially explain our results, as the statement about real estate value was the only statement that explicitly referred to losses or risks from mapping. Thistlethwaite et al.

(2018) found that Canadians living in high flood risk areas currently lack willingness to pay for property-level flood protections and post-flood disaster relief, believing instead that these expenses should be covered by governments. As of the 2023 Federal budget, a national, affordable insurance program is currently being implemented across the country which would aim to reduce potential financial strain on those worried about the impacts of future flooding on their assets (Public Safety Canada, 2022). Consideration of the implementation of additional programs, including buyouts and property-level nature-based solutions, may help to further reduce the number of property owners who feel threatened by the financial impacts of the rollout of publicly available flood risk mapping. Further solutions which focus on framing communication during the rollout of flood risk mapping to focus on empowerment of the community to prepare together for future floods may be an effective strategy to combat this resistance as well (Badullovich et al., 2020).

A previous study (Howard & Sherren, 2023) exploring perceptions of flood risk mapping in Nova Scotia's South Shore region, specifically the communities of Liverpool and Bridgewater, similarly found that real estate concern was the core driver of resistance to the implementation of flood risk mapping, however only 16% of respondents expressed resistance in that region, as compared to 30% of our respondents from the Minas Basin region. A possible cause of this difference may be due to geography and the elevated actual flood risk in the Minas Basin region. As the Minas Basin region is generally lower lying, and includes the dykelands region, it is more prone to flooding and has experienced unprecedented floods recently, which in July 2023 (after the survey was done) led to the deaths of four individuals from Hants county (Cooke, 2023), within the

surveyed area. Such heightened experiences with flooding may contribute to fears surrounding financial impacts resulting from the rollout of publicly available flood risk mapping, as for many their home is a significant asset that they may be relying upon for their future. Despite these concerns, only 2% of respondents disagreed that property-level flood risk mapping provided important information for current and future home buyers and renters.

This disconnect between agreeing to the importance of flood risk mapping for the public, yet being protective of one's own assets, must be understood and addressed if we are to effectively roll out publicly available flood risk mapping in the Minas Basin region. Striking this balance is complicated, however previous scenario planning research conducted in the United States by Mobley et al. (2020) shows that investment in mitigation strategies is an effective and financially robust way to ensure asset protection. Building in buyout and funded mitigation strategies may help to encourage those hesitant about flood risk mapping to reduce resistance. Recently, publicly available flood risk mapping was attempted in Lunenburg County, however it was rescinded due to public pushback, including concern from homeowners who were notified by personal letters that their homes were at risk of flooding if they were identified on the flood risk maps. By contrast, Raikes et al. (2023) found that Canadians living in high flood risk areas expressed general overall social acceptability of flood risk maps, as well as disaster assistance, flood insurance, flood risk disclosure and liability, and property buyouts. Raikes et al. (2023) did, however, also find that to achieve high social acceptability, flood risk management costs as well as access to information needed to be distributed equitably across stakeholders. A more productive approach would avoid alarming homeowners, and

provide them with solutions and the chance to discuss with experts who may be able to help them protect their assets both physically and financially.

4.5.2 Risk Perception Influences Resistance to Flood Risk Mapping

Our structural equation model suggests that increased risk perception can have a strong positive influence on resistance to flood risk (

). This suggests that those who feel they are more at risk of flooding damages are less likely to want that risk status to be publicly known, due to fear about the impacts on real estate values. This risk perception paradox is well described in the literature, notably by Wachinger et al. (2013) who found that in a review of risk perception in connection to natural disaster preparedness, those with high risk perception often still choose not to act. In the context of flooding, this would indicate that those who are at elevated flood risk would not implement flood protections on their property. Risk perception can be influenced by trust in local authorities, as well as perception of one's own agency and responsibility for preparing (Wachinger et al., 2013). The risk perception paradox is further corroborated by findings from Howard & Sherren (2023), who found that within the context of resistance to flood risk mapping, a lack of understanding of one's own capacity to adapt and the influence of one's actions on others significantly increased resistance to flood risk mapping.

The positive relationship found in this work between risk perception and resistance can also be explored through different understandings of risk. Risk is traditionally understood through a rationalist approach, however a constructivist approach, which emphasizes social conditions as well as barriers to adoption including time, money, and knowledge, may help explain why risk perception leads to increased resistance to flood

risk mapping (Birkholz et al., 2014). While a rationalist approach to understanding risk perception explores how cognitive variables may impact risk, a constructivist approach additionally explores social and cultural variables which contribute to ones understanding of risk. Future research should explore how flood risk perception is measured and understood, and may seek to engage in a constructivist approach to understand risk perception more holistically.

4.5.3. Climax Thinking Framework Helps Understand Drivers of Resistance

This study employed the Climax Thinking theoretical framework (Sherren, 2021), which seeks to explore why individuals maintain that their current landscape is in its final and ideal form. Our model suggested that an increase in 'other focus' and having descendants (a proxy for future focus) both significantly reduced resistance to flood risk mapping with respect to concerns about impact on real estate value.

The significance of 'other focus' and having descendants suggests that thinking about others affects decision making, both within the immediate family and beyond. The role of concern for others and flood resistance has been demonstrated in previous research, for example a study in Indonesia suggested that solidarity was an important force for collective climate action for the community to rebuild after a flooding event (Rahayu et al., 2022). Research by Monteil et al. (2022) in France found that community solidarity did impact individual preparedness for flooding, however disaster risk reduction was hindered due to confusion around what scale of governance was responsible for its implementation, leaving both individuals and the government to believe the other party was responsible for the implementation of disaster risk reduction strategies. This thought pattern could also be present within our sample, as there may be

the expectation that adding publicly available flood risk mapping would reduce individual responsibility for the level of flood preparedness within their own property. More broadly, it is well understood that in the context of collective climate action, including natural disaster risk management, solidarity with one another is a key driver in achieving climate action (Blau, 2017; Doan & Sherwin, 2016). As it is well understood that community solidarity fuels flood preparedness actions on a collective level, future research which explores differences in individual versus community risk perception, and how this impacts individual versus community preparedness, could show us how to harness collective efficacy.

Having descendants significantly negatively influenced resistance to flood risk mapping, further supporting the importance of communicative framing techniques which work to engage in future-focused thinking when rolling out potentially concerning climate adaptations. Those with descendants may be more likely to already be thinking about future impacts, as they are thinking about impacts for their children or grandchildren. A national scale study across the United States found through the discussion of potential future climate impacts that future framing was effective in encouraging openness to adaptation strategies (Stern et al., 2020). Sherren et al. (2022) also found that future priming was effective in encouraging openness to nature-based coastal climate adaptations in Nova Scotia, as it prompted thought surrounding duties to future generations. A future-focused communicative priming strategy may be effective in reducing resistance to publicly available flood risk mapping, as we found that those with descendants (thus maybe considering impacts for future generations) are less likely to be resistant to its implementation, despite potential impacts on real estate values today.

Although being *self concerned* was not a significant direct driver of resistance to flood risk mapping, it did maintain a strong indirect influence. Specifically, being *self concerned* had a significant negative impact on *biospherism*, *other focus*, and *future focus*. This remains consistent with the Climax Thinking framework, as the 'climax thinker' is more likely to prioritize themselves and their current landscape, despite potential impacts that preserving this status quo may have on the natural world, others, or future generations. This was consistent with research from (Howard & Sherren, 2023), who found using the Climax Thinking framework, that self concern was a driver of resistance to publicly available flood risk mapping. Here, communicative priming techniques may also prove useful, as Sherren et al. (2022) found that in other contexts where self concern due to Climax Thinking is present, altruism-focused priming techniques which focus on collective action were effective in reducing the presence of Climax Thinking.

4.6 Conclusion

This study explored perceptions of publicly available flood risk mapping within the Minas Basin region of Nova Scotia. Employing a multiple-mail out hybrid survey methodology, data was collected from a random sample within the region, who overall expressed support for publicly available flood risk mapping and its importance for current and future homebuyers and renters. Despite this, there remained 30% of participants who expressed that publicly available flood risk mapping would have an unacceptable impact on real estate value for impacted landowners in the region. The rollout of flood risk mapping within the Minas Basin region of Nova Scotia is rapidly approaching, with the province having recently assigned the contract for this region to an engineering firm (D.

Bryce, personal communication, July 12, 2023). This rollout must work to anticipate and address potential resistance from the community, specifically with regards to concerns for potential impacts on property value. Focusing on communication, outreach, and education strategies which harness community solidarity and a focus on impacts and equity for future generations may help to reduce resistance to the rollout of publicly available flood risk mapping. Furthermore, an understanding of the influence of risk perception must be further explored within this region ahead of the rollout of flood risk mapping, in order to work towards increasing the public's understanding of their actual risk, not their perceived risk. This can include education and preparedness measures surrounding how to evaluate and understand individual and community flood risk in an evidence-based way.

Chapter 5: Conclusion

5.1 Overview of Findings

Flooding is one of the greatest challenges that we are facing as a result of the climate crisis. Flooding is among the most dangerous natural disasters in Canada, often isolating individuals and communities from essential services of food, water, electricity, and access to health care. In 2019, the Canadian federal government declared a climate emergency in recognition of the threats faced by Canadians, and the need for urgent and impactful mitigation and adaptation measures. Coastal climate adaptations have the goal of addressing climate challenges in coastal environments and protecting coastal areas and their residents (Glavovic et al., 2022).. Within coastal flood management, this can include both information-based strategies to raise awareness, such as publicly available flood risk mapping, as well as restoration-based strategies to protect the natural and built environment, such as managed dyke realignment. Flood risk mapping allows for open and accessible communication of flood risk, usually at the property level, for all levels of decision makers, from the individual to the government decision makers. Managed dyke realignment allows for the retreat of dyke infrastructure and restoration of tidal wetlands to provide protection against flooding in tidal areas.

Despite the need for coastal climate adaptations, there is evidence of individual and community resistance to both adaptation strategies. Principal reasons for resistance are often cited to be strong cultural attachment to coastal areas, as well as concerns that the implementation of adaptation strategies may lower property value or render properties unsellable (Bradley, 2016; Mallette et al., 2021). Canadians living in high flood risk areas also express a lack of willingness to pay for individual or property-level flood

protections, despite expressing overall acceptability of flood risk maps, public flood insurance, flood risk disclosure and liability, and property buyouts as flood risk management policy tools (Raikes et al., 2023; Thistlethwaite et al., 2018). Research on the implementation of nature-based climate adaptations has also found that drivers of resistance to implementation are often interdependent, and often include lack of public awareness, resistance to change, lack of knowledge, actual and perceived costs, and lack of standards and frameworks (Sarabi et al., 2020). While many of these drivers can be addressed through policy instruments, there is poor understanding of the underlying psychological influences that may drive this resistance. Understanding this will help to develop best practices for communicating flood risks to make adaptation strategies more acceptable, and therefore more successful.

The goals of this study were to understand how residents of the Minas Basin region of the Bay of Fundy, Nova Scotia perceive the implementation of nature based coastal climate adaptation strategies, specifically publicly available flood risk mapping and managed dyke realignment, and why they are perceived as they are. The Minas Basin region provided an interesting study area, as it is located at the tip of the Bay of Fundy and experiences the most dramatic tidal ranges in the world. In addition, the region experiences significant coastal, pluvial, and fluvial flooding events, and is at risk of future flood impacts. The region is also home to many of the Bay of Fundy's dykelands, which are at risk of overtopping due to projected levels of sea level rise, which consequently can exacerbate freshwater flooding. We designed a hybrid mail-out survey to explore how publicly available flood risk mapping and managed dyke realignment are perceived, as well as the psychological and demographic drivers that influence these

perceptions. The survey was sent out to a random sample of residents within the counties of Hants, Kings, Cumberland, and Colchester.

This research was grounded in the Climax Thinking framework, which seeks to understand why people tend to believe that their current landscape is in its final and ideal form, and express resistance to public good landscape changes. In this study, we also sought as a secondary interest to improve the construct validity of this framework by testing the spatiotemporal dimensions of Climax Thinking using pre-existing theoretical frameworks. The theoretical design of this study was able to improve construct validity of the Climax Thinking framework, as it established that some of the constructs hypothesized to be expressed by a 'Climax Thinker' (i.e., who seeks to maintain the status quo and resist public good landscape changes) were found to increase resistance to managed realignment.

The results of this study provide new insights into perceptions of managed dyke realignment and flood risk mapping, as well as which psychosocial drivers influence these perceptions. We found that the vast majority of people were open to both the idea of managed dyke realignment and publicly available flood risk mapping. This is consistent with research from Raikes et al. (2023) who found that policy instruments, including flood risk mapping, which seek to reduce, share, and manage flood risks have high acceptability among Canadians (including those living in high flood risk areas). When considering situations where managed dyke realignment or flood risk mapping may be unacceptable, concerns were mostly related to potential impacts on homes. For managed realignment, concern was only raised surrounding the acceptability of relocation of

homes or businesses to allow for managed realignment. For flood risk mapping, concern was predominantly about potential impacts on real estate value of homes or land.

Interestingly, while the drivers of concerns about managed realignment and flood risk mapping were similarly related to personal assets of homes, the underlying psychological drivers of this resistance for each management strategy differed significantly. For managed realignment, we found that being past and *other focused* resulted in being more resistant to managed realignment relative to concerns for relocation or homes or businesses, while being *future focused* and *concerned for nature* resulted in being less resistant to change. For flood risk mapping, we found that perceiving higher flood risk resulted in being more resistant relative to concern for unacceptable impacts on property value, while having descendants and being *other focused* resulted in being less resistant. This diversity of drivers indicates that how coastal climate adaptations are perceived is not consistent across adaptations, and remains unique to the specific adaptation measures (and likely the specific context) in question. As a result, when implementing policies and programs that seek to minimize or reduce resistance throughout the rollout of climate adaptations, it is critical to gather information about the local perceptions of that specific adaptation, and to design strategies and communication approaches to meet the specific needs and concerns of the community. These strategies are not universally applicable and may be highly dependent on both context and geography.

Despite the significant differences in direct drivers of resistance from the structural equation models exploring resistance to both managed realignment and flood risk mapping, *self concerned* was found to be an underlying driver of resistance in both cases,

having a significant negative impact on *other focused*, *biospherism*, and *future focused*, which were three constructs that had significant negative impacts on resistance within the various models. This suggests that *self concerned* has a significant underlying role in influencing resistance to coastal climate adaptations. This is consistent with previous research which tested Climax Thinking by Howard & Sherren (2023) which found that *self concerned* (called self ignorance) was one of the most significant drivers of resistance to publicly available flood risk mapping in the South Shore of Nova Scotia.

5.2 Implications for the Minas Basin region

The acceptability of coastal climate change adaptations within the Minas Basin region is dependent upon the implementation of measures to reduce resistance to these adaptations. We found that although a majority of the population surveyed was in favour of the implementation of managed realignment and publicly available flood risk mapping adaptations, there was still a minority who were concerned about the impacts on personal property, both in terms of the potential relocation of homes or businesses and impacts on property value.

For both managed realignment and flood risk mapping, public trust in governments and decision makers was found by other researchers to be an important influence in the acceptability and success of these projects around the world (Myatt et al., 2003; Roca & Villares, 2012). It will be important to understand the landscape of trust in public officials within the region ahead of any implementation of flood risk mapping or managed realignment, in order to address resistance resulting from mistrust. Appropriate financial mechanisms and compensation for impacted landowners has also been found to be important for increasing the acceptability of both flood risk mapping and managed

realignment projects (de la Vega-Leinert et al., 2018; Jones et al., 2014; Raikes et al., 2023). As resistance in the region was principally connected to concerns for impacts on homes or property value, the implementation of equitable and robust programs, including buyouts and financial protection, is likely to be important in reducing resistance to both managed realignment and flood risk mapping projects.

Finally, proponents for nature-based solutions should develop programs and communication methods to increase knowledge and understanding of the importance of coastal climate adaptations to preserve the cultural and working landscapes for future generations, particularly for complex methods like managed dyke realignment that are difficult for the public to understand, to help reduce resistance to these adaptations. Communicative framing and priming of information, in particular with a focus toward future generations, has been shown to be effective in increasing openness to adaptation strategies (Badullovich et al., 2020; Sherren et al., 2022). In both the managed realignment model and the flood risk mapping model, being *future focused* and/or having descendants (thus likely being more concerned about the future) were found to decrease resistance. By engaging the community to think about the future impacts of adaptations, or the potential consequences from lack of adaptation action, through communicative priming techniques, there may be opportunities to further address reduction of resistance. Exploring how communicative framing and priming techniques impact the rollout of flood risk mapping and managed realignment projects in the region is a rich area for future research, and as both adaptations are currently under development within the region, there is a unique opportunity to explore these impacts in real time, and potentially using experimental methods. As a result of recent flooding events in the region since the

survey has closed, future research might find higher risk perception overall in the region, and should possibly query the value of publicly available flood risk mapping for avoiding such loss of life.

5.3 Implications for theory

A secondary goal of this study was to use pre-existing theories to strengthen the construct validity of the Climax Thinking framework, to help operationalize the framework in the context of public good coastal landscape changes. This was done through the exploration of seven constructs based on the Climax Thinking framework presented by Sherren (2021), and testing, using established scales, if these constructs acted in the same way as the hypothesized dimensions of the Climax Thinking framework. This framework suggests that the 'climax thinker' is stuck in the mentality that the current landscape is in its final and ideal form, and thus resistant to the proposed coastal climate adaptations. Based on past work (Chappell et al., 2020; Howard & Sherren, 2023; Sherren, 2021), we expected resistance to be expressed through positive relationships with *self concerned*, *past focused*, and *present focused*, or negative relationships with *future focused*, *other focused*, and having decedents.

Our results support and help to refine the Climax Thinking framework, specifically within the context of public good coastal climate adaptations. We found that within the context of resistance to managed realignment, being *past focused* had a significant positive effect on resistance, and being *future focused* and *concerned for nature* had a significant negative effect on resistance, which is consistent with the Climax Thinking framework. In the context of flood risk mapping, being *other focused* and having descendants (which was assumed to be related to being future-minded) had a significant

negative effect on resistance, which is also consistent with the Climax Thinking framework. Furthermore, *self concerned* having an underlying negative effect on the constructs of *other focused*, *future focused*, and *biospherism*, all of which were hypothesized to reduce resistance, is also consistent with the Climax Thinking framework.

By contrast, in the managed realignment model, other focus was found to have a significant positive effect on resistance, which was opposite to what is hypothesized within the Climax Thinking framework. This may be due to concerns for potentially depreciating property value of friends or neighbours, as there is sense of community within the dykeland region (Eger & Courtenay, 2021; Sherren et al., 2021). As a first experimental validation of the Climax Thinking framework through related theoretical constructs, this study helps to validate the existing framework, as well as guide where future research is needed in order to fully understand the theoretical dimensions of Climax Thinking.

Additional research is needed to test these constructs across different proposed or hypothetical public good landscape changes, and in different settings, especially as the constructs which contributed to resistance differed within this study. Further research is also needed to validate and strengthen these constructs. Specific dimensions worth exploring are self and other concern, and temporal dimensions of future and past focus. Additional work is also required to explore the relative importance of these variables with trust (in governments, other people, etc.) and place attachment.

Overall, surveyed residents in the Minas Basin were well disposed towards the implementation of both dyke realignment and flood risk mapping to mitigate an

anticipated increase in the frequency and severity of flooding. Resistance to both strategies was elicited from a minority of residents. Climax Thinking was a useful framework in exploring the sources of this resistance. The sources of resistance were different for the different intervention strategies, highlighting the importance of considering resistance to mitigation strategies in specific contexts rather than in general. Broader concepts such as self concern, however, may more generally underlie resistance to climate mitigation. The urgency of addressing increasing flood risks imposed by the climate crisis will require rapid and iterative adaptation strategies. Proactive communication and management of community acceptance will be improved by ongoing attempts to understand and address the drivers of resistance to these necessary and important climate adaptations.

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Appendices

Appendix A: Demographic Comparison of Surveyed Population to Canadian Census

Table A 1: Demographics comparison. *Demographics of surveyed sample compared to demographics of the 2021 Canadian Census for the counties of Hants, Kings, Cumberland, and Colchester.*

Category	Census (% of total)	Survey (% of total)
Household Income		
Under $10,000	8%	0
$10,000 to $19,999	14%	1%
$20,000 to $29,999	18%	5%
$30,000 to $39,999	14%	9%
$40,000 to $49,999	13%	7%
$50,000 to $59,999	9%	8%
$60,000 to $69,999	7%	13%
$70,000 to $79,999	5%	11%
$80,000 to $89,999	4%	6%
$90,000 to $99,999	3%	8%
$100,000 to $149,999	4%	17%
$150,000 and over	1%	15%
Age		
20 to 24	6%	2%
25 to 29	6%	6%
30 to 34	7%	2%
35 to 39	7%	7%
40 to 44	7%	11%
45 to 49	8%	11%
50 to 54	9%	6%
55 to 59	10%	11%
60 to 64	10%	21%

65 to 69	9%	11%
70 to 74	8%	5%
75 to 79	6%	5%
80+	7%	2%
Gender		
Male	49%	34%
Female	51%	66%
Education		
High school or lower	41%	12%
Some college	39%	28%
Some university	20%	60%

Appendix B: Complete survey questions

Understanding perceptions of Coastal Landscapes and adaptation options in the Minas Basin, Nova Scotia

Welcome, and thank you for taking part in this survey! Your input is extremely valuable and will help your region prepare for climate challenges ahead. There are a total of four sections.

Section 1: Use of dykelands and tidal wetlands in the Bay of Fundy

This first section asks about how you see and use the agricultural dykelands and tidal wetlands of the Bay of Fundy, if at all, and what you think about their future.

Dykeland is the land that was created out of tidal wetlands by building earthen walls to keep out tides, thus draining them of salt water. Dykeland was originally designed for farming but many different land uses exist in dykeland today.

Dykes are the linear earthen walls that protect dykeland. Dykes are interrupted every so often by aboiteaux that help to drain rainwater from dykeland during low tide to keep it dry.

Tidal wetland is not always in front of dykes as shown here, but comprises vegetated areas that are flooded to some degree by regular tides.

What (aspects) features, of dykeland, dyke and tidal wetlands as described earlier, do you use for the given activities or values? Please select which of the three landscapes you use for each. You may select none or more than one landscape per activity. There may be overlaps between some of the uses in the way that you think about them, and that is fine (e.g. you enjoy the beauty of the natural landscape, which makes you inspired to create art).

I use *this* to...	Dykeland	Dyke	Tidal Wetland	None of these
a) Keep me safe (e.g. flood or storm protection)				
b) Make my living (e.g. farming, tourism)				
c)Produce or gather food (e.g. crops, wild food, game, fish)				
d) Be active outdoors (e.g. running, biking, commuting, fishing, hunting, birdwatching)				
e)Practice my culture (e.g. weaving fibre, food for ceremony)				
f) Perpetuate a legacy (e.g. stewardship, cultural heritage)				
g) Enjoy nature and landscape views and other senses (e.g. smells or sounds)				
h) Be with others (e.g. spend time with family or friends)				
i) Educate myself or others (e.g. teach, research, learn)				
j) Feel like myself (e.g. identity including specific cultural identity such as Mi'kmaq, Acadian, New England Planter)				
k) Feel like I am home (e.g. sense of place and belonging)				
l) Inspire me (e.g. to make art, be creative)				
m) Make me reflect (e.g. think, be calm, be spiritual)				

On average, how often do you use dyke, dykelands, or tidal wetlands for the purposes selected previously?

- ○ Never
- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ A few times a year
- ○ Seasonally (please explain which)

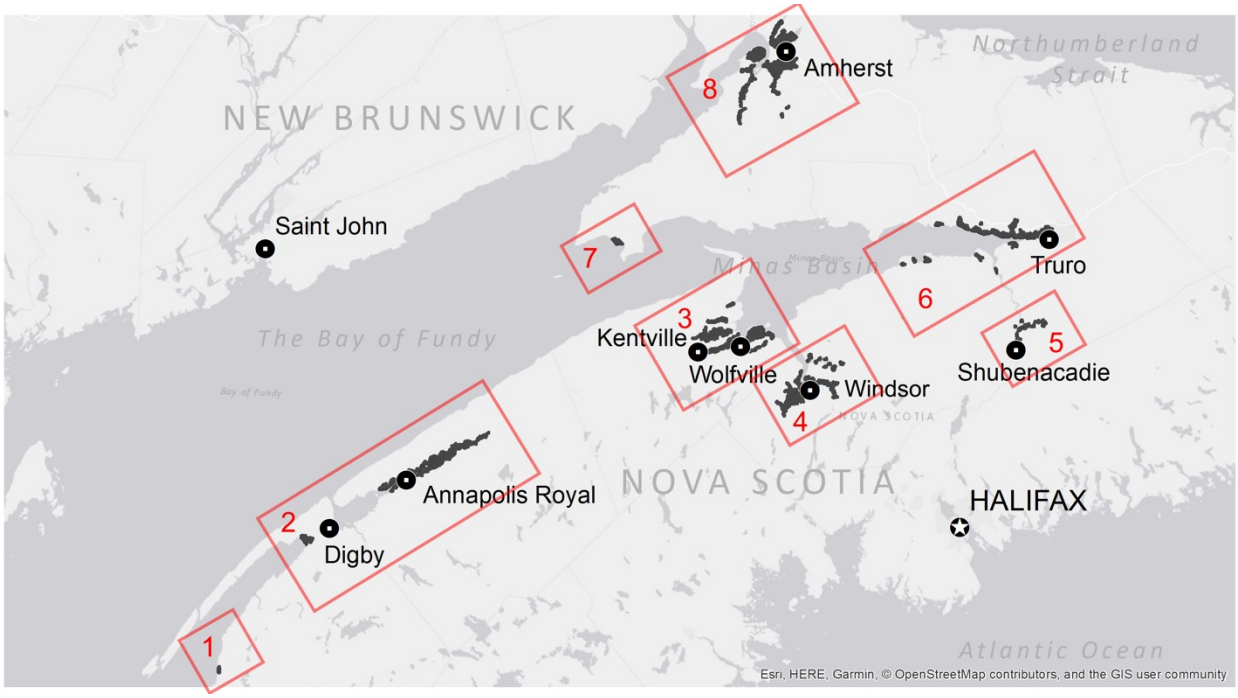
_____

- ○ Other _____

Are there particular areas of dyke, dykeland or tidal wetland that you use more than others?

- ○ Yes, I use some more than others
- ○ No, I use all dykeland, dyke and tidal wetland in Nova Scotia the same amount

Which of the below dykeland areas in Nova Scotia do you use most? Choose as many as appropriate.



- ○ 1 (Saulnierville)
- ○ 2 (Digby/Annapolis Royal)
- ○ 3 (Kentville/Woldville)
- ○ 4 (Windsor)
- ○ 5 (Schubenacadie)
- ○ 6 (Truro)
- ○ 7 (Advocate)
- ○ 8 (Amherst)
- ○ Other (please list or describe)

_____

How many total years have you lived in mainland Nova Scotia? _____

How many years have you lived at your current property? _____

How many total years have you lived in your current region? (i.e. community, town) _____

Please describe your local area, in terms of what it means to you personally and how you use it.

_____

_____

_____

_____

_____

Do you have any connection to dykeland farming? Choose as many as relevant.

- ○ Currently a dykeland farmer
- ○ Descendant of a dykeland farmer
- ○ Other connection to dykeland farming

_____

Managed realignment is the process of building higher dykes further inland from current ones and restoring the former dykeland in front of them back to tidal wetlands. Below is a photograph of a recent managed realignment project at Belcher Street, along the Jijuktu'kewjk/Cornwallis River, near Kentville, NS, where a new dyke has been built to continue to protect active farmland. Some former dykeland areas in front of the new dyke are being restored to tidal wetland.

Have you heard of managed realignment before?

○ Yes

○ No

Please briefly share any experiences you have had with managed realignment, if any.

_____

_____

_____

How do you feel about managed realignment, as described above? Please respond to each statement below using a scale from agree-disagree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) Dykes in Nova Scotia should be raised to counter storm surges and rising sea levels.					
b) Restoring tidal wetlands would help protect Nova Scotia against storm surges and sea-level rise.					
c) Moving dykes back will allow us to keep protecting useful dykeland while providing space for flood water.					
d) Restoring dykelands to tidal wetlands represents more risk than benefits.					
e) In some cases, it would be acceptable to relocate homes or businesses to allow for dyke realignment.					

Section 2: Climate Change and the Environment

This section asks about your perspectives on the environment, climate change and its potential impacts where you live.

How important is the issue of climate change to you personally?

- ○ Extremely important
- ○ Very important
- ○ Somewhat important
- ○ Not too impostant
- ○ Not at all important

How worried are you about climate change?

- ○ Very worried
- ○ Somewhat worried
- ○ Not very worried
- ○ Not worried at all

How much do you think climate change will harm you personally?

- ○ A great deal
- ○ A moderate amount
- ○ Only a little
- ○ Not at all
- ○ Don't know

How much do you think climate change will harm future generations?

- ○ A great deal
- ○ A moderate amount
- ○ Only a little
- ○ Not at all
- ○ Don't know

How do you feel about the natural environment? Please respond to each statement below using a scale from agree-disagree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) Protecting the environment will threaten jobs for people like me.					
b) Laws to protect the environment will limit my choices and personal freedom.					
c) A clean environment provides me with better opportunities for recreation.					
d) We don't need to worry much about the environment because future generations will be better able to deal with these problems than we are.					
e) Claims that current levels of pollution are changing the earth's climate are exaggerated.					
f) Over the next several decades, thousands of species will become extinct.					
g) The balance of nature is delicate and easily upset.					

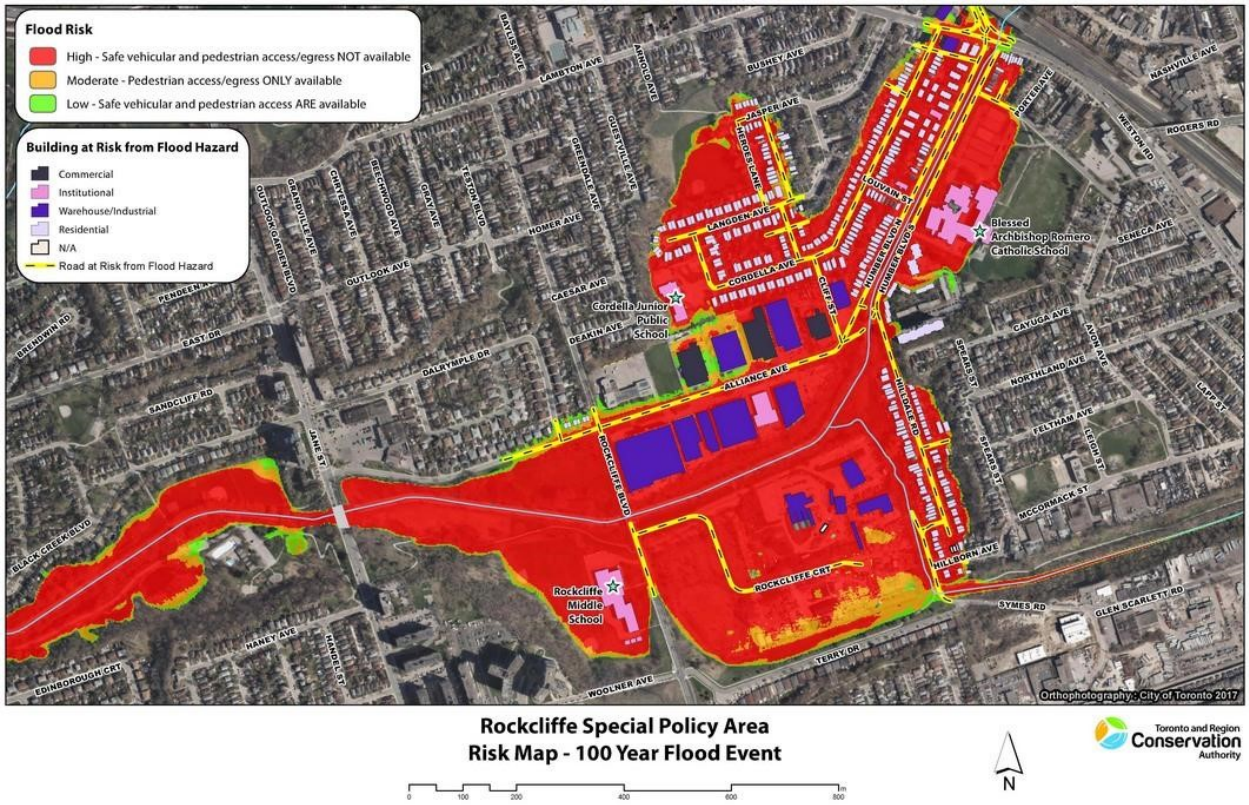
Suppose a flood occurred in your region within the next five years. **How <u>likely</u> do you think each of the following would be?**

	Not likely at all	Unlikely	Somewhat likely	Extremely likely
Supplies (i.e. electricity, telephone, water) would be interrupted.				
Some of your assets, not including your home, would be seriously damaged or destroyed.				
Your home would be seriously damaged or destroyed.				
You or some of your loved ones would be hurt.				

Now suppose a flood occurred in your region within the next five years. **How <u>worried</u> are you about each of the following?**

	Not worried at all	Somewhat worried	Quite worried	Extremely worried
Supplies (i.e. electricity, telephone, water) would be interrupted.				
Some of your assets, not including your home, would be seriously damaged or destroyed.				
Your home would be seriously damaged or destroyed.				
You or some of your loved ones would be hurt.				

A **flood risk map** is a map that shows an area of land, homes, roads, buildings, and other infrastructure that may be at risk in a specified region in the event of a flood. Below is an example of a flood risk map in the City of Toronto during a 1 in 100 year flood event, which is a flood that has a 1% probability of occurring in any given year.



Have you ever seen a flood risk map for your region?

- ○ Yes
- ○ No

Please elaborate on the sources or locations of these maps, if you have seen any.

_____

_____

_____

_____

Much of the country, including the majority of Nova Scotia, lacks standardized, publicly available flood risk mapping. **How do you feel about flood risk mapping?**

Please respond to each statement below using a scale from agree-disagree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) Flood risk mapping for a given property should only be available to the specific landowner(s).					
b) Publicly available flood risk mapping would have an unacceptable impact on the real estate value of affected landowners.					
c) Flood risk mapping for properties in my region should be publicly available for all to use.					
d) Property-level flood risk mapping provides important information for current and future home buyers and renters.					

Section 3: Perceptions and decision making

This section asks you to reflect on your past, present, and future, and the priorities that guide your decisions.

For this set of questions, we are interested in how you think about the passage of time because this can influence how people feel about climate change and climate adaptations, such as flood risk mapping.

How do you feel about the passage of time? Please respond to each statement below using a scale from agree-disagree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) I think about the good things I have missed out on in my life					
b) Familiar childhood sights, sounds, smells often bring back a flood of wonderful memories					
c) It doesn't make sense to worry about the future, since there is nothing that I can do about it anyway					
d) I think about the consequences before I do something					
e) I think about how things might be in the future					
f) I am willing to sacrifice my immediate happiness or well-being in order to achieve something in the future					
g) I consider how things might be in the future, and try to influence those things with my day to day behavior					

What is your outlook on life? Please respond to each statement below using a scale from agree-disagree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) I believe I can succeed at most any endeavor to which I set my mind.					
b) I hardly ever expect things to go my way.					
c) I am usually able to protect my personal interests.					
d) I am always optimistic about my future.					
e) I think that all the Earth's systems, from the climate to the economy, are interconnected.					
f) I have had the experience of feeling 'at one' with nature.					
g) I easily see connections between events and things even when they first seem unrelated					

In this section, we ask you to compare yourself to a hypothetical person and ask: **"How much is this person like me?".** This helps us understand your personality and how that relates to your views on climate change and climate adaptation options, such as flood risk mapping. The options

you can choose are: Not like me at all, A little like me, Somewhat like me, Like me, Very much like me.

	Not like me at all	A little like me	Somewhat like me	Like me	Very much like me
a) They think it is important that every person in the world be treated equally. They believe everyone should have equal opportunities in life.					
b) It's important to them to show their abilities. They want people to admire what they do.					
c) It is important to them to live in secure surroundings. They avoid anything that might endanger their safety.					
d) Having a good time is important to them. They like to 'spoil' themself.					
e) It is important to them to make their own decisions about what they do. They like to be free and not depend on others.					
f) It's very important to them to help the people around them. They want to care for the wellbeing of others.					
g) It is important to them that the government insure their safety against all threats. They want the state to be strong so it can defend its citizens.					
h) They look for adventures and like to take risks. They want to have an exciting life.					
i) It is important to them always to behave properly. They want to avoid doing anything people would say is wrong.					
j) It is important to them to get respect from others. They want people to do what they say.					
k) They strongly believe that people should care for nature. Looking after the environment is important to them.					
l) Tradition is important to them. They try to follow the customs handed down by their religion or family.					

Section 4: Demographic Questions

Finally, we need to know a little bit about you so that we can understand how representative a sample we have achieved of your region.

Do you have any children?

- ○ Yes
- ○ No
- ○ Prefer not to say

Do you have any grandchildren?

- ○ Yes
- ○ No
- ○ Prefer not to say

Can you tell us about your current work situation?

- ○ I currently work/study mostly from home (including house or care work for my family)
- ○ I work/study mostly outside the home
- ○ I am retired
- ○ Other _____

Year of birth: _____

Gender

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer not to say

Average annual household income

- ○ under $10,000
- ○ $10,000-19,999
- ○ $20,000-29,999
- ○ $30,000-39,999
- ○ $40,000-49,999
- ○ $50,000-59,999
- ○ $60,000-69,999
- ○ $70,000-79,999
- ○ $80,000-89,999
- ○ $90,000-99,999
- ○ $100,000-149,999
- ○ $150,000 and over
- ○ prefer not to say

What is your highest level of education

- ○ lower than high school diploma
- ○ high school diploma
- ○ some university
- ○ bachelor's degree
- ○ professional or graduate degree
- ○ some college, apprentice, or non-university post-secondary program
- ○ college, apprenticeship, or non-university post-secondary program certificate or degree
- ○ other (please specify) _____
- ○ prefer not to say

Do you self-identify as a member of any of the following communities or groups? Select as many as apply.

- ○ Mi'kmaq
- ○ Wolastoqiyik or Peskotomuhkati
- ○ Acadian
- ○ New England Planter
- ○ African Nova Scotian
- ○ None of the above

Where would you place yourself on a scale from 1-10, with 1 being socially conservative and 10 being socially progressive?

_____

Where would you place yourself on a scale from 1-10, with 1 being the desire for the economy to be run by a cooperative collective agency (i.e. government), and 10 being the desire for the economy to be left to it's own devices (i.e. market)?

_____

Is there anything else you would like to tell us?

Thank you so much for taking the time to complete our survey! If you would like to be entered into an optional draw for a $50 (first 100 respondents) or $25 (remainder of respondents) gift card to Irving Gas or Tim Hortons, please complete the form below.

First Name:_____ Email Address:_____

What is your gift card preference if you were to win?

- ○ Tim Hortons
- ○ Irving Gas