Households' Willingness to Install Water Meter

Case Study: Corner Brook, Newfoundland and Labrador

by

© Seyedeh Anahita Mireslami

A Thesis submitted to the School of Graduate Studies

in partial fulfillment of the requirements for the degree of

Master of Arts in Environmental Policy

Environmental Policy Institute, School of Science and Environment

Memorial University of Newfoundland - Grenfell Campus

February 2025

Corner Brook, Newfoundland and Labrador

Abstract

Water resources are essential for socioeconomic growth, ensuring human survival, and play an integral role in sustainable development (UN Water, 2015). Water resources benefit societies in a variety of forms and include advantages of a commodity nature in the contexts of industry, agriculture, and residents (Young & Loomis, 2014). As income rises and populations expand, water usage also grows to meet the demands of agriculture, industries, and households alike. This puts pressure on the limited freshwater reservoirs around the world (Watts et al., 2015). With climate change underway, temperatures will change, rainfall will become less predictable, and water systems may face challenges, so it is important for communities to prepare for what lies ahead (Watts et al., 2015). Such shifts increase the potential for socioeconomic and environmental disruptions and significantly impact the management and planning of water resources in the future (Gleick, 1989). In the City of Corner Brook, NL, water usage is not directly metered, and residents are not charged based on the amount of water they consume. Instead, the residents of Corner Brook pay an annual water and sewage tax, which is included in the property tax receipt. In fact, Corner Brook residents do not pay their water bills based on their consumption levels, which may lead to negligence and over-consumption within the households, making the current approach environmentally unsustainable. A binary choice model is applied to determine what affects people's willingness to install water meters, relying on survey data collected directly from residents. The results show that a few key factors make it more likely for people to consider installing a meter. For example, older residents, those who know how much installation costs, people awareness of NL's high water use per person, and those who believe meters help conserve water were more open to the idea. On the other hand, some factors make residents less interested in adopting water meters. Families with more members saw meters as an added expense. People with higher education levels may think that managing water conservation should be handled by the government, not individuals. Retired residents and those who are satisfied with the current water pricing system are also less likely to support installation. These findings highlight both the variables that encourage and discourage water meter adoption. Using these insights, policymakers could create strategies to get more homes to install meters, improving water use and solving water management issues in the city of Corner Brook.

Keywords: Households' willingness, water meter installation, water pricing strategies, sustainable water usage, water management.

Acknowledgement

I want to thank my supervisor, Dr. Morteza Haghiri, whose guidance and support were essential for completing my thesis. His advice and feedback were a big help and made it possible for me to finish this project successfully.

I am also deeply appreciative of Dr. Gabriela Sabau and Dr. William Newell for their invaluable feedback. I thank the faculty at the Environmental Policy Institute (EPI) at Grenfell Campus for their great teaching and the knowledge they shared. Their help gave me the skills I needed to complete this thesis.

I wish to express my heartfelt thanks to my parents, Nahid and Mostafa, for their unwavering encouragement and support, which has been vital to the completion of this project. I am thankful to my sister, Mehrnaz, and my brother-in-law, Amin, for consistently motivating me during this endeavour. I am very thankful to everyone who shared their expertise and encouragement during my studies. I sincerely appreciate the Municipality of Corner Brook City for their meetings and valuable input, which helped advance my research.

Table of Contents

Contents **Page**

List of Tables

List of Figures

List of Acronyms

ACWWA	Atlantic Canada Water and Wastewater Association
AMI	Advanced Metering Infrastructure
AWN	Atlantic Water Network
BRACE	Building Regional Adaptation Capacity and Expertise
CCAP	Climate Change Action Plan
COP	Conference of Parties
EDA	Exploratory Data Analysis
GC-REB	Grenfell Campus Research Ethics Board
IPCC	of the IPCC Technical Paper on Water
IRM	Integrated Resource Management
ME	Marginal Effects
NB	New Brunswick
NCC	Nature Conservancy Canada
NGO	non-governmental organization
NL	Newfound and Labrador
NS	Nova Scotia
OLS	Ordinary Least Squares
PEI	Prince Edward Island
SWP	source water protection
UN	United Nations
UNECE	the UN Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization

WRMD	Water Resources Management Division
WTA	Willingness to Accept

Chapter 1

1. Introduction

1.1 Background

It has been documented that around 70 percent of the Earth is covered by water, yet just three percent of this amount is fresh water from sources including rivers, wetlands, lakes, and glaciers (NCC, 2023). The significance of freshwater ecosystems extends beyond their provision of water for human consumption and industry; they are vital habitats for a diverse range of species including fish, birds, insects, and many more (Wendy, 2022). These freshwater ecosystems are home to 10 percent of all species. However, since 1970's the decline in freshwater animal populations was rapidly increased. Freshwater ecosystems have been disrupted, and in some cases, they have vanished entirely due to the increasing demand for fresh water across various services. Therefore, preserving freshwater habitats is important for people's well-being as well as for safeguarding endangered species (NCC, 2023; Wendy, 2022).

Although Canada possesses large freshwater resources, its residents rank among the highest in global per capita water consumption (Danamark, 2024). Canada uses about 64 percent of the 44.7 billion cubic meters of freshwater it takes each year to generate thermal power. Of the entire usage, 15 percent comes from manufacturing and mining, 9 percent from the agricultural sector combined, and 12 percent from non-industrial sectors like as for residential, rural, and municipal use (Danamark, 2024). In Canada, 35 percent of residential water use is for personal hygiene activities like bathing and showering, whereas 30 percent is consumed through toilet use. The allowance is further divided as follows: 25 percent is for cleaning and laundry, and 10 percent is for drinking and cooking (Bush, 2024). Canada, despite having abundant water resources, is faces growing difficulties, primarily because of the effects of global climate change (Danamark, 2024). For example, in 2015, parts of Saskatchewan had to limit water use due to problems caused by algal blooms (WSP, 2024). In 2016, southern Ontario and some areas in Eastern Canada faced drinking water restrictions because supplies were running low. In addition, reduced glacier runoff in Alberta in 2018 led to water shortages, creating difficulties for farmers trying to manage their crops. By 2019 and 2020, British Columbia and Manitoba were also dealing with serious droughts that required people to cut back on water use, even though these regions are usually known for having plenty of water. Urban expansion, industrial activities, and water-intensive farming practices are some of the causes of these problems (WSP, 2024). Therefore, improving strategies for water management and conservation is essential to meet the rising water demands projected for the future (Danamark, 2024).

In addition, global concerns over water quantity and quality are being exacerbated by economic development, population increases, climate warming, and past water management methods. The World Bank (2020) highlights that global water demand is anticipated to outpace supply by 40 percent by 2030, with the main contributors being increased consumption across agriculture, industry, and households (World Bank, 2022; The Guardian, 2023). It is becoming clear that leaders and international bodies are recognizing the importance of water in climate change efforts. Remarkably, water was given a significant place on the agenda of the United Nations Conference of Parties (COP), which is the annual convention on climate change, for the very first time in the history of the event (Suga, 2022). The event, which took place in Egypt in November 2022, is referred to as "the Water COP," highlighting the increased focus on water-related matters within the climate action framework (Suga, 2022).

Canada's freshwater ecosystems, despite their abundance, are at risk due to issues like degradation, fragmentation, and pollution (Wendy, 2022). The Nature Conservancy of Canada (NCC) has been ensuring the protection of aquatic habitats for both humans and animals for nearly 60 years. Wetlands, woods, and grasslands have also been revitalized, all of which contribute to the purification and storage of water (Wendy, 2022). The Newfoundland and Labrador Water Resources Portal (2023) indicates that Corner Brook City's water supply mainly comes from surface water bodies, including reservoirs, brooks, and ponds (Water Resources Portal, 2023).

According to Statistics Canada (2019), the residential sector in the country had an average daily water consumption of 220 litres per individual in 2017, making it the primary user of water and placing it among the highest consumption rates globally. This was 2,445 million cubic meters, or half of the entire volume of drinkable water produced. The provinces of Newfoundland and Labrador (474 litres), Yukon (383 litres), British Columbia (291 litres), the Northwest Territories (286 litres), New Brunswick (265 litres), and Quebec (240 litres) respectively all had higher per capita (on average daily) water consumption compared to the rest of Canada in 2017 (Statistics Canada, 2019). Differences in water consumption can largely stem from a wide range of causes, such as pricing systems and the implementation of water metering, water scarcity, commercial endeavours, the adoption of conservation practices (such as low-flow toilets), weather, population and housing characteristics (Statistics Canada, 2019). In 2017, the Atlantic Canada provinces (i.e., Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick) displayed various levels of their average daily residential water consumption. Among these provinces, the province of Newfoundland and Labrador was the one with the highest average daily residential water consumption. This was followed by New Brunswick, which recorded 265 liters per person and then Prince Edward Island, with 218 litres. Nova Scotia had the lowest water consumption, with 186 liters recorded amongst the other provinces in Atlantic Canada. These numbers highlight the significance of developing solutions that are appropriate to an area to achieve sustainable water management and represent the distinct patterns of water consumption that exist within each province (Statistics Canada, 2019).

1.2 Problem Statement

Corner Brook, located on the western shores of Newfoundland (City of Corner Brook, 2021), consumes approximately 20 million litres of water daily, which city staff describe as excessive for a community of its size (Connors, 2021). With a population of 20,046 (City Population, 2023), the average water use per resident in Corner Brook is higher than the provincial average in Newfoundland and Labrador. In the City of Corner Brook residents are not charged based on their water usage. Rather, they pay an annual water and sewage tax based on the property unit they own. According to the City of Corner Brook (2023 Tax Rates)," A REAL PROPERTY TAX: of not less than $275 on every parcel of real property within the city, and every parcel of real property outside the city, which is situated on, in or over, or underwater and is accessible from land within the city, and the rate of tax shall be, subject to the minimum property tax." (City of Corner Brook, 2023). The significance of water as an essential element for sustaining life is undervalued in terms of its pricing in Corner Brook. The city of Corner Brook established a tax rate of 8.25 mills (The mill rate is the tax amount owed for each dollar of a property's assessed value) for fully serviced residential properties in 2023; This is in addition to the $600 per unit charged for water and sewer services annually. A $100 sewer levy is also included in this all-inclusive charge (City of Corner Brook, 2023). The absence of a structured water pricing system in the region is the primary problem being addressed. Understanding the factors that are related to the absence of structured water pricing in Corner Brook is aimed to be gained. The inconsistency between water pricing and consumption patterns shows up in two ways: residents with water meters are still not billed according to actual usage, while those without meters have no measurement of their water consumption. In this city, water consumption is not influenced by pricing, so residents tend to use water without considering its cost.

According to Section II of the city of Corner Brook Act RSNL1990 chapter C-15, (amended 2022), which states that “Where the water and sewage tax is set at a metered rate and there is no meter installed or working in relation to a building to which a metered rate applies, the council may for the purpose of imposing the tax estimate the quantity of water used in that building until a meter is installed and working.” As reported by the City of Corner Brook, water bills for residents are not based on their real water consumption or meter readings (City of Corner Brook, 2024). The city of Corner Brook has been dealing with increasing water treatment expenses in the recent years. (CBC, 2023). As a response, in 2017, an extra $75 annual charge for water and sewer services was planned to be introduced for residents and businesses (Hurley, 2021). The goal was to ease on the city’s financial burden during that time. However, to avoid placing an excessive burden on local citizens, the council has no plans to raise the mill rate, as the Corner Brook Deputy Mayor pointed out (Hurley, 2021). In 2023, Mayor Jim Parsons announced that the city had seen water treatment expenses climb by about 40%, mainly because of higher prices for the chemicals used in the process (CBC, 2023).

Over the years, the city of Corner Brook has encountered a variety of challenges, and it is becoming clear that improving water management depends largely on understanding residents' water consumption. There is also a need to create a payment system that better matches the services people receive, especially for households with higher water consumption. The issue of fairness comes up since high water users are not paying extra, while households with lower consumption face the same charges. This uneven setup negatively impacts on both the environment and on the government.

1.3 Research Questions

This study seeks to address the following questions: (i) What factors may influence Corner Brook residents' willingness to install water meters in their households? (ii) How do demographic and socio-economic factors influence households' attitudes in the City of Corner Brook toward residential water meter installation? (iii) What are the major attitudes and issues that residents in Corner Brook have concerning water meter installation and water pricing? (iv) How do awareness of water consumption issues and potential government incentives in this city influence residents' decisions about installing water meters?

1.4 Research Objectives

The primary objective of this study is to assess the factors that influence households' willingness to consider installing water meters in their homes in the City of Corner Brook, Newfoundland and Labrador. This study is about finding out what affects households' choices about water meters and determining the challenges or impediments that might limit their willingness to adopt this measure. We plan to evaluate the status quo within the city given the unstructured water pricing system. More specifically, in this work, demographic, socio-economic, and attitudinal factors that influence households' choices regarding the acceptance or refusal of water meter installation will be investigated. The key factors influencing residents' willingness to adopt water meter installation should be identified. These include residents' awareness of the benefits of having a water meter, the associated installation and maintenance costs, and their understanding of water conservation.

`This research study offers significant policy insights for municipal and provincial governments on water conservation, emphasizing the need for a better understanding of the issue to guide decisions.

1.5 Significance of the Study

Fair water pricing and resource management are needed for sustainability and conservation goals (Volker & Honey-Rosés, 2019; Alves et al., 2024). Governments at the provincial and municipal levels, along with environmental groups, are increasingly recognizing how implementing structured water pricing can enhance resource management and promote water conservation (Sandhu et al., 2020; Gurung, 2019; Vander Ploeg, 2011; Max Bell Foundation, 2011). Corner Brook, NL, has a serious water use problem because people there use much more water daily than the provincial and national averages (Connors, 2021). This situation highlights how important it is to improve water pricing systems to make them more effective. The study examines the main factors that affect residents' interest in installing water meters and explores why some may or may not support their installation. This information helps policymakers and municipal leaders create useful strategies and offer incentives to increase water meter coverage in this study region. Recognizing the key factors and barriers will allow for better policy design to address both practical problems and perception-related issues tied to water meters. Upon publication, this research will fill significant gaps in the related literature concerning the acceptance of water meter installation and its effects on water conservation and management. Future researchers and policymakers interested in city-wide water metering initiatives could find the result of this study quite useful. In addition, the finalized thesis will be stored in the MUN's library system, providing a foundational academic resource for future researchers, and undergraduate and graduate students.

1.6 Organization of the Thesis

This thesis, organized into five chapters, covers various aspects of the research. Chapter Two reviews a detailed literature covering freshwater availability concerns and global challenges, complemented by an analysis of Canada's water management systems at both the national and provincial levels, with a focus on Atlantic Canada provinces, especially Newfoundland and Labrador. Then, this chapter ends with an assessment of the current gaps in the literature and a summary of the existing related research landscape. Chapter Three delivers a detailed exploration of relevant research methodologies, including quantitative, qualitative, and mixed-method approaches, and reviews specific statistical models, including linear, polynomial, and logit regressions. The purpose of this chapter is to offer a thorough understanding of the various methodological approaches that are associated with research studies in this field. Chapter Four presents the empirical analysis section of this study looking at the sample collected data and giving a full description of the ways the data were gathered, the questionnaire's structure, and the sample method used in the study. Results from running the logistic regression analysis are presented and discussed in this chapter. Chapter Five reviews the significant findings of this research, derives conclusions from the analysis, and presents recommendations for policy improvement. This chapter concludes with a discussion of research gaps and suggestions for future studies.

Chapter 2

2. Review of the Literature

2.1 Introduction

This literature review provides insights into various elements of freshwater availability, water management, and related global and local concerns in an effort to give a broad picture of current freshwater governance challenges. The key factors explored in this section include: governmental oversight, environmental awareness, and social concerns. The selected information in this critical review of literature includes a wide variety of sources, such as peer-reviewed publications, governmental reports, gray literature, case studies, and important book excerpts. The impact of climate change on water management initiatives and barriers is covered in this chapter through a Canadian perspective focusing on the Maritime provinces, such as Prince Edward Island, New Brunswick, and Nova Scotia, Then, the following section explores the complexities of water management in Newfoundland and Labrador, discussing the challenges and approaches specifically related to this province. The chapter concludes with an in-depth analysis of the selected sources to determine the relevant findings which have formed the basis of research. In addition, this study identifies gaps in the reviewed literature and provides suggestions for future studies in relevant areas.

2.2 Freshwater Availability and Global Challenges: Implications for Canada

The availability of fresh water is vital for economic growth, human welfare, and ecosystem resilience (Gleick & Cooley, 2021). Water scarcity is defined as a major lack of freshwater resources needed to meet water demands (Tzanakakis et al., 2020). This issue is recognized as a pressing global challenge, remaining a serious concern in many regions and identified as one of the most critical risks for the coming years (Tzanakakis et al., 2020). This definition includes physical scarcity, where water supply fails to meet demand, and economic scarcity, which arises from financial or institutional obstacles preventing access to available water (Hasan & Tarhule, 2022; Vallino et al., 2020; Jarvis, 2013). Water scarcity is no longer just about how much water is available; it also depends on social, economic, and political factors, as well as how water is governed and managed (Jarvis, 2013; Bozorg-Haddad et al., 2021). According to the survey conducted by Gleick and Cooley (2021), the gap between what people need and what freshwater is available raises more concerns about water scarcity. These difficulties accelerate the number of political and socioeconomic problems greatly impacting the industrial and agricultural sectors. Gleick and Cooley (2021) emphasize the importance of gaining comprehension and overcoming the global challenges related to the supply and distribution of freshwater.

According to scientific standards, fresh water can be classified into two main groups. Water found in rivers, lakes, groundwater reservoirs, glaciers, and the ice caps of the polar regions is categorized as blue water. In addition, moisture within rain and soil, along with that inside plants, is classified as green water (Krieger, 2022). In this context, the effective management of blue and green water resources is essential for maintaining the sustainability of ecosystems (Shrestha et al., 2017). Since rivers are replenished annually through precipitation and snowmelt, these sources are considered renewable. However, the amount of available water can change with the seasons due to climate change and other environmental factors (Neighbour, 2020). Conversely, non-renewable freshwater largely consists of groundwater that has accumulated over long periods, potentially centuries or millennia, in arid regions that receive more rainfall. Renewing these resources can be lengthy, and excessive use can quickly deplete them. As a notable point, more than one-fifth of the world's freshwater is located in Canada. However, only about 7 percent of this freshwater is renewable (Neighbour, 2020). A large volume of this water heads north toward Hudson Bay and the Arctic Ocean, bypassing the densely populated southern parts of Canada, which contain 85 percent of the population (Neighbour, 2020).

Even though water resources are globally abundant, divergences in the distribution of water resources across different regions and times substantially impact how people perceive the scarcity of water resources (Gleick & Cooley, 2021). Different strategies have been designed over time to deal with water scarcity. The focus of these strategies has moved away from simply boosting water supply toward a broader approach that includes holistic and soft path ideas. According to Gleick and Cooley (2021), these thorough strategies include multiple options, such as innovative water supply methods, water demand optimization techniques, better water efficiency, and the adoption of complex economic policies. Water efficiency involves the consistent effort to conserve water resources by adopting technologies and practices that reduce water usage over time (EPA, 2013). As identified in this paper, enhancements in modelling regional assessments and cooperation with sectors like agriculture and energy are essential areas needing attention. Gleick and Cooley (2021) hold the view that more research is still needed, particularly regarding household water consumption in light of the consequences of climate change. This gap must be filled to create effective water management plans appropriate for the ever-changing environmental conditions (Gleick & Cooley, 2021).

The goal of this thesis is to enhance local understanding by examining how willing households are to install water meters and analyzing the factors that could affect their decision-making process for this adoption in their homes. To put it simply, this research consists of household surveys and econometric modelling techniques to meet the need for enhanced modelling and regional assessments (Gleick & Cooley, 2021). Additionally, this study tries to understand household water practices better by looking into demographic, socioeconomic, and attitude-related factors. These results will, ultimately, show which approaches can best support resilience to climate change impacts.

2.3 Global Perspectives on Water Management

The Natural Resources Conservation Service of the United States (n.d.) describes water management as systematically controlling water resources to lessen risks to public health and property while promoting effective, beneficial use. As stated in UNESCO's executive summary (2012), water management includes a variety of activities and implications. In addition, managing water resources involves overseeing natural sources, such as groundwater, rivers, and lakes. On the other hand, water service management focuses on the activities related to the infrastructure of capturing, treating, and delivering water, as well as collecting and treating wastewater (UNESCO, 2012). Moreover, because of water scarcity, balancing trade-offs requires working through detailed administrative procedures to distribute water among various socio-economic sectors (UNESCO, 2012; Natural Resources Conservation Service, n.d.). In addition, Haasnoot et al. (2009) highlight the importance of water management strategies that consider the dynamic interactions between water systems and societal changes, while addressing uncertainties such as climate change and socio-economic variability. Their research advocates using scenario-based approaches to explore future water demands and identify adaptive strategies (Haasnoot et al., 2009). It has conclusively been demonstrated that water management encompasses a range of separate but interconnected actions that together contribute to the overall management of the water system (UNESCO, 2012; Natural Resources Conservation Service, n.d.).

Hoekstra (1998), who highlights the need for integrating economic and cultural values, argues that water pricing, which is important, cannot resolve scarcity on its own. Hoekstra (1998) argues that it is important to balance social and environmental needs in water management, especially in regions where water availability is highly unpredictable. It is important to note that effective water allocation and management requires a detailed look at how different uses interact. Such an assessment should consider wider societal and economic objectives, particularly public health and safety. This shows that a good policymaking process is important because it helps decision-makers work better together. Mekonnen and Hoekstra (2016) highlight that addressing water scarcity on a global scale involves improving water-use efficiency and sharing limited resources equitably. In addition, their findings show that about two-thirds of the global population encounters severe water scarcity for at least one month annually, stressing the necessity for immediate action in managing and conserving water resources (Mekonnen & Hoekstra, 2016). According to UNESCO (2012), the public sector is often involved in the administration of water services; however, this involvement might vary based on political considerations and pragmatic factors. However, this varies among countries. Research conducted using data from prosperous nations highlights that there is no universal reason for solely favouring either sector (UNESCO, 2012).

According to the proposals of Gleick (2003) and Pahl-Wostl (2006), water planners and managers should adapt their strategies and perspectives gradually to effectively meet water demands. Water use, as noted by Reig (2013), refers to the total volume of water taken from a source for use in activities such as agriculture, industry, and households. Measuring how much water is used helps in understanding the demand from different sectors. Additionally, Scheele and Malz (2007) highlight that water demand tends to grow as efforts are made to ensure better living standards and improved sanitary conditions. Water use and its changing definitions were the focus of Glick's 2003 research. In his work, Gleick (2003) looks at water use on both global and local levels, highlights issues with data collection in the water sector, and suggests ways to improve water efficiency. The need of including interdisciplinary approaches and incorporating stakeholders in the water management decision-making process is underlined in this study. The researcher also emphasizes how important it is to apply modern technologies and follow new legislation in order to satisfy developing water issues including those related to population increase and climate change. Gleick (2003) holds the view that, water managers are increasingly interested in this topic as part of a more significant effort to support sustainable water consumption (SWC) in the long run and decline the adverse impacts of human water extraction on the environment. Sustainable water consumption involves actions that go beyond saving water during daily activities (Kang et al., 2017). It also includes choices like thinking about how much water a product needs throughout its life before buying it. Such habits are important because they help people use water in better ways and reduce waste over time (Kang et al., 2017). The current difficulties have been the subject of some research in water resource management. Global challenges have brought different groups together in agreeing that it is essential to closely examine the effectiveness of current policies, technologies, and water management systems. These findings show that water management needs to be continuously explored for inventive ways of shifting, adjusting, and responding to future demands (Ward et al., 2023; Brown & Farrelly, 2009).

According to another study, Abel et al. (2012) focus primarily on sustainability targets related to the water-related sectors. The researchers' report aims to be useful for different water sectors in improving their target-setting processes. The importance of this topic is so high that UNESCO includes the topic of targeting to measure the performance of different water units as a part of its Programme and Budget for the 2010–2011 plan. This effort focuses on governance techniques for improving affordability and securing financial support for water-related projects. According to UNESCO's 2012 guidelines, effective water management needs thorough planning and execution in every domain. As mentioned in previous reviews, Abel et al. (2012) also indicate the importance of cooperation among stakeholders and governmental organizations to achieve sustainable development. The authors identify gender-based target setting as an essential part of sustainable water management, which means alleviating the significant strain water scarcity places on women. The results of this study indicate that the issue with water resources management and water services is not a lack of tools but instead that improper tools are being applied to make policy and investment decisions.

Water meters play an essential role in managing water supply systems by allowing municipalities to monitor water flow from dams, through treatment facilities, and into individual households (Amir, 2022; Zyl, 2011). According to Amir (2022) and Zyl (2011), water meters are very important in monitoring and managing water flows to prevent losses and assure efficient resource distribution. It also helps municipalities make better decisions. A good metering system also means water charges are based on real usage, which gives people control over how much water they use and can reduce waste (Zyl, 2015). Water meters also encourage people to use water more responsibly. Studies show that metered households in the UK use 10–15% less water than unmetered ones, and in Canada, this difference can go up to 50% (Zyl, 2011). This shows how much metering can help save water. Plus, the data from meters can be used by municipalities to plan for the future, detect leaks, and monitor illegal connections (Zyl, 2011). These points make it obvious that water meters are not just tools for managing demand but also a way to encourage people to use water more wisely. Recent studies have primarily examined the transition from traditional water meters to advanced smart metering systems. Madias et al. (2023) highlight that the Technology Acceptance Model (TAM) introduced by Davis (1989) effectively explains consumer intention to adopt smart technologies like IoT-based water meters. This attitude is influenced by perceptions of the meters' ease of use and the practical benefits they provide, such as improved water management and cost savings. The perceived practical benefits of smart meters significantly influence people's willingness to adopt them (Madias et al., 2023). Public attitudes, based on the reading, are clearly a key factor. Koop et al. (2021) pointed out that around 78% of people are willing to accept water meters if they see clear benefits, such as saving money or helping the environment. These benefits really seem to encourage people to adopt the technology, especially when the meters are provided at no cost. This shows how much people value the advantages they get from using these systems.

Koech et al. (2021) explain that smart water meters can help households find leaks and manage their water use better, saving money. One of the most significant barriers to the adoption of these meters is the high initial cost. As technology improves, prices will reduce and become economically feasible. Other factors, like trust in the system, knowledge of the benefits, and adequate information flow from appropriate authorities, hugely influence the acceptance of people to use these technologies. It demonstrates that simply introducing technology is not enough, people need to see how it helps and feel reassured that their concerns are taken seriously (Koech et al., 2021). Millock and Nauges (2010) emphasize that socioeconomic factors and financial incentives play a key role in households' decisions to adopt water-efficient technologies. These put together focus on the interrelationship between the technical, social, and economic factors that determine the adoption of water meters; therefore, this provides a strong foundation for the research. In 2020, the study for the District of Mission found issues to address, such as worries about installation, costs, and changing to a system based on how much water people use (Econics, 2020). This study identified trust-building and community participation through strong communication in gaining public support for the project. On the other hand, the authors Okoli and Kabaso (2023) explain the benefits that could be derived from a smart water meter. It also covers the barriers surrounding high installation costs, general low public awareness, and cybersecurity risks. They claim that governments need to take responsibility for curbing the challenges by helping develop beneficial policies and, simultaneously, giving financial aid access to reduce costs. This therefore calls for proper planning and financial support in order to encourage the adoption of water metering systems (Okoli & Kabaso, 2023). While these studies provide useful ideas, they have focused mostly on the improvement of existing systems. A gap still exists in how households make decisions for first installation of water meters in areas where the technology has not been commonly adopted.

Hester and Harrison (2011) emphasize in their study the need for policy solutions to tackle global issues related to the effect of climate change on water. The findings of their study emphasize that policymakers all around the world are increasingly aware of the significance of developing comprehensive regulations and acts to manage the effects that climate change would have on water systems. Using the IPCC's technical paper on water systems, Hester and Harrison (2011) examine the complex ways climate change impacts water processes and supplies. They provide an overview of possible adaptation approaches across sectors, from agriculture to water management. Nevertheless, despite this raised awareness, a well-defined global framework for addressing these concerns requires further improvement (Hester & Harrison, 2011). There has been a lot of discussion around global water management strategies, particularly in the context of climate change. These authors shed light on key global efforts to improve river basin management. The research centers on studying the effects of climate change on water resources in high-population areas with established dams. Even with efforts to confront these challenges, a unified global policy framework for adapting water management to climate change is still needed. In addition, the UN Economic Commission for Europe (UNECE) is among the agencies supporting this view. While acknowledging the potential benefits in some areas, their analysis highlights the difficulties these UNECE countries face, such as increased susceptibility to floods and droughts (Hester & Harrison, 2011).

As noted by Anderson (2001), the broad numbers of organizations involved in international water management activities provide invaluable information for individuals functioning within this system. The objective is to address international water problems through coordinated efforts, policy development, and initiatives to build capacity. Each organization has a unique focus, ranging from promoting sustainable water use to addressing water-related health concerns. This review gives a simple introduction to water governance, showing the work, aims, and successes of key international groups (Anderson, 2001). The focus of this paper is on the collaborative efforts to address significant water issues worldwide, which provides detailed information regarding the actions and goals of a range of groups from international institutions to non-governmental organizations (NGOs) and research organizations. For instance, the GWP helps with sustainable water use by sharing advice and building partnerships between regions. Similarly, the Global Environment Facility (GEF) funds projects that protect international waters and promote sustainable economic growth (Anderson, 2001). In addition, considering the complex nature of global water resource management, this offers valuable insights for policymakers, scholars, and professionals (Anderson, 2001). In his work, Anderson (2001) explains the challenges of water governance and describes the efforts of groups trying to fix water problems around the world. A detailed list of major international organizations involved in water management efforts is presented in Table 1, offering valuable guidance for those unfamiliar with the topic.

Table 1: Major Players in Global Water Management. A Comprehensive Overview

Organization/Program Name	Website
Blue Planet Project	https://canadians.org/tag/blueplanetproject/
Global Applied Research Network (GARNET)	http://info.lut.ac.uk/departments/ cv/wedc/garnet/grntover.html
Global Energy and Water Cycle Experiment (GEWEX)	http://www.gewex.org
Global Environment Facility (GEF)	http://www.gefweb.org/
Global Water Partnership (GWP)	https://www.gwp.org/
Hydrology for the Environment, Life and Policy (HELP)	https://www.nwl.co.uk/help/
International Association for Hydraulic Engineering and Research (IAHR)	https://www.iahr.org/
International Association of Hydrological Sciences (IAHS)	https://iahs.info/
International Commission on Irrigation and Drainage (ICID)	https://icid-ciid.org/home

Organization/Program Name	**Website**
International Commission on Large Dams (ICOLD)	https://www.icold-cigb.org/
International Network of Basin Organizations (INBO)	http://www.oieau.fr/riob/friobang.htm
International Rivers Network (IRN)	http://www.irn.org/
International Water and Sanitation Centre (IRC)	http://www.irc.nl
International Water Management Institute (IWMI)	https://www.cgiar.org/
International Water Resources Association (IWRA)	https://www.iwra.org/
The Pacific Institute	http://www.pacinst.org/
Stockholm International Water Institute (SIWI)	http://www.siwi.org
United Nations Development Programme (UNDP)	http://www.undp.org
United Nations Environment Programme (UNEP)	http://www.unep.org
United Nations Food and Agriculture Organization (FAO)	http://www.fao.org
United Nations Educational, Scientific and\ Cultural Organization (UNESCO)	http://www.unesco.org/

Organization/Program Name	Website
Water For People (WFP)	http://www.water4people.org/
WaterWeb Consortium	http://www.waterweb.org
World Health Organization (WHO)	http://www.who.org
World Meteorological Organization (WMO)	http://www.wmo.ch
World Resources Institute (WRI)	http://www.wri.org/
World Water Council (WWC)	http://www.worldwatercouncil.org
World Water Forum (WWF)	http://www.worldwaterforum.org

Source: Adapted from an article by Anderson (2001).

Anderson’s (2001) study provides a good description of major international organizations and programs involved in water management. Nevertheless, the level of detail offered for each organization’s actions or plans is relatively limited.

2.4 National Water Management and Policy Frameworks in Canada

Canada’s national strategy promotes effective water resource management and efficient use in cooperation with other nations. Water management within Canada operates under policies established at federal, provincial, and territorial levels (Benidickson, 2017). This structure aims to maintain a balance among various interests, ensuring that freshwater resources are both used sustainably and preserved (Benidickson, 2017). Canada is dedicated to supporting global agreements that promote sustainable water management, like the UN's Sustainable Development Goals and the climate commitments in the Paris Agreement (Government of Canada, 2024; United Nations, 2023). The Government of Canada (2020) highlights the importance of understanding how various departments operate in implementing freshwater practices to grasp the country's federal water management system. Effective coordination across more than 20 federal organizations is crucial to supporting the development of well-structured policy frameworks. Moreover, Environment and Climate Change Canada works together with other government agencies to handle important freshwater challenges (Government of Canada, 2020). Canada's Federal Water Policy is an innovative effort that was developed through consultations. Its main objective is to balance water consumption with the demands of society, the economy, and the environment. This policy supports the smart allocation of freshwater resources to meet both present and future needs, with a focus on preserving water quality and encouraging responsible water use. In order to minimize water waste, it also emphasizes the need to raise public knowledge of the value of water and support sensible usage (Government of Canada, 2020). Table 2 shows Canada's key federal legislation regarding water management and environmental protection. These laws include the regulations overseen by Environment and Climate Change Canada in relation to its water-related endeavours, along with other notable federal legislation.

Table 2: Key Federal Legislation and Responsibilities

Key Federal Legislation	**Legislation administered by Environment and Climate Change Canada**
International Boundary Waters Treaty Act (1985)	Canada Water Act

Key Federal Legislation	Legislation administered by Environment and Climate Change Canada
Canadian Environmental Protection Act (1999)	International River Improvements Act
Fisheries Act	Department of the Environment Act
Navigable Waters Protection Act	
Northwest Territories Waters Act	
Mackenzie Valley Resource Management Act	
Nunavut Waters and Nunavut Surface Rights Tribunal Act	
Arctic Waters Pollution Prevention Act	
Canada Shipping Act	
Dominion Water Power Act	

Source: Adapted from the Government of Canada (2020).

Canada's Federal Water Policy, developed through consultations, is an innovative approach to addressing water management (Government of Canada, 2020). The core purpose is to maintain a proper balance of water intake with the requirements of society, the economy, and the environment. Emphasizing effective freshwater allocation, the policy aims to meet both present and future needs, conserve water quality, and promote responsible management. It also points out the importance of public awareness about water's value and supports responsible consumption to prevent waste (Government of Canada, 2020). Table 3 lists the federal government's departments that are responsible for freshwater resources in the country. In the report provided by the Government of Canada (2013), it is highlighted that Canadian federal departments are assigned a range of responsibilities regarding the management and creation of policies for freshwater resources. It stresses the importance of cooperation to guarantee long-term water management in line with national and international commitments.

Table 3: Departments of the Federal Government Responsible for Freshwater Resources

Departments
Agriculture and Agri-Food Canada
Canada Mortgage and Housing Corporation
Canadian Environmental Assessment Agency
Canadian International Development Agency
Environment Canada
Fisheries and Oceans Canada
Foreign Affairs Canada
Health Canada

Departments
Indian and Northern Affairs Canada
Industry Canada
Infrastructure Canada
International Trade Canada
National Defence
National Research Council
Natural Resources Canada
Parks Canada
Public Works and Government Services Canada
Statistics Canada
Transport Canada
Treasury Board Secretariat

Source: Adapted from the Government of Canada (2013).

The Government of Canada (2021a) indicates that the country is dedicated to enhancing water management at a national level through the application of different frameworks. In order to gather information from different stakeholders, such as cities, industry executives, NGOs, and Indigenous groups, a consultation process was set up and finalized in 2021 (Government of Canada, 2021a). The establishment of the Water Canada Agency clearly reflects Canada's dedication to protecting freshwater resources and promoting water safety. Although the public feedback session was successful, it is the government's ongoing involvement with Indigenous communities that highlights its dedication to considering diverse perspectives in water management policy (Government of Canada, 2021a). This strategy aligns with Canada's plan to effectively address freshwater challenges both locally and globally. This approach is in line with Canada's plan to effectively address freshwater challenges at local and global scales. To ensure strong water governance, Canada has also established a broad framework under the management of multiple agencies. It is important to highlight that the Canada Water Act and the Fisheries Act demonstrate Canada's dedication to sustainable water management and environmental protection. These acts demonstrate a strong dedication to water sustainability by promoting wise water use and increasing public awareness of water's importance to the ecosystem (Government of Canada, 2021a). It has conclusively been shown by the Federal Water Policy and the Canada Water Agency Discussion Paper that Canada is dedicated to managing its water resources proactively to ensure that future generations have access to adequate, safe water (Government of Canada, 2021a).

2.5 Water Management in Atlantic Provinces

Atlantic Canada covers the eastern part of the country, including the provinces of New Brunswick (N.B.), Nova Scotia (N.S.), Prince Edward Island (P.E.I.), and Newfoundland and Labrador (N.L.), as mentioned by Dietz and Arnold (2021). According to Vasseur et al. (2008), this area is unique for its diverse climate zones, including cool, humid-continental, sub-Arctic, and Arctic tundra. Water management in the Atlantic provinces is influenced by particular regional traits, goals, and challenges (Vasseur et al., 2008). This observation is consistent with other research, which shows that the unique ecosystems, water resources, and socio-economic context of these provinces shape their water management approaches (Côté, 2013; WESP-AC, 2022).

In 2021, Atlantic Water Network asserted that Atlantic provinces collaborate on regional endeavours to improve water management and tackle existing barriers. In this regard, these provinces share best practices and promote regional cooperation by tracing water quality, adapting to climate change, and managing watersheds (Atlantic Water Network, 2021). Two important efforts in Atlantic Canada's water management are the Atlantic Water Network (A.W.N.) and the Atlantic Canada Water Supply Guidelines (2022). The A.W.N. notably strengthens the region's approach by supporting community-focused water monitoring practices (Atlantic Water Network, 2024b). It has been demonstrated that A.W.N. encourages collaboration throughout a vast network of almost one hundred community contributors in the region for nearly twenty years. In order to improve water management practices in this region, A.W.N., as a practical approach, empowers regional communities to actively contribute to auditing and securing water quality via interconnected instruction and specialized technical guidance. The Atlantic Water Network (A.W.N.) continues to support its partners by offering essential resources, including equipment loans, regular training, and data management tools. A.W.N. further strengthens the region by connecting water monitoring experts, enhancing cooperation for the lasting health of Atlantic Canada's lakes, rivers, and wetlands (Atlantic Water Network, 2024a). The Government of Canada (2021a) indicates that the country is dedicated to enhancing water management at a national level through the application of different frameworks. In order to gather information from different stakeholders, such as cities, industry executives, NGOs, and Indigenous groups, a consultation process was set up and finalized in 2021 (Government of Canada, 2021a). The establishment of the Water Canada Agency clearly reflects Canada's dedication to protecting freshwater resources and promoting water safety. Although the public feedback session was successful, it is the government's ongoing involvement with Indigenous communities that highlights its dedication to considering diverse perspectives in water management policy (Government of Canada, 2021a). This strategy aligns with Canada's plan to effectively address freshwater challenges both locally and globally. This approach is in line with Canada's plan to effectively address freshwater challenges at local and global scales. To ensure strong water governance, Canada has also established a broad framework under the management of multiple agencies. It is important to highlight that the Canada Water Act and the Fisheries Act demonstrate Canada's dedication to sustainable water management and environmental protection. These acts demonstrate a strong dedication to water sustainability by promoting wise water use and increasing public awareness of water's importance to the ecosystem (Government of Canada, 2021a). It has conclusively been shown by the Federal Water Policy and the Canada Water Agency Discussion Paper that Canada is dedicated to managing its water resources proactively to ensure that future generations have access to adequate, safe water (Government of Canada, 2021a).

The Atlantic Canada Water Supply Guidelines show that the Atlantic provinces have made a lot of work in improving their water systems. They set the rules for how the drinking water sharing system should be run. This structure mostly uses factors related to climate change, showing a forward-thinking method in building water infrastructure that can endure and adapt to problems (Atlantic Canada, 2004; ACWWA, 2022). The standards demonstrate how the region is focused on ensuring that water supply systems remain safe and feasible for the future by working with stakeholders (ACWWA, 2022). It should be emphasized that this document was provided by reviewing external sources and adopting standards compatible with Atlantic Canada (Atlantic Canada, 2004).

The groups that helped update the water supply and waste standards for the Atlantic provinces are shown in Table 4. By working alongside government, cities, and other groups, these organizations offer diverse skills and experience (ACWWA, 2022). Their joint effort within the Building Regional Adaptation Capacity and Expertise (BRACE) initiative supports the securing and distributing of information and instruments for adapting to climate change in water management practices throughout this region (ACWWA, 2022).

Table 4: Key Contributors to Atlantic Province Water Guidelines Update (2022).

Project Committee
Water Supply Guidelines Lead
Wastewater Guidelines Lead
ACWWA Executive Director
Environment and Local Government
Environment and Climate Change
Nova Scotia Environment
Environment, Energy and Climate Action
Atlantic First Nations Water Authority

Source: Adapted from the Atlantic Canada Water Waste Association (2022).

The Atlantic Canada Water Supply Guidelines (2022) recommend in Section 9.10.6 that all properties install water meters for efficient water management. So far, however, despite this recommendation, the actual situation in the province of Newfoundland and Labrador totally differs from the preference for the guideline. Minnes and Vodden (2017) express that there is not enough water meter coverage on a residential scale in the province of Newfoundland and Labrador, which shows a big difference between recommended guidelines and actual local infrastructure implementation. This disparity shows that Newfoundland and Labrador's water management strategy has a significant deficiency. This research is being conducted with the intention of providing thorough insights into ways in which water management in the region might be improved. The identification of implementation gaps and the proposal of solutions to improve water meter coverage will be the means by which this objective will be fulfilled.

2.5.1 Water Management in Nova Scotia

According to Weston and Conrad (2015) and Cervoni et al. (2013), household water management in Nova Scotia is a complicated problem which needs various stakeholders' involvement and calls for a thorough strategy to encourage the efficient and sustainable water resources consumption. In 2005, Valcour et al. stressed the importance of applying effective approaches to water management practices in regions of Atlantic Canada. These programs are designed with the aim of solving problems about drinking water quality, access to water, and fixing water system infrastructure. As this case clearly demonstrates, to develop a sustainable solution, it is important to understand the socioeconomic and environmental variables that influence household water management in this area. In addition, to have a better understanding of the obstacles and opportunities in this area, it is important to examine research, reports, and similar projects and initiatives in detail. Moreover, some studies have considered residential water management in Nova Scotia. Residential water management in this province is a complicated topic involving several stakeholders that calls for a comprehensive approach to preserve effective and sustainable water usage (Weston & Conrad, 2015; Cervoni et al., 2013). In their 2013 study, Fullerton and co-researchers explored water usage in Halifax's municipal areas, emphasizing the critical role of efficient water management in cities. Their research also identified challenges and potential improvements in water management for urban areas in Nova Scotia (Fullerton et al., 2013). This study used an error correction model to evaluate municipal water usage in this city. The results from the regression model of this study indicate that labor market circumstances and demographic factors significantly influence municipal water use.

Along with municipal water consumption, community-based ecological monitoring is important for understanding and managing local natural resources (Sharpe & Conrad, 2006). Weston and Conrad (2015) point out the importance of community-based water monitoring in Nova Scotia to ensure sustainable management of watersheds. This study emphasizes the importance of watershed-based community stewardship organizations working with governments to build official partnerships (Weston & Conrad, 2015). It is important for the local community to engage in water management initiatives in order to guarantee the implementation of environmentally responsible practices and to increase awareness about the need to protect the environment. As Sharpe and Conrad (2006) pointed out, this is consistent with the necessity for scientifically valid data to inform decision-making processes in water management (Weston & Conrad, 2015; Sharpe & Conrad, 2006).

Cook et al. (2016) emphasize the importance of using evidence-based practices to enhance the effectiveness of water management. These strategies, which help meet the need for real data to guide decisions in water management, depend a lot on advanced metering systems and ways to control water loss (MacDonald et al., 2016; Cook et al., 2016). Halifax Water's 2018 Business Plan describes core plans for infrastructure and metering. The report explains the utility's strategy for managing non-revenue water and shows why reducing leaks is a crucial part of keeping an eye on the water distribution network. Halifax Water's strategy allows for prompt detection and repair of underground leaks, contributing to significant water and cost savings. The water loss control mechanism also addresses minor leaks quickly to prevent further impacts (Halifax, 2018). This business plan focuses explicitly on implementing Advanced Metering Infrastructure (AMI) across

Nova Scotia. The AMI system, which was authorized in 2016, involves the creation of a plan to upgrade household meters and finally install an innovative network in this region (Halifax, 2018). This initiative aimed to enhance customer service by offering features like monthly water billing, live tracking of water usage, and notifications to detect leaks across the region's water supply system. The technology advances water metering processes and supplies crucial data for promptly identifying leaks in the distribution system. The investment in AMI technology supports Halifax Water's mission of improving customer service and water infrastructure. Through AMI, the utility hopes to achieve greater operational efficiency, environmental benefits and cost savings, by decreasing the reliance on vehicle-based meter readings. According to the Halifax Water 2018 Business Plan, the Nova Scotia utility is highly focused on managing water in a way that is both sustainable and efficient. They achieve this by using leak detection tools that are very advanced, along with modern water metering systems. These projects in Nova Scotia not only boost operational efficiency but also raise customer service standards, while also promoting environmental care (Halifax, 2018).

Cervoni and colleagues (2013) express that integrated water resources management (IWRM) is widely recognized as a comprehensive structure for sustainable freshwater management. The authors assert that Nova Scotia has attempted to provide a comprehensive water management plan in this regard. Overall, the result of their study shows that coordinating partnerships among different governmental bodies is necessary to run a successful water management plan. The watershed modeling process, community-based monitoring, and water resource protection are all constitute part of water management that Nova Scotia applies to make its water resources more sustainable. (Nafees Ahmad et al., 2011; Timmer et al., 2007). To manage residential water resources well in Nova Scotia, it is important to include community involvement, use practices supported by research, and set up connected systems for managing water resources. The results of this province's literature review indicate that integrated water resource management (IWRM), ecological monitoring, evidence-based practices, and policies and initiatives about water consumption can help Nova Scotia achieve water resource sustainability. In addition to these features, residential water management in Nova Scotia involves additional concerns, includes water billing procedures and average water consumption. (Nacario, 2024a). According to Halifax Water (2023), water consumption in this province is consistently monitored by water meter system, which accurately measures the amount of water going through. As Nacario (2024a) states, the Nova Scotia Utility and Review Board is responsible for supervising water bills in Nova Scotia. Local utilities are in charge of managing the water supply and wastewater treatment facilities. Based on water system, customers are billed according to their water consumption in this province. In addition, a basic monthly fee is charged, with the amount determined by the size of the property's water meter (Nacario, 2024a). Water expenses for households in Nova Scotia are affected by population size, seasonal usage, and the costs associated with maintaining the water system. This includes both the rates for drinking water and sewage services. These findings enhance our understanding of the billing system in Nova Scotia province. Nacario (2024a) also illustrates this point clearly that the water bill consists of two major sections, including fixed and variable rates. The fixed charges include items such as meter readings and maintenance, while the fluctuating price covers water extraction, water treatment, distribution, sanitary drainage systems, and wastewater (Nacario, 2024a).

Nacario (2024a) illustrates that the regular monthly cost of water is $108 for residents of Nova Scotia. For residents in this province, this cost contributes to a total monthly utility bill of $420. The average cost of water per cubic meter is also $3.387 (Nacario, 2024a; Halifax Water, 2023). This thorough knowledge about residential water management and costs in Nova Scotia gives a useful framework for comparing water management strategies in the Atlantic provinces. As a public utility, Halifax Water does not add any profit to its charges (Halifax Water, 2023). funds are allocated for capital investment and operational and service development. As a result of transitioning to a daily pricing model, households are currently billed based on their actual water consumption throughout the billing period rather than on an annual basis. Significant water users also benefit from extra monitoring services that can recognize and address their unexpected water usage (Halifax Water, 2023). Moreover, this report explains that this system can help municipalities and household consumers know about any leaks in water systems. Halifax Water monitors the rate of water use according to the applied water system and provides customers with equipment to detect leaks. Through a Customer Connect account, households are able to observe their water usage patterns while also getting notifications in case if there is unusual usage, which could indicate a plumbing leak. Consumers can easily check their water use by reading the meter themselves before and after times when they have not used any water. Halifax Water's focus on finding leaks and reducing water loss shows its commitment to saving water responsibly and improving efficient water management in the province (Halifax Water, 2023).

2.5.2 Water Management in New Brunswick

Water management in New Brunswick is addressed by implementing a flexible framework. This framework was devised to accelerate the operation of fundamental control and supervision measures linked to timing and location (Cardy, 1981). According to the Government of New Brunswick (2017), climate change is a primary concern for water management in the province as it might affect the management of water resources and modify both the volume and quality of water. New Brunswick is dealing with the consequences of climate change, such as a rise in the average annual temperature. There are also predictions for more extreme seasonal and annual changes, along with heavier rainfall (Government of New Brunswick, 2017). These changes have different consequences affecting residents, economic growth, and ecosystems. To deal with these challenges efficiently, it is key to keep prioritizing and implementing the measures described in New Brunswick's Climate Change Action Plan (CCAP).

Beaulieu et al. (2021) offer a detailed report on how New Brunswick's Climate Change Action Plan (CCAP) was developed, with a strong focus on water management strategies. This province introduced its first Climate Change Action Plan in 2007, which recognized how important it is for communities to adapt and work together. New Brunswick has been working on important water issues through action research funded by the Environmental Trust Fund. Beaulieu et al. (2021) point out that top priorities include land erosion, coastal flooding, and saltwater entering groundwater. This effort is bringing the province forward and helping to set up a base which may lead to changes in future policies. New Brunswick introduced major updates to its climate policy in 2016, which included strengthening the CCAP and adding measures to make water systems more resilient. The authors discuss how municipalities had to work together and manage the effects of climate change. They also state it is important to have guidelines on how to apply related restrictions. In 2024 and 2025, 195 initiatives in areas like coastal and watershed management, wetland conservation, and climate change efforts will get financial support from New Brunswick's Environment Trust Fund, as shared by the provincial government (2024). This investment reflects New Brunswick's focus on sustainability. This province is moving forward with this joint effort, which is creating a foundation for future policy improvements. Beaulieu and others (2021) also mention that using specific tools for land planning can bring together different groups, which helps them work together toward common goals and also respond to the effects of climate change.

Kurylyk et al. (2014) note the crucial role of realizing the implications of climate fluctuations on groundwater for the effective application of sustainable water management methods in the province of New Brunswick. This is an important aspect to consider because this region relies heavily on underground water for several reasons (Kurylyk et al., 2014). Researchers investigate how climate change affects water from shallow underground sources. They note that certain shallow aquifers are quite vulnerable to climate change. Their research also shows that changes in rainfall patterns and groundwater recharge rates could quickly affect when and how much groundwater moves. These findings show how closely climate change and groundwater are connected, pointing to the importance of adaptive water management in New Brunswick. Green et al. (2011) and Kurylyk et al. (2013) introduce different viewpoints centered on groundwater suppliers. These studies focus mostly on hydrological features and do not go in-depth on how subsurface temperatures respond to climate change. This missing part points to an important factor that has been left out of understanding how climate change affects groundwater.

According to Tol Smit et al. (2014), collaboration is an essential method for managing the intricate challenges posed by environmental issues. Research from Tol Smit et al. (2014) explores the challenges of cooperative environmental governance in New Brunswick, with a specific look at the process of water classification. The study describes the complex ways that different types of knowledge are used in collaboration, focusing on how scientific and practical expertise work together with local knowledge from community experiences. The authors indicate that scientific knowledge is typically considered the most influential, yet local knowledge, which is based on the experiences of communities, also has a substantial impact. This blurs the traditional distinction between expert and local information (Tol Smit et al., 2014). In addition, the researchers claim the importance of a comprehensive perspective on knowledge that goes beyond restricted classifications, reflecting the ideas of Wolfe (2009). Research by Raymond et al. (2010) in environmental management and Taylor et al. (2013) in collaborative water governance underscores the importance of adopting methodologies that are reflexive, systematic, and adaptable. Additionally, the researchers' findings highlight that successful collaborative environmental governance in New Brunswick depends on the strategic use of diverse knowledge resources. Enhancing the efficiency and reliability of governance initiatives through a comprehensive strategy involving all stakeholders could lead to better water management and environmental conservation.

Plummer and Stacey (2000) declare that community-based initiatives are important for addressing sustainability concerns in New Brunswick's water management system. In their detailed discussion on sustainable water management, Mitchell and Shrubsole (1997) underscore the importance of assessing water management initiatives. Mitchell and Shrubsole (1997) highlight the critical need for increased engagement by critiquing the insufficient involvement of community-based groups. Their analysis points out the significance of involving only twelve community groups in water resource management, highlighting the need to solve this issue promptly, especially in the context of New Brunswick. The foundational work of Mitchell (2005) proposed integration indices as a key strategy for promoting integrated water resource management (IWRM), a view later reinforced by Plummer and Stacey (2000). It underlines the significance of planning in management processes and the interconnections between indices. Plummer and Stacey's (2000) research findings indicate that almost every organization can enhance integration, emphasizing the importance of both procedures and human factors in effectively implementing integration endeavours. Community-based water management organizations in New Brunswick contribute substantially to the discussion on integrated resource management and sustainability. Although some organizations show signs of being in line with IRM principles, others have difficulty integrating effectively due to operational challenges (Plummer & Stacey, 2000).

According to Nacario (2024b), the effective management of water resources is crucial for the sustainability of life and community well-being, especially in New Brunswick, Canada's largest marine province. More recent attention has focused on the functionality of water billing systems and water costs across Atlantic provinces. Nacario (2024b) reports that the average monthly water bill in the province of New Brunswick is $79 per household, excluding wastewater fees. In this report, it has been mentioned that in the province of New Brunswick, this amount adds to the total monthly utility charges for households, reaching $344, exclusive of natural gas costs. Water billing in New Brunswick is on average much lower than in Nova Scotia, where monthly expenses are documented at $108 (Nacario, 2024a). A comprehensive awareness of the complexities of water billing arrangements and associated charges is essential for improving residential water management (Inman & Jeffrey, 2006). According to the City of Fredericton (2024), municipal water supply agencies oversee New Brunswick's water management. These organizations are responsible for processing and distributing clean water for residential usage, as well as managing wastewater and sewage systems. Water meters play a crucial function in the province of New Brunswick. Billing for residents is based on water usage, combining fixed service fees with variable rates tied to volume. These fees help fund the distribution system and the upkeep of water infrastructure. This includes the upkeep of pumping stations, the operation of aqueducts, and water treatment facilities (Nacario, 2024b; City of Fredericton, 2024). For example, a network of water pipes spanning 433 kilometres distributes drinking water from deep wells to urban regions such as Fredericton (City of Fredericton, 2024). In addition, wastewater is treated at centers to meet national water quality requirements (City of Fredericton, 2024). The $36.4 million in funding announced in 2020 for Fredericton's water, wastewater, and stormwater projects highlights efforts to sustain and improve this system. Investments in water supply and treatment services are important for ensuring the resilience and functionality of these services, especially in response to changing environmental and infrastructural difficulties (City of Fredericton, 2022; Government of New Brunswick, 2022). Additionally, integrating remote meters represents a significant advancement in utility management, signifying a commitment to customer service enhancement and operational efficiency. By enabling accurate meter readings from a distance, this technology streamlines leak detection and supports correct billing practices without the need for property access (City of Fredericton, n.d.; Water Canada, 2009). Although water plays a crucial role in supporting communities and preserving the environment, there has been a lack of scholarly focus on comprehending the economic elements that influence water usage behaviours and the efficacy of current pricing systems.

2.5.3 Water Management in Prince Edward Island

The province of Prince Edward Island (PEI) relies entirely on its groundwater reserves for freshwater, which are also critical for sustaining the flow of its streams (Bhatti et al., 2021a). There is an expanding need to assess the efficiency of current groundwater management strategies and the sustainability of PEI's groundwater supplies because of growing demand from municipal as well as agricultural sectors (Jiang et al., 2004). To manage these challenges, numerical models of groundwater flow were created for watersheds in this province. These models evaluate groundwater flow and existing policies for managing groundwater. The findings of Jiang et al., (2004) indicate that the existing groundwater management system effectively deals with local groundwater issues and prevents the depletion of aquifers. However, the research indicates that more enhanced management strategies might be required to protect aquatic habitats thoroughly.

The research illustrates that the province of Prince Edward Island's hydrogeological characteristics are inconsistent. The Jiang et al.'s (2004) study shows that local changes in heterogeneity and topography affect groundwater dynamics within the province's watershed. As an example from Jiang et al. (2004), data from 1962 onward show that the water flow in Mill River in September is about half of what is recorded in Winter River. This difference illustrates how stream flow varies due to local conditions and the surrounding landscape. This emphasizes the importance of avoiding making broad generalizations based on model outcomes. Furthermore, pumping groundwater in the vicinity increases stream-aquifer interactions, which are essential to these processes. To prevent a steady decline in the water table, policies set extraction limits to below 50 percent of the annual recharge (Jiang et al., 2004). The results reveal the distinct challenges in managing water resources in PEI, highlighting the importance of using specialized strategies for sustainable groundwater management.

The unique geographical position of Prince Edward Island, encompassed by the ocean, emphasizes the need for careful and effective water management (Abbas et al., 2020). To deal with unpredictable rainfall caused by climate variability, Abbas et al. (2020) stress the need for groundwater use in agricultural irrigation. Afzaal et al. (2020) underscore the importance of a reliable approach to irrigation and alternative irrigation methods in solving the urgent challenges of water resource management in this province. In addition, they highlight the importance of water resource management in potato farms on Prince Edward Island, underscoring that this island accounts for around 25 percent of Canada's annual potato production (Mukezangango, 2015). As it has been also mentioned by Food and Agriculture Organizations (n.d.), potato production is highly vulnerable to water conditions. Inadequate water availability can significantly impact both the quality and quantity of resources. Afzaal et al. (2020) show how groundwater pumping for more irrigation affects groundwater levels and increases the likelihood of saltwater intrusion. This points out the importance of sustainable water management strategies in agriculture (Afzaal et al., 2020). In addition, the study highlights the notable improvement in water-use efficiency and waste reduction by evaluating the effectiveness of irrigation using pressurized approaches for covering up irrigation deficits. In addition, the authors claim that this assessment is important for marketable potato growers and policymakers in the province of Prince Edward Island due to the lack of related research in this region. The insights gained from this study can be used to develop evidence-based strategies for sustainable water resource management. Afzaal et al. (2020) highlight the importance of these regional strategies that can be used to overcome challenges related to the integrity and sustainability of the agricultural sector. Aligned with this finding, further research conducted by Bhatti et al. (2021b) emphasize the importance of developing an effective water policy that considers the implications of climate change. This development would contribute to establishing sustainable management of water resources and agricultural practices in this province (Bhatti et al., 2021b).

Monk and Curry (2009) point out that there is a substantial global research challenge in connecting hydrology and ecology to generate suitable environmental flows and successful water resource management strategies. The researchers conducted a comparative analysis of PEI's Agricultural Irrigation Policy (1995) with the comprehensive method developed in the United Kingdom according to the European Union's Water Framework Instructions, as described by Acreman et al. (2008). It is demonstrated by Acreman et al. (2008) that for establishing methods to regulate water extraction and maintain environmental flows, a comprehensive approach is preferred, but it is costly as it requires considerable data collection and various analyses (Monk & Curry, 2009).

Previous studies have highlighted the impact of climate change on PEI's water resources, emphasizing the need for efficient water management. For instance, Haldane et al. (2023) report that changes in rainfall and rising temperatures will impact the island's hydrological cycle. According to their study results, warmer springs cause the snow to melt down earlier and cut down on freshwater availability throughout the summer period. In addition, the researcher asserted that higher evaporation worsens the problem of water scarcity. According to recent studies like those by Jardine et al. (2021) and Haldane et al. (2023), this small coastal island is especially vulnerable to climate change. Jardine et al. (2021) found that the island's coastlines are experiencing severe erosion due to frequent storms and rising sea levels. Haldane et al. (2023) highlight the importance of tourism to the province's economy, as it creates jobs and supports local businesses. Climate change impacts, including coastal erosion and unpredictable weather, may impact tourists' behavior and satisfaction (Phillips & Jones, 2006; Haldane et al., 2023). The province's municipalities are developing adaptation methods, prioritizing the sustainable management of water supplies and the conservation of coastal areas. In addition, maintaining PEI's tourist sector in face of climate change depends on including adaptive water management and establishing climate resilience. Protecting water resources and coastal areas would help preserve the island's natural features and ensure its economic sustainability as a popular tourist destination (PEIFSN, 2021; Haldane et al., 2023). The ParCA program's study points to the vulnerability of coastal communities when dealing with climate change impacts (Fook, 2015). This study relies on government data, social-ecological systems, and a community-based framework. To help communities adapt, it presents adaptable plan scenarios and emphasizes the need for local stakeholder participation in strategy building. The findings show that collaborative partnerships are essential for effective adaptation planning, which helps build resilience to climate change impacts and supports sustainable water management (Fook, 2015).

According to Environmental Science & Engineering Magazine (2020), Charlottetown launched a mandatory water meter program in 2015, following approval in 2013, to improve water management and support conservation. The project, known as "Take Control," aimed to install water meters in every residential property by the end of 2019. The Utility Rules and Regulations have been enhanced by the Charlottetown City Council, mandating that all customers with flat rates transition to metered billing no later than December 31, 2019 (Charlottetown, 2013). The utility company installed residential meters free of charge to help homeowners with the procedure, which is covered by the city (Curtis, 2014; CBC, 2015). The newly installed water meters quantify water use in cubic meters (m^3), and the billing is determined by the number of cubic meters utilized throughout each billing period (City of Charlottetown, 2014). These digital meters are equipped with a remote feature enabling the meter to be simply read from outside the residence (City of Charlottetown, 2015). In 2019, water usage among residents declined by one million cubic meters compared to the peak in 2008, even though the population grew to about 40,000 by 2020 (Environmental Science & Engineering Magazine, 2020; CBC, 2020; CBC, 2024).

Environmental Science & Engineering Magazine (2020) reports that the province of Prince Edward Island’s total water use has decreased by 13% since implementing the water metering program and new summer watering restrictions. According to Water Canada (2020), to motivate the installation of meters, the city implemented a penalty on customers who have not yet installed meters. In this regard, beginning on October 1, 2020, the fee is set to reach $100 quarterly. Several water conservation programs were applied to promote the metering plan, including incentives such as the "Water Saver Champions" program, which provided households with a maximum of $75 to motivate others to participate in the water-metered program. (Environmental Science & Engineering Magazine, 2020). Additionally, initiatives such as the Flood Protection Rebate and Showerhead Exchange Programs help promote water conservation across multiple cities in the province (Be Water Friendly, n.d.).

Based on data from Nacario (2024c), the mean monthly water bill in the province of Prince Edward Island is $105 per household, contributing to total utility bills that average $382.95 per month, excluding charges for heating oil. In the province of Prince Edward Island groundwater is the primary source of drinking water. The water is naturally purified as it flows through aquifers (Nacario, 2024c; Lips, 2012). Nearly 45 percent of the population get their water from public systems run by municipalities or private water companies. People dwelling outside of urban areas may use septic systems and private wells. In the province of Prince Edward Island, water bills include fixed rates for service based on the size of the meter and the type of property, as well as variable volumetric rates that cover the cost of significant repairs and infrastructure improvements (Nacario, 2024c). Additionally, the size of the meter and the monthly water usage determine water prices in the capital city of the province, Charlottetown. Monthly charges also range from $76 to $482, based on the meter size (Nacario, 2024c).

2.5.4 Water Management in Newfoundland and Labrador

This section of the literature review explores water management in Newfoundland and Labrador, focusing on existing resources, management techniques, obstacles, and the feasibility of installing residential water meters. The annual report on drinking water safety in the province of Newfoundland and Labrador (2014) indicates that 471 public water supplies support 366 communities. The provincial government's report (2014) shows that groundwater provides 175

(37.2 percent) of them, while surface water accounts for 296 (62.8 percent). According to the Government of Newfoundland and Labrador’s 2020 reports, boil water advisories are applied to protect residential health from microbiological contamination in drinking water systems. These advisories are regularly issued to address the difficulties as well as additional community concerns related to water quality and water treatment (Government of Newfoundland and Labrador, 2014; Government of Newfoundland and Labrador, 2020). As stated by Eledi et al. (2017), the legal framework overseeing public drinking water systems in the province of Newfoundland and Labrador is made up of the Water Resources Act, the Municipalities Act, and the Municipal Affairs Act. Specifically, the Water Resources Act (SNL 2002 cW-4.01) in Section 39 highlights the mandate for source water protection (SWP) to ensure the safety of public water supply areas legally (Eledi et al., 2017).

Research by Eledi et al. (2017) highlights key challenges in implementing SWP programs in the province’s rural areas, even with several efforts to address these issues. Based on data from 2012 to 2016, the study identifies gaps in SWP implementation that continue to exist. Insufficient management, conflicts over shared watersheds, and low awareness of SWP and municipal roles contribute to the gap. The optional status of SWP laws, along with weak enforcement, limits their ability to protect drinking water, worsening the existing gap. In addition, this case study indicates that communities with watershed management committees and plans can get desirable results through proactive and coordinated SWP initiatives. However, the authors consider these instances an exception (Eledi et al., 2017). The study suggests that municipal and provincial governments, as well as users of watersheds, may benefit from more communication and cooperation, which could help bridge this gap. Due to limited resources, mainly from recent provincial budget reductions, communities need to develop innovative source water protection (SWP) programs.

Even though regional education and collaboration have advanced, there is still a big gap in policy application. This research highlights the need to take preventative measures rather than waiting to react to avoid water contamination and health risks (Eledi et al., 2017).

Numerous socio-demographic and socio-economic factors affect households' willingness to participate in the municipal water quality initiatives in western Newfoundland (Sabau and Haghiri, 2008). Using a cross-sectional logistic model, the researchers indicated that higher levels of education and annual family income positively impacted households' choices to participate in these programs. This study also suggests that effective water management should be integrated into a nation's economic and social policies while at the same time underscoring the everyday responsibilities of individuals regarding sustainable water management (Sabau & Haghiri, 2008). The researchers say it is important to include demand-side strategies in water governance, such as conservation pricing and public awareness campaigns. The widespread use of water conservation devices in places such as the City of Corner Brook suggests an existing culture of conservation. Sabau and Haghiri (2008) conclude that proactive measures such as watershed conservation and employing metering are being considered for further development. Municipalities, including the City of Corner Brook, can impact sustainable water management by encouraging local initiatives, which can lead to changes in regional policy (Sabau & Haghiri, 2008).

The 2020 Annual Report on Drinking Water Safety in the province of Newfoundland and Labrador, delivered by the Honorable Bernard Davis, Minister of Environment and Climate Change, highlights notable progress in resolving water quality concerns in the area (Government of Newfoundland and Labrador, 2020). The dedication to having improved water management infrastructure is shown in the rise in the number of qualified operators as well as the number of certificates that have been issued. Consistent with this, regional service boards, government organizations, and municipalities have all collaborated to advance infrastructure, maintenance, and educational programs. In addition, through the application of adaptive frameworks and collaboration across various sectors, the Drinking Water Program in this province fosters management as well as the safety and reliability of public drinking water systems. This effort is governed by the Government of Newfoundland and Labrador under the Multi-Barrier Strategic Action Plan (Government of Newfoundland and Labrador, 2020).

In accordance with the Water Resources Act, the Water Resources Management Division (WRMD) in this province controls the allocation of water use, ensures the safety of drinking water, sustains water supply sectors, certifies well-drilling operators, and addresses any related matters (Government of Newfoundland and Labrador, n.d.). The Water Resources Management Division (WRMD) is instrumental in a number of key aspects. Its responsibilities include managing water rights and allocation, regulating both public water supplies and wastewater systems, and supervising government programs to track and report on drinking water quality for consumption (Government of Newfoundland and Labrador, n.d.). In addition, the WRMD conducts research on water resource appraisal, usage, conservation efforts, and economic aspects as well. With a focus on adapting to climate change, it provides flood forecasting services as well as hydrological simulations and evaluations of flood risk (Government of Newfoundland and Labrador, n.d.).

Although there have been notable accomplishments, there are still considerable obstacles, mainly in applying home water meters and billing systems based on residential consumption. According to Although there have been notable accomplishments, there are still considerable obstacles, mainly in applying home water meters and billing systems based on residential consumption. According to Klassen (2010), the province of Newfoundland and Labrador is not fully covered with water meters. As a result, inhabitants of the City of Corner Brook, located in the western region of Newfoundland and Labrador, continue to be charged an annual fee per unit for water and sewer facilities instead of receiving a monthly statement according to their water usage (Corner Brook, 2023). Every year, property tax bills are released in early January by the City of Corner Brook. In addition, these bills provide a thorough breakdown of a property's tax account, including payments related to water and sewer services (City of Corner Brook, 2023). By adopting universal metering, Corner Brook could lower water consumption and reduce losses (GMF, 2007). The city's 2024 budget also highlights a critical approach to water-related taxation for managing resources in Newfoundland and Labrador. Further, both business and residential properties are subject to a base tax rate plus an extra annual water and sewer levy under the city's real property tax system. According to the City of Corner Brook (2023), residential units with total water and sewer services are taxed at 8.0 mils (The mill rate is the tax amount owed for each dollar of a property's assessed value) plus a fee of $650 per unit for water and sewer services, which includes a $100 sewer levy. This framework provides a stable flow of funds for maintaining and developing water infrastructure, regardless of how water demand might change. According to the City of Corner Brook's (2023) report on the 2024 budget, the city is facing rising costs for water treatment chemicals. These treatments are essential for keeping drinking water safe and preventing pipe corrosion. The city is tackling these financial issues by investing in monitoring equipment, doing leak detection evaluations, and increasing the unit charges for water services (City of Corner Brook, 2023). Although there have been successes, major challenges remain, particularly with installing home water meters and using billing systems based on household consumption. According to Although there have been notable accomplishments, there are still considerable obstacles, mainly in applying home water meters and billing systems based on residential consumption. According to Klassen (2010), the province of Newfoundland and Labrador is not fully covered with water meters. As a result, inhabitants of the City of Corner Brook, located in the western region of Newfoundland and Labrador, continue to be charged an annual fee per unit for water and sewer facilities instead of receiving a monthly statement according to their water usage (Corner Brook, 2023). Every year, property tax bills are released in early January by the City of Corner Brook. In addition, these bills provide a thorough breakdown of a property's tax account, including payments related to water and sewer services (City of Corner Brook, 2023). Universal metering could help Corner Brook reduce water consumption and prevent losses (GMF, 2007). The city's 2024 budget also highlights a critical approach to water-related taxation for managing resources in Newfoundland and Labrador. Further, both business and residential properties are subject to a base tax rate plus an extra annual water and sewer levy under the city's real property tax system. According to the City of Corner Brook (2023), residential units with total water and sewer services are taxed at 8.0 mils (indicate what it is) plus a fee of $650 per unit for water and sewer services, which includes a $100 sewer levy. This framework provides a stable flow of funds for maintaining and developing water infrastructure, regardless of how water demand might change. According to the City of Corner Brook's (2023) report on the 2024 budget, the city is facing rising costs for water treatment chemicals. These treatments are essential for keeping drinking water safe and preventing pipe corrosion. The city is tackling these financial issues by investing in monitoring equipment, doing leak detection evaluations, and increasing the unit charges for water services (City of Corner Brook, 2023).

Connors (2021) reports that Corner Brook's director of public works, Don Burden, has asked locals to reduce their water consumption, noting that Corner Brookers use more water than Newfoundlanders and Labradorians on average. The Western Environment Centre's Chair, Glen Keeling, stressed the need for water conservation and monitoring. It has been specified that houses built after 2014 must have water meters installed; however, they are monitored instead of being charged for water usage. Although the public works department lacks the authority to enforce water metering, it remains a valuable approach for monitoring, with current efforts focused on promoting water conservation during the hot and arid summer (Connors, 2021). According to the Government of Canada (2021b), this metering system is essential for achieving the country's environmental goals. One benefit of using this system is that it provides efficient monitoring of household water use (Government of Canada, 2021b). Identifying and fixing leaks fast is made possible by an accurate metering system, which is crucial for building a sustainable water system along with lowering water resource waste (Government of Canada, 2021b).

2.6 Literature Review Gaps and Conclusion

An analysis of existing water management studies in Newfoundland and Labrador highlights the need for further research, especially on household water meters. This literature review highlights research centered on general water management approaches, socio-economic aspects, and legal systems that influence water quality. This study indicates a gap in research, as no evidence was found concerning households' willingness to adopt water meters or participate in water conservation activities in this region. This research focuses on understanding the preferences, motivations, and barriers influencing household decisions regarding water meter adoption. In Corner Brook, where water meters are not yet widespread, this approach is particularly relevant for addressing behavioral and socio-economic factors, which remain underexplored in the existing literature. Some works, such as Eledi et al. (2017) and Sabau and Haghiri (2008) focused on broader water management concerns, such as source water protection (SWP) and public awareness of water quality. While these studies give valuable perspectives on the challenges and sociodemographic factors that impact water management, they do not evaluate residents' willingness to use water meters as a method for conserving water and fair billing, as their objectives are centred on broader management concerns. The continued reliance on flat-rate payment systems and the absence of water meter implementation in Corner Brook, even after more than 15 years, reveal a significant gap this study aims to address. Most of the literature reviewed in this chapter, like government reports and water quality studies, mainly focuses on the technical and regulatory sides of water management. For example, while the Water Resources Act and its policies focus on safeguarding source water and creating legal structures to ensure drinking water safety (Eledi et al., 2017), there is limited research on the behavioral economics of water use and on the advantages of billing based on water usage.

The existing literature, including the work of Sabau and Haghiri (2008), discusses the application of water conservation devices and the possibility of applying proactive strategies such as metering. However, more research is needed to determine the acceptance of these measures by households and the literature does not include any insight regarding the influence of government or household budgets on the transition to a metered system. This gap is important since financial factors are likely to influence how policymakers and households make choices. Also, there is a general lack of research to look at the feasibility of installing water meters in relation to constraints such as initial costs, privacy concerns and the necessity of educating the public. Analyzing these challenges is key to understanding what factors may influence households' choices about installing water meters and finding ways to handle them. Global studies mostly focus on improving water metering systems in areas where they are already used, especially with advanced smart meters. These studies, which examine water meter adoption, do not address the challenges of introducing them in Newfoundland and Labrador. There is also a lack of research that explores how households in places like Corner Brook decide to install water meters for the first time. Specifically, there is no study that investigates households' decisions to adopt water meters for the first time in unique geographic locations such as Corner Brook, an island-based community. Understanding residents' financial and practical support for water conservation calls for further research. These factors have not been examined in depth, which shows clear gaps in current studies. In conclusion, these gaps in the reviewed literature highlight the need for more studies on households' willingness in Newfoundland and Labrador's municipalities to adopt water meters and what their choices mean in a bigger context. This research studies the economic, social, and environmental sides of water metering and collects helpful information for policymakers. The study is intended to fill these literature gaps to gain valuable insights into household decision-making processes and facilitate the development of effective water management strategies particularly in the City of Corner Brook. The study focuses on bridging the gap between general research and the unique water management challenges faced in this region, delivering region-specific solutions. This research is very relevant as water treatment costs increase and the focus on sustainable resource management grows in the region. It aims to help create strong water management strategies for Newfoundland and Labrador.

Chapter 3

3. Research Methodology

3.1 Introduction to Research Methodology

Mishra and Alok (2017) explain research methodology as a systematic and scientific process that guides how research is carried out and problems are addressed. Research consists of seeking out and compiling information to answer questions concerning a specific area of focus. It can also be described as conducting a systematic and organized investigation (Mishra & Alok, 2017). Put another way, research includes problem definition and re-definition, hypothesis formulation, data collection, organization, and assessment, drawing and reaching conclusions, and then meticulously testing these conclusions to verify their consistency with the generated hypotheses (Mishra & Alok, 2011). A typical research process consists of these steps in order: defining the problem, establishing research objectives, planning the study design, gathering data, analyzing the collected data, interpreting outcomes, and validating findings (Panneerselvam, 2014). The methods for gathering and analyzing data are comprehensively reviewed in this chapter.

3.2 Research Problem Definition

Panneerselvam (2014) states that avoiding ambiguity in defining and determining research problems is crucial. The systematic method that results in the development of a specific research problem or hypothesis in scientific research starts with the identification of a research topic (Bahçekapılı et al., 2013).

3.3 Research Objectives

The primary focus of any research activity is to reveal unknown truths and facts that have yet to be discovered (Mishra & Alok, 2017). While each research activity has its specific purpose, the objectives of the research study can generally be categorized as follows: (i)Exploratory or Formulative Research: This type of research aims to develop expertise in a trend or gain new insights into an issue. (ii)Descriptive Research: This research type seeks to capture and detail the qualities of a specific individual, group, or situation (iii)Diagnostic Research: This research examines how events correlate and investigates the relationship between different factors. (iv)Hypothesis-Testing Research: This type of study examines a hypothesis to evaluate potential relationships between variables (Mishra & Alok, 2017). For instance, Hobbs et al. (2006) used a random effects panel data model to study how much people were willing to pay for bison meat features. The study checked whether the model was suitable by using the Lagrange Multiplier (LM) test, which tests if there is any connection between the error terms across bids. This method helped make sure the analysis was reliable by confirming the model's accuracy when studying consumer behavior. Similarly, Hobbs et al. (2005) tested the appropriateness of a random effects panel data model using the Lagrange multiplier (LM) test to assess consumer responses to traceability and food safety assurances in the Canadian red meat sector, establishing the null hypothesis of no correlation across individual-specific error terms. These methodological approaches underscore the importance of well-defined hypotheses informed by theoretical frameworks to guide empirical analysis and validate findings.

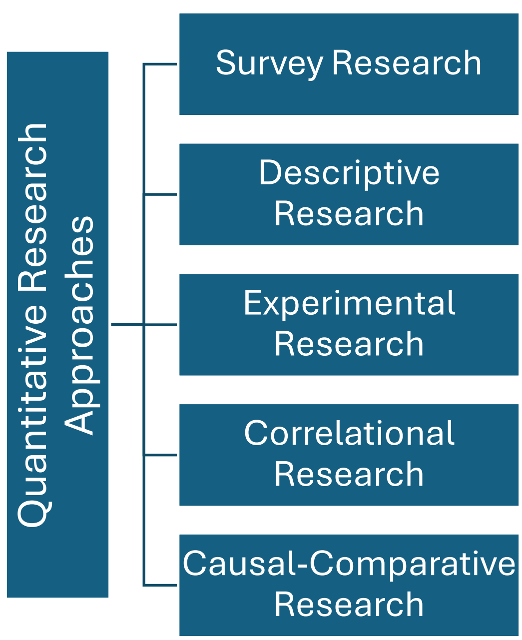
3.4 Research Design

A study and its findings can be evaluated and explained using various techniques, including numerical analysis, descriptive narration, or a combination of both (Taherdoost, 2022). In other words, quantitative, qualitative, and mixed methods are the three research approaches frequently used by researchers in different areas of study. These wide ranges of research design options cause a challenge for researchers in selecting the most proper method for their research study and recognizing the distinctions between these approaches (Taherdoost, 2022).

3.4.1 Quantitative Approach

Quantitative research explains and describes phenomena by using numerical values obtained from observational data (Taherdoost, 2022). Moreover, this method in the social and natural sciences centers on the concept of amount. This concept is similar to objects with a value that can be quantified or computed (Mishra & Alok, 2017). This kind of research systematically analyzes observable phenomena through mathematical, statistical, or computational techniques, presented in numerical forms such as percentages and statistics (Mishra & Alok, 2017). Quantitative research can also be classified into various approaches. Figure 1 lists different strategies of qualitative research, described as follows:

Figure 1: Quantitative approach classification.



Source: Taherdoost (2022).

3.4.1.1 Survey Research

This survey research strategy is designed to evaluate the qualities of the target population by choosing a smaller portion of that group, known as a sample (Taherdoost, 2022). This can be achieved with the use of a structured set of questions called a questionnaire and the application of statistical techniques. In addition, through this approach, an individual's beliefs, viewpoints, and other related factors can be analyzed by applying appropriate techniques (Taherdoost, 2022). This approach allows the sample information to be generalized to the target population. Therefore, it represents the whole population's beliefs and viewpoints. The sampling procedure, survey questionnaire design, questionnaire distribution and data analyzing procedure are the main steps of this quantitative approach (Taherdoost, 2022). While surveying is often associated with collecting and interpreting quantitative evidence, this is oversimplified. In fact, scholars conduct surveys to study attitudes (Vogt et al., 2014). As Vogt et al. (2014, p. 8) point out, a Likert scale can be used by researchers to measure attitudes, offering options such as "strongly agree, agree, neutral, disagree, and strongly disagree." Each response is usually assigned a numerical value, commonly 5, 4, 3, 2, and 1. Then, in the next step, researchers can get help from quantitative techniques to determine if the items on the scale are related. Therefore, researchers may find that the variables actually form two very different numerical scales when they use that quantitative method, which usually uses graphic tools like scree plots (Vogt et al., 2014). Basically, a scree plot helps determine the right number of components to summarize data. It shows how the fit of the data improves with added dimensions, making it easier to decide when more dimensions no longer add value (Manjunatha et al., 2024).

Additionally, survey research has been the primary method for collecting quantitative social science data. This method has been very useful in social sciences, like network analysis and predicting elections (Vogt et al., 2014). According to Spens and Kovács (2006), survey research has become essential and predominant in the logistics sector. Moreover, survey research can only be considered quantitative if mathematical and statistical methods are used to analyze the data. Quantitative survey analysis adopts a deductive research method. To conduct numerical surveys effectively, preparing specific questions in advance that link to prior theories and hypotheses is important. In addition, without open-ended questions and focusing on statistical-quantitative analysis, these surveys evaluate the pre-established hypotheses in deductive study, preventing the emergence of unmeasured items (Spens & Kovács, 2006).

3.4.1.2 Descriptive Research

Descriptive research is a helpful way to understand events and situations more clearly (Taherdoost, 2022). It looks at possible connections between different things by observing them or works to explain their features through a well-planned study (Taherdoost, 2022)

3.4.1.3 Experimental Research

It is possible to investigate the treatment of an intervention by using an experimental research strategy to accomplish the result of the treatments on the group that is being studied (Taherdoost, 2022). These strategies cover the following three categories of designs: pre-experimental design, true experimental design, and quasi-experimental design (Taherdoost, 2022). There are three main ways to structure experimental research. Pre-experimental design works with groups that are not selected randomly, and the conditions stay the same throughout the study. True experimental design gives researchers greater control over the process, which helps produce stronger, more reliable findings. In comparison, quasi-experimental design offers less control, and since the participants are not randomly chosen, the results may not be as solid or consistent (Taherdoost, 2022).

3.4.1.4 Correlational Research

The purpose of correlational techniques, considered exploratory procedures, is to test two general elements concerning the correlations between two or more variables in the sample or the entire population (Taherdoost, 2022).

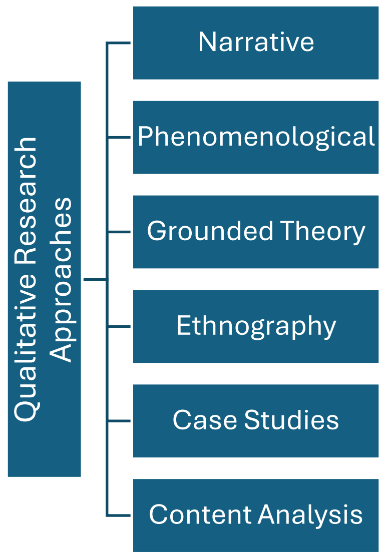
3.4.1.5 Causal-comparative Research

Using the causal-comparative research method, the cause-effect linkages are investigated by establishing the ways in which the independent variables can influence the dependent variables (Taherdoost, 2022). As a result, this type of analysis assists researchers in determining the interaction of independent factors with one another as well as the impact that these interactions have on dependent variables. A casual-comparative approach can be classified into two different types. The first, called the retrospective type, concentrates on determining whether one variable has prejudiced another and considers the effects of the issue as having already occurred. This technique is commonly applied. The second kind of study is the prospective one, which seeks to understand the impact of a problem by first identifying its causes (Taherdoost, 2022).

3.4.2 Qualitative Approach

Qualitative research is defined in many ways, yet its methods generally focus on tackling scientific and practical issues faced by societies (Taherdoost, 2022). Qualitative research is centred on examining qualitative phenomena which pertain to qualities or variations (Mishra & Alok, 2017). The descriptive research method is also generally connected to this type of study and usually involves more analytical difficulties than the quantitative method. This type of research focuses on thoroughly evaluating non-numerical data, often using naturalistic or anthropological methods (Mishra & Alok, 2017). Qualitative data collection should aim to meet the research's goals. Furthermore, using defined protocols and tools is vital for recording the data effectively (Taherdoost, 2022). In this type of case, the primary means of gathering data is through spoken communication, utilizing an audio or video recording device (Vogt et al., 2014). So, researchers transcribe the participants' words to be analyzed with implementing textual techniques. In addition, those audio or video records provide opportunities for the researchers to analyze participants' facial expressions or even tone of voice. In this type of case, the primary data is acquired through spoken communication, utilizing an audio or video recording device (Vogt et al., 2014). In qualitative research, it is important to apply an appropriate sampling method since collecting data from the entire population is usually impractical (Taherdoost, 2022). Because collecting data from the entire population is often not possible, in qualitative research suitable sampling technique should be used. It is important to evaluate the strengths and weaknesses of each data collection method that selected for the research project. There are several ways to gather data, including observations (both semi-structured and unstructured), document analysis, and interviews. Moreover, scholars may collect data implementing unconventional approaches, such as applying prompts during interview procedures to encourage feedback or integrating sensory inputs such as sounds and flavours (Taherdoost, 2022). Regardless of the method that is used for the research, several elements must be considered when arranging, conducting, and evaluating interviews (Bolderston, 2012). The process involves first identifying proper participants for the study, then developing a research procedure, followed by making effective interview questions designed to get the vital information. Ethical problems like consent and confidentiality should be considered by researchers while conducting the interview method (Bolderston, 2012). Figure 2 outlines the main methodological approaches available to researchers in qualitative studies.

Figure 2: Qualitative approach classification.



Source: Taherdoost (2022).

3.4.2.1 Narrative Research

The narrative method places a focus on the characters' roles and the order in which they occur in stories that people tell about themselves or significant events (Taherdoost, 2022). In other words, by examining individuals' stories, their lives can be analyzed by posing two general questions: "Who are they?" or "What changes occur in their lives as time passes?". Therefore, in this kind of research approach, personal life experiences are used as data (Taherdoost, 2022).

3.4.2.2 Phenomenological Research

The phenomenological approach applies people's perspectives to interpret an event, involving both internal and external aspects of the experience using tools like memory, definition, and imagery while stressing the intentionality of consciousness (Taherdoost, 2022). Through interviews lasting one or two hours, the phenomenological technique seeks to answer research questions by relying on the person's grasp of events (Taherdoost, 2022).

3.4.2.3 Grounded Theory

The grounded theory approach results in the development of abstract theories (Taherdoost, 2022). These theories primarily focus on the processes, behaviors, and interactions of individuals, shaped by their perspectives. Instead of depending on sources in the existing literature, in this approach, theories are formed based on data collected from the research field (Taherdoost, 2022). In addition, the components of a research project include formulating the research question, reviewing relevant literature, explaining the chosen methodology, developing theory from data analysis, and examining the implications of the findings. Moreover, in this approach, researchers outline five main parts in their reports: a description of the research question, a review of relevant literature, a description of the methodology employed, an explanation of the theory developed from data analysis, and a discussion of the implications (Taherdoost, 2022).

3.4.2.4 Ethnography

In the ethnography method, long-lasting observations are mainly used to describe and understand the cultural-sharing communities (Taherdoost, 2022). In addition, ethnography emphasizes understanding the meaning behind the collected data, focusing on both the process of gathering it and what the outcomes show. Interviews and observation are the two major techniques of data collection that are utilized in this approach (Taherdoost, 2022).

3.4.2.5 Case Studies

It is the main goal of case studies to have a better understanding of the events, people, and processes (Taherdoost, 2022). There are many areas where this scientific approach can be used. Case studies are structured around the problems and lessons derived from the events. Regarding data collection for this approach, researchers have different options to choose including mixed methods of interviews, artifacts, historical documents, and different visual or auditory sources. In addition, Taherdoost (2022) notes that on-site data collection is important, as it allows researchers to have the opportunity to connect directly with the study participants which can have significantly enhance the outcomes of their research.

3.4.2.6 Content Analysis

The content analysis method focuses on systematically and thoroughly assessing contents to identify biases or patterns (Taherdoost, 2022). These items contain different types of human communication, including books, films, and especially newspapers. In addition, it is an appropriate approach for assessing open-ended queries. Researchers obtain distinct attributes from the content of these forms through careful examination (Taherdoost, 2022).

3.4.3 Mixed-method Approach

The mixed-method research approach integrates qualitative and quantitative methods aligning with the study's objectives and research questions to better understand the topic (Taherdoost, 2022). In this method, the focus may be on one of these two methods or both equally. In addition, researchers can deal with more complicated situations in areas like health and social research when they use both methods together. In contemporary research environments, scholars from various disciplines collaborate and employ mixed methods to their advantage, even when they have diverse methodological preferences (Taherdoost, 2022).

3.5 Comparison of Research Methods

There are some advantages and disadvantages to applying qualitative and quantitative research methods (Taherdoost, 2022). Applying the qualitative method provides better opportunities for researchers to obtain detailed information like feelings. In addition, researchers can interact with people while gathering data and discovering people's experiences in different situations. Addressing complicated problems is another significant advantage of the qualitative method, as it provides freedom to the participants. A significant disadvantage of the qualitative method is its small sample size, which prevents generalization. Also, researchers find this method difficult to analyze data and consider it time-consuming.

Moreover, in some fields, such as policymaking, the low credibility of qualitative findings can be a significant limitation (Taherdoost, 2022). On the other hand, in the quantitative method, generalizing findings is possible mainly because of the large sample size. In addition, this method is fairly time-efficient and cost-effective, which makes it appealing to researchers. Moreover, documentation of methods may also be shared. However, the quantitative method has limitations when it comes to uncovering detailed explanations or the deeper reasons behind people's emotions and actions (Taherdoost, 2022).

3.6 Regression Analysis

As Greene (2008) points out, econometric research is based on forming economic hypotheses at the outset. Demand equations, production characteristics, and macroeconomic models highlight the precise, deterministic correlations between variables as described by the theory (Greene, 2008).

By providing estimates of unknown parameters such as elasticities or monetary policy effects, the empirical investigation usually studies the theory's validity against observable data behaviour. The constructed model can then be implemented for prediction or behaviour analysis. As Dennis and Weisberg (1999) note, regression is a primary data analysis tool. This method is frequently used to analyze the relationship between two or more variables in the research (Dennis & Weisberg, 1999).

Regression analysis helps determine whether a single independent variable or a group of independent factors strongly impacts the dependent variable. In addition, regression analysis can determine the relative importance of the effects of different explanatory variables on a specific dependent variable. Furthermore, regression analysis can create reliable predictions (Sarstedt & Mooi, 2018). Regression models are usually represented in the following way:

$$y = \alpha + \beta_1 x_1 + e$$

In this context, y stands for the dependent variable, the outcome that is aimed to be described. The constant of the regression model is presented by an unknown parameter α, which shows the dependent variable's value when the independent variable equals zero. In addition, β is considered as another unknown parameter representing the slope of the regression function, describing the relationship between the dependent and independent (Sarstedt & Mooi, 2018), and x1 is an indication of an independent variable in this regression formula. The use of regression analysis has long been vital to econometrics, the study of economic statistics (Sykes, 1993). Chatterjee and Hadi (2012) define the application of regression analysis in different areas: “A partial list would include economics, finance, business, law, meteorology, medicine, biology, chemistry, engineering, physics, education, sports, history, sociology, and psychology” (Chatterjee & Hadi, 2012, p. 2). Sykes (1993) categorizes regression analysis into primary forms: simple regression and multiple regression. Simple regression analysis assumes that one variable can be approximated as a linear function of another variable (Sykes, 1993; Allen, 2004).

Among the various mathematical functions that can predict one variable from another, a linear function is just one example. The simplicity of a linear function is the best reason for describing the relationship between two variables. Linear functions are seen as less intricate than most other mathematical functions, and according to the "principle of parsimony" in science, simpler explanations should be chosen given equivalent conditions (Allen, 2004, p. 16). As mentioned by Allen (2004), many theoretical statements in the social sciences can be formulated as linear functions, which usually make linear functions the best fit. Mignon (2024) also points out that the most regularly employed technique to estimate the parameters of a simple regression model is the ordinary least squares (OLS) method. In a multiple regression analysis, additional independent variables are incorporated separately to evaluate the impact of each explanatory variable (Sykes, 1993). This type of regression analysis is useful for evaluating the effect of multiple concurrent factors on the dependent variable. Because simple regression can result in omitted variables bias, multiple regression is often vital, even when examining the effects of just one independent variable (Sykes, 1993). There are different regression analyses, including linear, polynomial, and logit regression.

3.6.1 Linear Regression Model

Among the tools available to econometricians, the linear regression model is the most practical analyzing method (Greene, 2008). While it is increasingly typical in contemporary literature to use it mainly as a starting point for comprehensive analysis, empirical research still predominantly relies on this method. A multiple linear regression model enables scholars to evaluate how a dependent variable relates to one or more independent variables (Greene, 2008). Abdulhafedh (2022) notes that this model is effective for predicting continuous outcomes. Qualitative or categorical dependent variables can be analyzed using classification. This method identifies the most suitable line for the data by minimizing the difference between actual and predicted values. These features of linear regression, as noted by Abdulhafedh (2022), show that this model is not suitable for classification. Simple linear regression involves a single independent variable for prediction, while multiple linear regression includes more than two independent variables. Price, age, and salary are examples of continuous variables that linear regression outputs are designed for (Greene, 2008). The basic format of the linear regression model is as follows

$$y= f(x_1 + x_2, \dots, x_k) + \varepsilon$$

$$= x_1\beta_1 + x_2\beta_2 + \cdots + x_k\beta_k + \varepsilon$$

The linear regression equation includes the dependent variable y and the independent variables x_1, . . . , x_k. This equation is generally recognized as the population regression equation for y with x_1, . . . , x_k as predictors. In this equation, y is considered as regressand, while covariates or regressors are shown by x_k, where k = 1, . . . , K. The term ϵ represents an error term or a random disturbance since it disrupts an otherwise predictable stable relationship. Error terms primarily result from multiple causes because it is impossible to include every component that affects an economic variable in this model, irrespective of its complexity (Greene, 2008).

3.6.2 Polynomial Regression Model

Polynomial regression analysis reveals a non-linear relationship between the dependent and independent variables (Sharma, 2024). In this multiple linear regression model variant, the best-fit line is curved instead of linear one (Sharma, 2024). In polynomial regression, a particular kind of multiple regression, there exists only one independent variable (Ostertagová, 2012). The formula for a one-variable polynomial regression model is:

$$\gamma_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 x_i^3 + \cdots + \beta_k x_i^k + e_i \text{ , for } i = 1,2, \dots, n$$

In this formula, k indicates the degree of the polynomial. Moreover, the order of the model is defined by the degree of the polynomial (Ostertagová, 2012). In polynomial regression, applying linear transformations to the data set results in a conversion of a polynomial model into another form of polynomial model (Peckov, 2012). Consequently, the polynomial models are not influenced by the underlying measure. Polynomial regression, despite fitting a nonlinear model to the data, is considered a linear statistical estimation issue. This is because the unknown parameters, estimated from the data, make the regression function linear. Accordingly, polynomial regression is recognized as a specialized version of linear regression (Peckov, 2012).

3.6.3 Logit Regression Model

Cokluk (2010) states that classification of individuals into specific categories is the main goal of logistic regression analysis. Like other statistical methods, it is also designed to support model generation. This analysis seeks to establish a model that precisely represents the relationship between the dependent (predicted) and independent (predictive) variables, minimizing variability for the best fit. Beginning in 1845, the logistic regression model was initially introduced in mathematical research that concentrated specifically on population expansion. "Logistic regression analysis" originates from the logit transformation used on the dependent variable. Depending on the measurement scale and the number of categories in the dependent variable, logistic regression analysis may be called "Binary Logistic Regression Analysis," "Ordinal

Logistic Regression Analysis," or "Multinomial Logistic Regression Analysis" (Cokluk, 2010. p.1398).

In applied social sciences, data associated with researched cases are mostly categorical, with discrete values or data obtained through an ordinal scale. A person, for example, can either be employed or jobless; he can be a member of a group or not; the party that is currently in power can either be from the right wing or the left wing; and a student can either be a graduate or not (Arabacı, 2002; Kılıç, 2000; Mertler & Vannatta, 2005). Predicting categorical outcomes is a common issue in academic research. Students, for instance, tend to fall into one of two categories: those who excel academically and those who struggle. An adolescent is either inclined to engage in risky actions or is not (Cokluk, 2010). Analyzing categorical data using multivariable statistical methods is significant for almost every field. This method is commonly employed in categorical data analysis because logistic regression offers specific benefits over alternative approaches.

To determine the value of the dependent variable, a standard regression equation employs the true values of some independent variables and weights that the model generates. Interpreting the mathematical model obtained through logistic regression analysis is easier to understand. However, because the maximum likelihood method is employed in logistic regression analysis for coefficient estimation, unlike the least squares method, it is critical not to work with a low number of observations, as this affects the model's reliability (Cokluk, 2010). Logistic regression models, such as multinomial logistic regression and ordinal logistic regression, have the capability to predict a dependent variable with multiple categories, but this research is concerned exclusively with a dichotomous dependent variable (predicting a binary outcome) (Agresti, 2019; Cokluk, 2010).

When outcomes have multiple categories, multinomial logistic regression is appropriate, while ordinal logistic regression should be employed for ordinal variables. The multinomial model is a viable alternative if the ordinal model fails to meet the parallel regression assumption (Liang et al., 2020). Identifying the predictors impacting the binary outcome (dependent variable y) can be achieved using a binary logistic regression model (Wolfe, 2009). Binary logistic regression is essential to ensure that predicted values fall within the range of [0, 1] (Wolfe, 2009). Consider a commuter choosing between driving a car to a workplace or using public transportation. Another instance is a worker might decide whether to accept a job or not. Choices like driving to work and accepting a job are denoted by y =1, whereas taking public transportation and not taking the job are denoted by y =0 (Horowitz & Savin, 2001). For instance, some socio-economic and environmental researchers use this model to analyze household waste management behaviour in order to understand the decisions behind binary outcomes. The study established that the availability of waste collection services, together with knowledge of regulation, were significant factors that influence proper waste management behaviour (Asfaw et al., 2024). Another example is research from Ethiopia. It used binary logistic regression to look at what affects farmers' willingness to use conservation agriculture practices. The study showed that education level, family labor, and primary employment were important factors that influenced adoption. This shows how useful the model is in making environmental decisions (Bekabil, 2022). These examples show how binary logit regression is used in finding important factors in decision-making in different fields.

In this model, as explained by Greene (2008), a structured joint probability density function of the variables that are dependent ($y_1 , y_2 , \ldots , y_n$) follows a Bernoulli distribution with probability $\boldsymbol{\pi}_{\mathrm{i}}$, that varies among observations. The expected value and variance of the dependent random variable are given by $E(y) = Pr[y_i = 1] = \pi_i$ and $Var(y_i) = \pi_i(1 - \pi_i)$, respectively. The probability of $\boldsymbol{\pi}_i$ is influenced by the independent variable X_i. As the probability of success must lie between zero and one, π (·) is constrained within this range. Hence, the probability of success can be demonstrated as:

$$\pi_i = \Lambda(\Omega_i) = \Lambda(X_i^1\gamma) = \frac{exp(X_i^1\gamma)}{1 + exp(X_i^1\gamma)}$$

In this formula, Ω_i denotes the set of independent variables, $X_i^1\gamma$ is the linear combination of these variables weighted by the unknown parameter vector γ and $\Lambda(\Omega_i)$ is the logistic cumulative density function. The logit model is then specified as:

$$\Omega_i = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = X_i^1\gamma \ = \ \gamma_{0+}\gamma_1 x_1 + \ \gamma_2 x_2 \ + \ \gamma_n x_n + \varepsilon,$$

$$i = 1, 2, \ldots, n$$

In this equation, Ω_i indicates the log odds of success for the ithobservation. The variables x_i are the independent variables, $\gamma_1, \ldots, \gamma_n$ are the parameters to be estimated, and ε represents the random error term. The estimated parameters' signs show how changes in the explanatory factors affect the chance of success (Y=1), as evaluated by the marginal effects (ME) (Greene, 2008). The calculation for the marginal effect of the jth independent variable on the probability of success is as follows:

$$\frac{\partial\pi(y_i=1|x_i)}{\partial x_{ij}} = scale^*\gamma_j \text{ where } scale = \frac{\exp(X_i^1\gamma)}{[1+\exp(X_i^1\gamma)]^2}$$

For continuous variables, MEs are typically calculated at the sample mean. In addition, for discrete or dummy variables, the change in the probability of success is computed using:

$$\pi(y = 1|x_j = 1, X_\Theta) - \pi(y = 1|x_j = 0, X_\Theta)$$

Within this context, $X_\Theta$is determined by assigning the modal values to all dummy variables and the mean values to continuous variables. The change in the probability of success (Y=1) resulting from altering x_j from zero to one is measured by this calculation, with other variables remaining constant (Greene, 2008).

In logistic regression models, multicollinearity arises when independent variables are highly correlated, a frequent occurrence with a large number of covariates (Midi et al., 2013). Unstable estimates and inaccurate variances caused by multicollinearity can adversely affect confidence intervals and hypothesis testing. Because collinearity raises the variances of parameter estimates, it is problematic to draw trustworthy conclusions about the connections between response and explanatory variables when it happens. While examining the correlation matrix can be useful for identifying multicollinearity, it is not adequate. Dropping one of the correlated variables is an entirely satisfactory method for reducing multicollinearity in moderate to large sample sizes (Midi et al., 2013).

Binary logistic regression is a valuable method for analyzing survey data within commonly used case-control and cross-sectional research designs (Harris, 2021). Using sample survey methodology, researchers gather information about a large population or aggregate by selecting and measuring a sample (An, 2002). Researchers adopt scientific sample designs during sample selection to effectively manage the variability of characteristics within the population. In addition, this method is designed to minimize bias in the inference of population characteristics from survey data. As An (2002) notes, integrating the sample design into data analysis ensures that conclusions drawn about the population are statistically accurate. Models of this type are applied using SAS, with SPSS, R, and Python (for machine learning) utilized whenever feasible (Géron, 2023; Wilson & Lorenz, 1970).

3.7 Importance of Methodological Fit in Research

Walker (1997) notes that selecting a right research methodology is one of the most challenging aspects of the research process. It could be challenging for researchers to choose the proper methodology for their research questions. The ability to match an appropriate research approach to a specific research problem or develop innovative methodological solutions is a pivotal research skill (Walker, 1997). According to Bradley (1992), a researcher must select the empirical inquiry methods that are most appropriate for their research topic and objectives. Successfully carrying out a research project requires matching the methodology to the specific details of what the researcher intends to explore (Bradley, 1992). Edmondson and Mcmanus (2007) assert that methodological fit involves aligning key research elements such as research objectives, existing literature, research design, and theoretical development to ensure internal consistency.

Within this context, researchers need to go beyond simply selecting a method and collecting data; there is a need to understand the fundamental tenets of the research tradition that they are engaging with (Blair, 2016). All methodologies come with their own advantages and limitations, and each includes ethical values and principles guiding research conduct. In addition, every methodology is grounded in ethical values and principles for conducting research, reflecting long periods of philosophical discussion and debate. Blair (2016) suggests that although researchers often prefer to carry out research rather than investigate the antecedents, which can be time-consuming, awareness of the tensions and criticisms associated with a methodology can result in more informed decisions

To sum up, researchers need to connect their selected methodology with the underlying theory contained in the existing literature (Ahmed et al., 2016). This approach enables researchers to position their research problem within an appropriate philosophical context, create a practical strategy to tackle the issue, select a relevant research methodology, choose suitable data collection methods, and concentrate on the correct unit of analysis. Hence, through the implementation of this process, the research results could be reliable and valid (Ahmed et al., 2016).

3.8 Methodology Adopted for this Research

Considering the methods which were discussed earlier in this chapter, a quantitative approach was chosen for this research, as it is well-suited for gathering household responses. The logit model was chosen because it fits well with dichotomous (yes/no) outcomes. This choice makes it easier to measure the dependent variables effectively. Detailed explanations and further elaboration will be provided in the next chapter, under the section on empirical application.

Chapter 4

4. Empirical Analysis

4.1 Introduction

An overview of the data collection and analysis approach is detailed in this chapter, alongside an in-depth description of the empirical model employed. The chapter's structure is clarified by its organization into five sections. To explain the data collection process, section 4.2 discusses the research plan, the chosen area, and the survey methods used. It also looks at how questions were structured, samples were taken, and ethics were handled to build a reliable study. Section 4.3 gives a summary of the survey data and looks at how participants responded, showing key trends and patterns in the study. Moving forward, section 4.4 explains the application of the binary logit model to analyze residents' willingness to install water meters. It explains how the model in this study looks at how different factors affect household decisions and lists the tools and methods used to get accurate binary results. In addition, as part of the report, Section 4.5 offers an overview of the study's variables and highlights the main outcomes of the data analysis. In this part, the relationships between different demographic, economic, and behavioural factors is explored, helping to identify patterns and insights relevant to water meter adoption. Finally, this section explains in detail about the important results from the regression model, showing what factors mainly influence residents' choices.

4.2 Data Collection

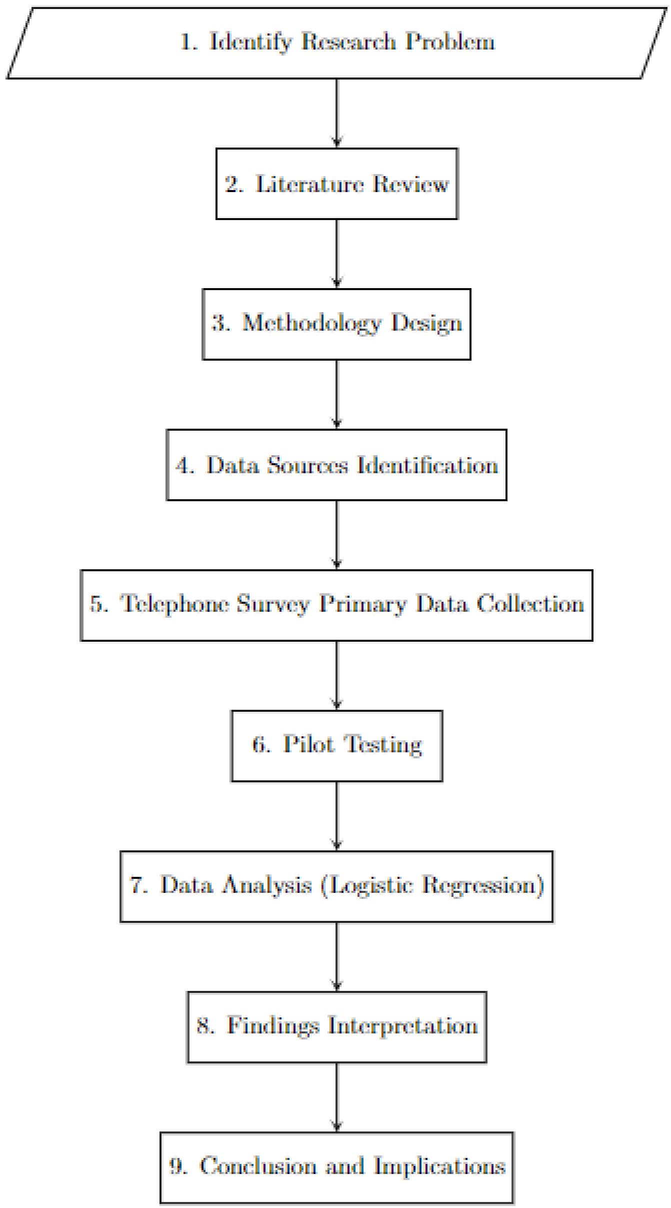
4.2.1 Research Design

This study conducts an in-depth literature review, exploring existing water management strategies and concerns in global and national contexts. In addition, the review includes relevant environmental approaches in the Maritime provinces to gain insights into water policies that can be adapted to areas resembling Newfoundland and Labrador, with a focus on the City of Corner Brook. This study uses quantitative data analysis methods. The goal of this research is to analyze households' willingness to install water meters in their residence which have not yet been installed on their properties.

4.2.2 Area of Study Selection

According to Mishra and Alok (2011), a sample design is a precise plan that is decided upon before any data collection is conducted to gather a sample from a designated population. The purpose of research design is to develop a procedure to incorporate diverse components of the study systematically and cohesively. In this regard, a well-defined research problem facilitates the creation of an effective research design (Mishra & Alok, 2011). A flexible research design would also provide an opportunity to consider different dimensions of the research problem in line with the primary objectives of the research study. Through this process, scholars should choose the approach for selecting a sample or develop a sample design for their research study (Mishra & Alok, 2011). A research process is identified as the required steps to conduct research. Each activity or step within the research process is entirely specific and distinct from other steps (Mishra & Alok, 2011). Figure 3 shows a flowchart of research process for this thesis.

Figure 3: Research process flow chart



Source: Author's Design, 2024

According to Feig and Stokes (2011), a researcher's general declaration of location involves a clear and explicit description of the research's objectives, the researcher's engagement, and the context in which potential bias might be dealt with. This study set out to solve a knowledge gap in the existing literature by investigating water management efforts in the City of Corner Brook located in western Newfoundland and Labrador as well as household collaborations concerning water conservation. A unique issue in Corner Brook is the flat-rate water billing included in property taxes, rather than consumption-based billing. In this context, concerns about fairness arising from this approach have led to an investigation into the feasibility and willingness of residents to adopt water meters. In addition, this study evaluates several factors affecting families' decisions to install water meters in their residences and identifies potential challenges or obstacles that may impede their willingness to accept this adaptation. Given the unstructured water pricing system, this study evaluates the city's status quo. Figure 4 shows the geographic layout of the City of Corner Brook, Newfoundland and Labrador.

Figure 4: Geographic Layout of the City of Corner Brook, Newfoundland and Labrador

Source: Google Map

4.2.3 Data Collection Methods

There are two different methods for data collection: primary and secondary (Taherdoost 2021). The primary data collection method is an approach that provides first-hand information for scholars for a specific research purpose (Taherdoost, 2021). These data are produced via primary databases or surveys (Barefield & Tweeten, 2013). On the other hand, secondary data collection methods are approaches where researchers gather information through published sources, which can be utilized for other research endeavours (Taherdoost, 2021). Typically, these data are collected by governmental agencies, private enterprises, and industry trade groups (Barefield & Tweeten, 2013). As Taherdoost (2021) mentions, primary data has some benefits, such as having access to more reliable and authentic data than secondary data. These features are considered core criteria for some types of research methods, such as statistical methods. However, there are some challenges in the process of gathering data. These difficulties could be described as the aim of data collection, the best procedure for data collection, the specific details to be obtained, and the most convenient schedule for data gathering (Taherdoost, 2021). In addition, it is worth mentioning that questionnaires, case studies, focus groups, and interviews are the most common methods with the intent of collecting primary data (Taherdoost, 2021). Data for this study is collected using primary data collection methods. Since this is the first study to analyze residents' perspectives in the City of Corner Brook regarding adapting water meters, primary data was required to conduct this research. For this study, the primary data are used to provide accurate and reliable information from households and provide opportunities to design a questionnaire that explores different households' perspectives regarding willingness to accept (WTA) installation of water meters.

4.2.4 Questionnaire Design and Structure

A questionnaire can be designed in two-fold: close-ended and open-ended questions (Taherdoost 2012). In the former type of questionnaire, questions are designed in a way that provides multiple answers for respondents to choose from, whereas in the latter type of questionnaire questions allow interviewees to provide their own responses. In this research, we design a questionnaire that contained 25 close-ended questions. In addition, dichotomous questions and multiple-choice questions are employed as close-ended question formats in this telephone survey. To analyze different aspects of the research population, this study provides a series of questions that are grouped into distinct parts. This questionnaire is a set of 25 questions to cover diverse aspects of demographic variables, socio-economic characteristics and attitudinal variables. Table 5 shows the category and frequency of questions in the households' survey.

Table 5: Category and frequency of questions in the households' survey.

Category	Number of questions
Demographic information	4
Socio-Economic information	4
Household attitudes	12
Willingness to pay	5
Total	25

Source: Author's Design, 2024

Before implementing the full survey, a pilot survey is conducted to ensure the effectiveness and clarity of the survey's questionnaires. Taherdoost (2021) mentions that researchers have the ability to gather a considerable amount of data through telephone calls, emails, or face-to-face interactions. Kabir (2016) asserts that there are some benefits and limitations to both telephone and face-to-face survey methods. A face-to-face survey method enables the interviewer to ask for more detailed questions and provide necessary clarifications. This method helps get a higher response rate and allows for looking into sensitive and complex cases. However, it might be quite expensive to use. Also, we need to think about possible bias and challenges with sensitive topics. Plus, training is needed before starting to collect data. The cost-saving and time-efficient characteristics of the telephone method make it stand out, especially when compared to alternative methods. In addition, it is possible to collect accurate data and clarify the questions for the interviewees (Kabir, 2016). However, in the telephone survey method, there is the possibility of not accessing the target people easily, especially the first time. Moreover, it should be considered that this approach is limited to surveying individuals who have phone access. Predictably, the possibility of discovering sensitive issues is lower in this method (Kabir, 2016). In this study, a telephone survey method is chosen to collect primary data. This approach facilitates direct engagement with participants and enables a reliable and standardized means of gathering data. A careful structure has been used to the design of questionnaire in order to guarantee clarity and show respect for the time of the participants. Several factors that may impact homeowners' decisions are investigated in this study, which was designed to determine whether or not residents are willing to consider installing water meters.

4.2.5 Sampling Method and Sample Design

It is a consensus that collecting data through the telephone survey method accompanies with some challenges (Panneerselvam, 2014). These include the dialled number being busy, no longer being in service, or not being answered. Panneerselvam (2014) has also provided some guidance in facing these challenges. For example, if the dialled phone line is busy or no one answers, that line should be called again later. In addition, if that number is answered but is not in the frame of the target sample, remove that telephone number from the list of data sampling. Also, the telephone numbers which are not in service should be excluded from the sampling frame numbers. Moreover, if the respondent is not free to engage in the telephone interview, that line should be called later based on their availability. Considering the information which pointed out by Panneerselvam (2014), similar challenges arise through our telephone survey at the time of data collection, which are managed and addressed properly according to the guidelines. Panneerselvam (2014) suggests some methods for telephone number selection in a telephone survey method, including reference to call local phone directory reference, plus-one dialling, random-digit dialling (RDD), and systematic random digit dialling (SRDD). A provincial telephone directory is used in this research study to locate households with alphabetic listings. This method helps achieve a higher response rate and enables the study of sensitive and complex cases. However, it may be somewhat costly to implement. Potential bias and challenges with sensitive topics should also be taken into account. In addition, training is necessary before beginning data collection. This survey relies on the latest telephone directory, issued in November 2023. Furthermore, telephone surveys to collect primary data are conducted on weekdays and weekends at various times of day.

During telephone surveys, the purpose of the study was explained, and verbal consent was requested from the participants in the survey before proceeding. Additionally, survey participants received an overview of the study at the beginning and were assured that their responses would be kept confidential. Also, they were informed that their participation in this survey was totally voluntary, and that withdrawal was possible at any stage of this survey. Therefore, all this information was provided to the participants through the consent letter that was read to them in the survey prior to completing the questionnaire, to ensure clarity and explain the nature and purpose of the study. Moreover, participants in this survey were allowed to ask questions and seek further explanations. As mentioned above, participants' information is kept confidential and is used only for research purposes at the aggregate level. At the beginning of the survey, all information was reiterated verbally to ensure participants felt comfortable and confident in their ability to opt out at any point.

A total of 380 telephone calls were made during this study. Of these, 150 were unanswered or directed to answering machines, and 100 individuals refused to participate. Additionally, 10 respondents had already installed water meters, and 20 were non-homeowners, thus ineligible for further survey questions. As a result, 100 respondents completed the survey, achieving an overall response rate of about 26.3 percent, based on the number of completed surveys with respect to the total number of attempted calls.

After completing the telephone surveys with residents of the City of Corner Brook, the collected information was critically analyzed to extract meaningful insights, forming the basis of the research findings. Because this research does not include inquiries with children, there was no requirement for parental or guardian consent. The focus was solely on involvement with adult participants in the region of the study through telephone surveys. Personal information such as names was not asked to preserve the anonymity of participants. All collected data were coded and stored securely, with restricted access limited to the research team.

4.2.6 Ethical Considerations

The timeframe for conducting data collection and analysis extended from October 2023 to June 2024. This timeframe encompassed designing the research proposal, developing research tools (survey, cover letter, informed consent, etc.), gaining approval from the Grenfell Campus Research

Ethics Board, conducting a literature review, carrying out telephone surveys, analyzing data, and completing the thesis. Although this study does not specifically target any group, the importance of ethical considerations was recognized in advance. Before starting the survey, following the principles of research ethics, the proposal of this research, the questionnaire and the provided consent letter for the questionnaire were all submitted and underwent a thorough review and received guidance from the Grenfell Campus Research Ethics Board (GC-REB). The GC-REB, within Memorial University's research integrity framework, reviews research involving human participants to ensure compliance with ethical standards and guidelines. We began to collecting data from the participants in the survey after we received confirmation from the GC-REB.

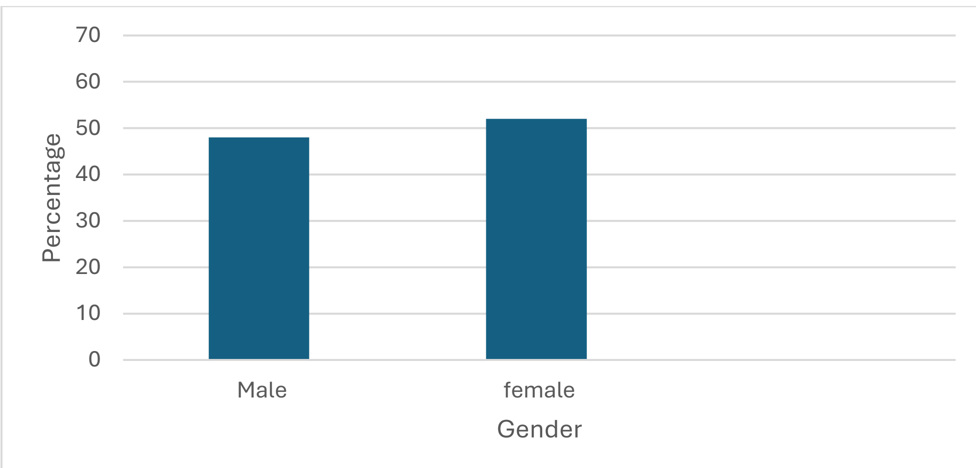
4.3 Survey Data Overview and Response Analysis

In the following section, we describe how we analyzed the information gathered from the phone survey. The major objective is to provide a comprehensive overview of the participants' demographic information and survey responses. In addition, we examined the collected data carefully to show how responses were distributed across different categories, shedding light on the households' attitudes regarding acceptance of the installation of water metering systems in their properties. Evaluating this breakdown helps us reveal patterns in the sample and finding important correlations between demographic factors and attitudes toward this adaptation. The following subsections describe the distribution of responses for each survey question, complemented by visual representations.

4.3.1 Gender

Figure 5 exhibits gender distribution collected from the respondents in the survey. As shown in this figure, out of the 100 participants in this telephone survey, 52 percent are females, while 48 percent are males. This balanced distribution helps to ensure that both male and female perspectives are sufficiently covered in the study. Gender is an important factor in understanding the willingness to adopt residential water meters, as household responsibilities often vary by gender and can affect this choice. City Population (2023) data show that Corner Brook consists of 47.9 percent males and 52.1 percent females, closely matching the gender breakdown in this study's sample and supporting its representativeness.

Figure 5: Gender Distribution of Survey Participants

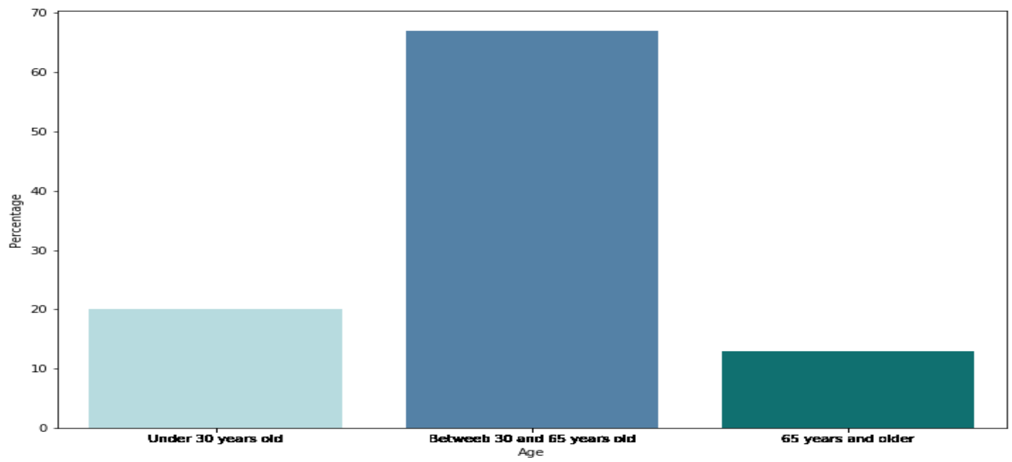


Source: Sample data, 2024

4.3.2 Age Distribution

Figure 6 shows the age distribution of the respondents in the survey. As it is observed, participants' years of living ranged within various group ages. According to the collected data, most of the respondents' ages are between 30 and 65 years (67 percent), followed by the participants' group who are less than 30 years of age (20 percent). In addition, nearly 13 percent of the respondents in the survey were more than 65 years of age. Hence, a significant proportion of the respondents fall into the age range of 30-65.

Figure 6: Age Distribution of Survey Participants

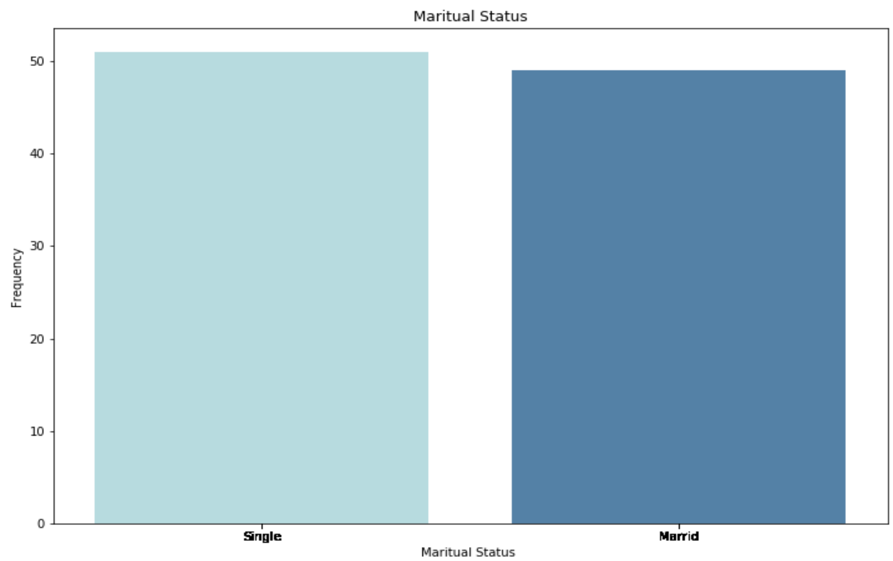


Source: Sample data, 2024

4.3.3 Marital Status

Figure 7 illustrates the marital status of the respondents in the survey. This chart segments the participants into two different categories: single and married. Each segment represents the percentage of participants within that specific marital status. From the chart below, it is evident that the majority of the survey participants are single, constituting 51 percent of the total respondents and married individuals make up 49 percent. This analysis shows that this survey sample includes predominantly single individuals.

Figure 7: Distribution of Marital Status Categories

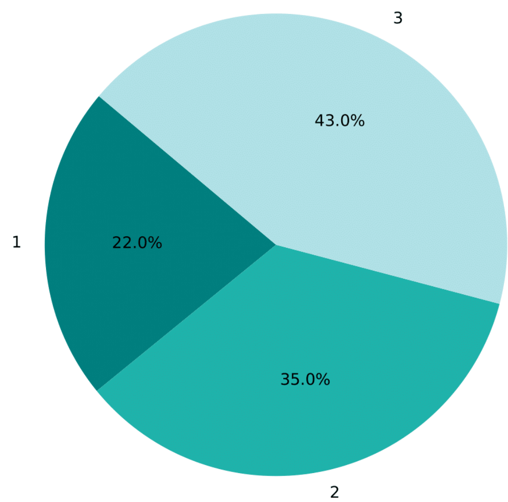


Source: Sample data, 2024

4.3.4 Family Size

Family size is one of the important criteria to be considered in this research regarding households' interest in installing metering devices in their dwelling. The focus of this evaluation is to see if there is a difference in how larger and smaller households view water meter installation. This perspective mainly arises from concerns about increased water bill costs since larger families may expect higher water consumption compared to households with smaller sizes. Figure 8 shows the family size of the respondents in the survey. Based on the sample data, 43 percent of the respondents in the survey have a family size of 3 or more, followed by 35 percent reporting 2 members in their household. Moreover, 22 percent of respondents indicate their family sizes as 1.

Figure 8: Survey Participants' Family Size Distribution

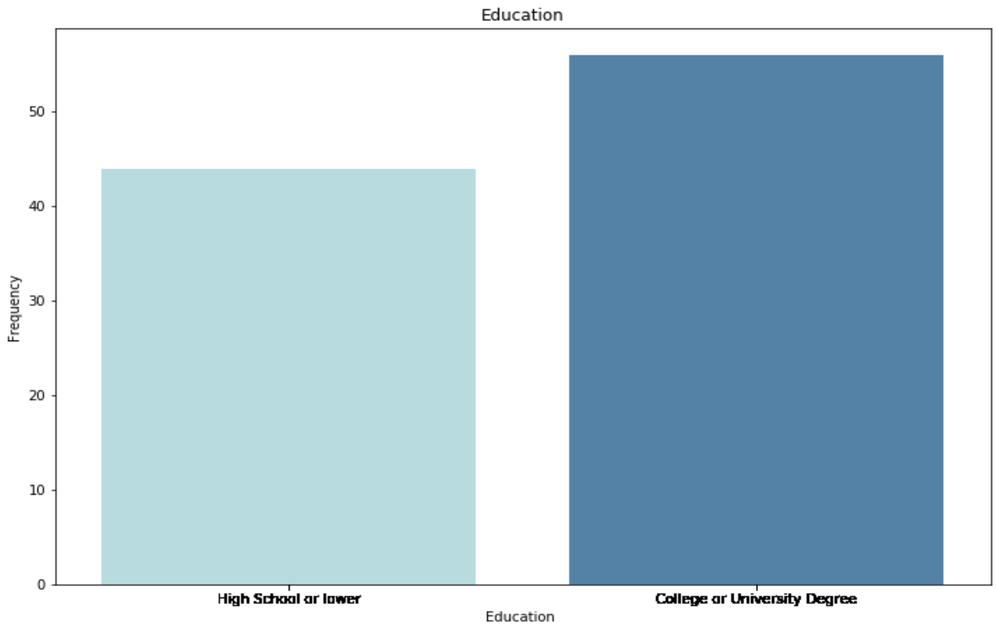


Source: Sample data, 2024

4.3.5 Educational Level

As depicted in Figure 9, 56 percent of respondents hold a college or university degree, and 44 percent have a high school diploma or less. This research views educational level as a key factor to assess if households with higher education backgrounds place a higher priority on water conservation or are more involved with policymakers.

Figure 9: Distribution of Educational Levels in Survey Sample

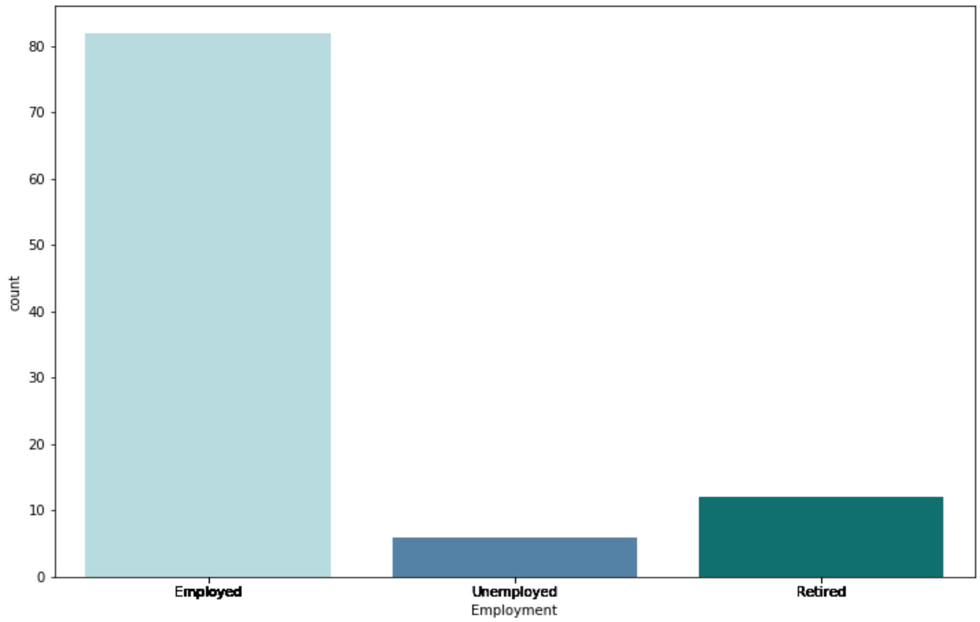


Source: Sample data, 2024

4.3.6 Employment Status

Figure 10 shows the employment status of the respondents in the survey. As it is shown, the respondents in the survey are categorized into three distinct groups. The table analysis shows that the largest group of participants is employed, with a total of 82 individuals. The next group is retired participants, who make up 12 percent of the responses. As shown in Figure 10, 56 percent of respondents hold a college or university degree, with 44 percent having completed only high school or below.

Figure 10: Employment Status of Survey Participants

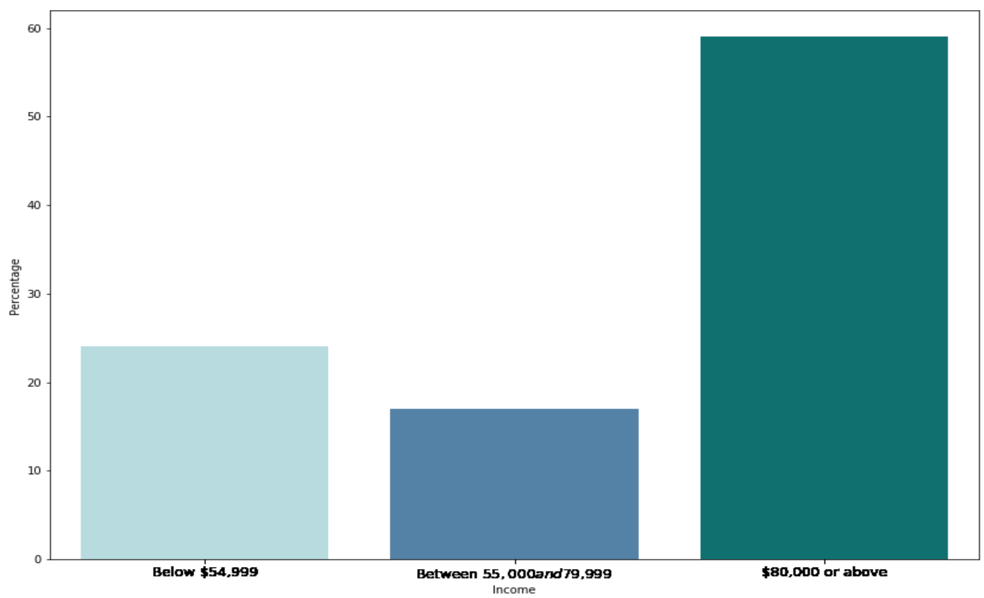


Source: Sample data, 2024

4.3.7 Annual Households Income Level

A clear overview of the yearly income levels of survey participants can be seen in Figure 11. Respondents are classified into three income groups in the survey, with each group's percentage clearly indicated. Analyzing this chart, it can be concluded that 59 percent of respondents have an income level of $80,000 or above. This is followed by participants with annual incomes below $54,999, which comprise 24 percent of the entire respondents. In addition, 17 percent of them have annual income levels between $55,000 and $79,000. It is important to note that the median household income in Corner Brook is $63,600, with a median after-tax household income of $56,800 per year (Point2home, 2021). This indicates that the surveyed households have income distributions skewed toward higher income brackets when compared to the median. This might be because only homeowners could join the study, and they usually have higher incomes. In addition, half of the lone-parent families in Corner Brook and the surrounding area had incomes of more than $50,400 in 2021 (Community Accounts, 2021). This information offers insights into the community's economic landscape. Looking at the income levels of respondents can help explain what affects their decisions to buy or install water meters.

Figure 11: Distribution of Annual Household Income Levels

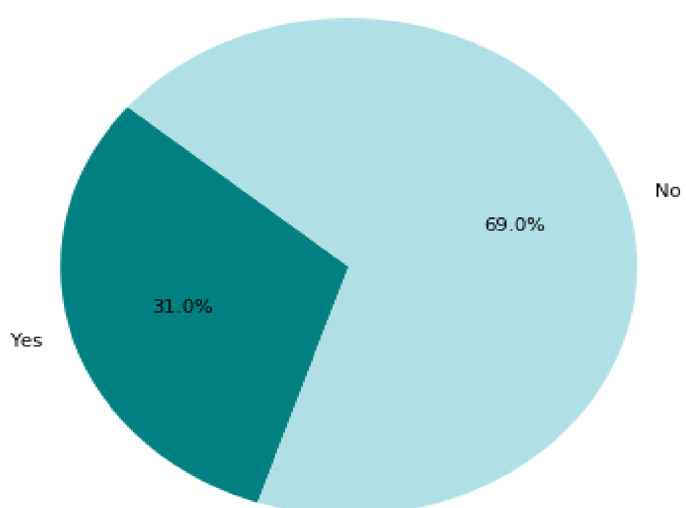


Source: Sample data, 2024.

4.3.8 Interest in Installing Water Meters

Figure 12 shows the respondents' interest in installing a water meter in their house. The chart segments the participants into two categories. Each segment represents the percentage of participants who responded either positively or negatively to this question. From the collected data, it is apparent that the largest portion of survey participants, 69 percent, indicate they are not interested in installing water meters. However, 31 percent of the respondents show interest in installing a water meter. The collected data shows that a big part of the respondents is not inclined to install water meters, which could make it more challenging to get them installed. In addition, this points to most of the surveyed population expressing hesitancy or resistance toward adopting water meters. Understanding this distribution is important for interpreting survey results because the level of interest influences how effective policies for water meter adoption can be. Residents might hesitate due to concerns over cost, limited awareness of benefits, or worries about the installation process.

Figure 12: Survey Results on Water Meter Installation Interest

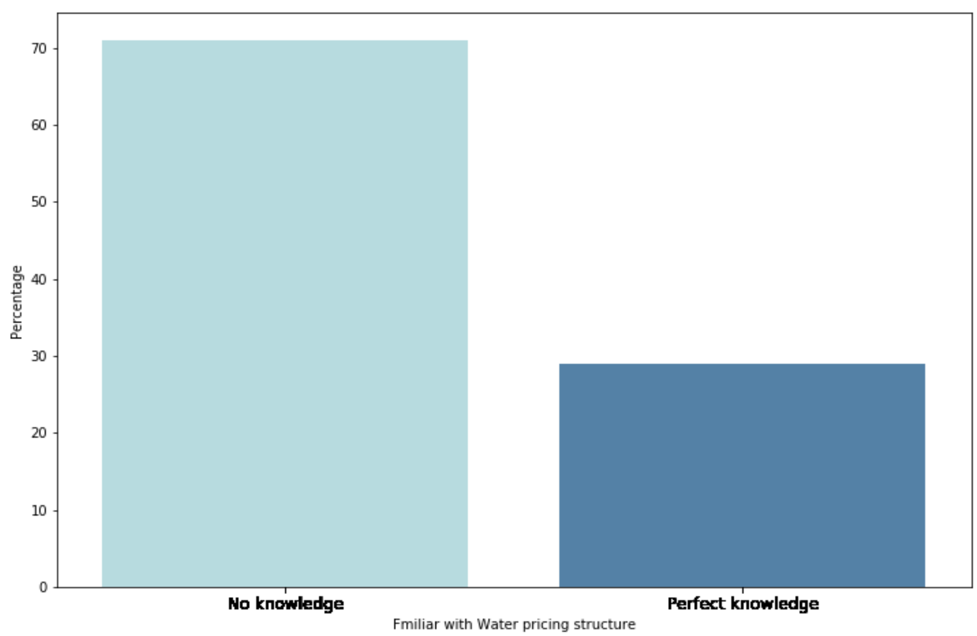


Source: Sample data, 2024.

4.3.9 Familiarity with water pricing

The familiarity with Corner Brook's water price system is shown in Figure 13. The data show that a large majority, 71 percent of respondents, lack knowledge of the current water pricing structure in this city, while 29 percent mention that they are informed. This figure clearly shows that most survey participants are generally unaware of the water pricing system.

Figure 13: Awareness of Water Pricing Structure Among Respondents.

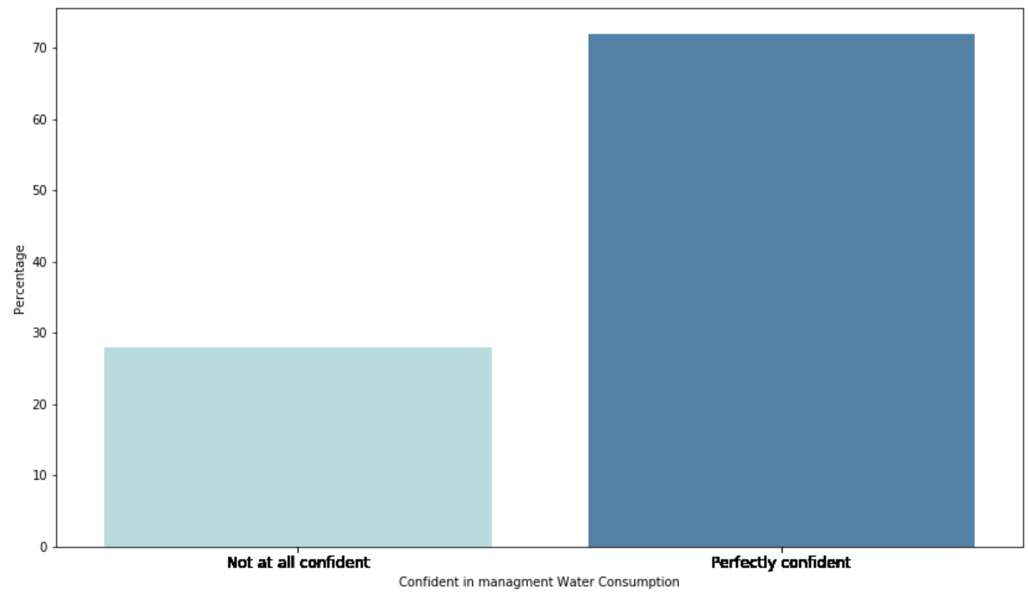


Source: Sample data, 2024.

4.3.10 Confidence Levels in Managing Household Water Consumption

Respondents' confidence in their capacity to monitor and manage their household's water consumption effectively is outlined in Figure 14. As it is shown, 28 percent of respondents are completely lacking confidence in their ability to monitor and manage their water consumption. On the other hand, a significant 72 percent of the participants are fully confident in their ability to manage water consumption effectively.

Figure 14: Survey Participants' Confidence in Water Management

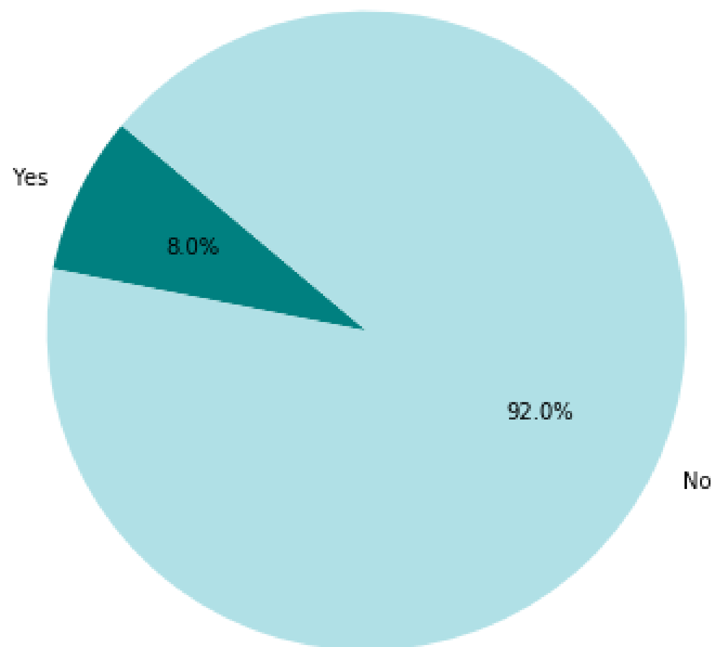


Source: Sample data, 2024

4.3.11 Awareness of Water Meter Costs

The awareness of participating households about the costs of purchasing and installing a water meter is illustrated in Figure 15. Each segment represents the percentage of participants who indicated whether they were aware of the cost. It is evident from the data that 92 percent of participants lack awareness regarding the costs of purchasing and installing a water meter. Merely 8 percent of the participants express their knowledge of these expenses. A significant lack of awareness about the financial aspects of water meter installation is evident from this distribution among the surveyed population. Hence, this lack of knowledge could impede the willingness to accept this metering system. This is one of the most important pieces of information that could be achieved by the residents of Corner Brook to help policymakers.

Figure 15: Awareness of Water Meter Costs Among Respondents

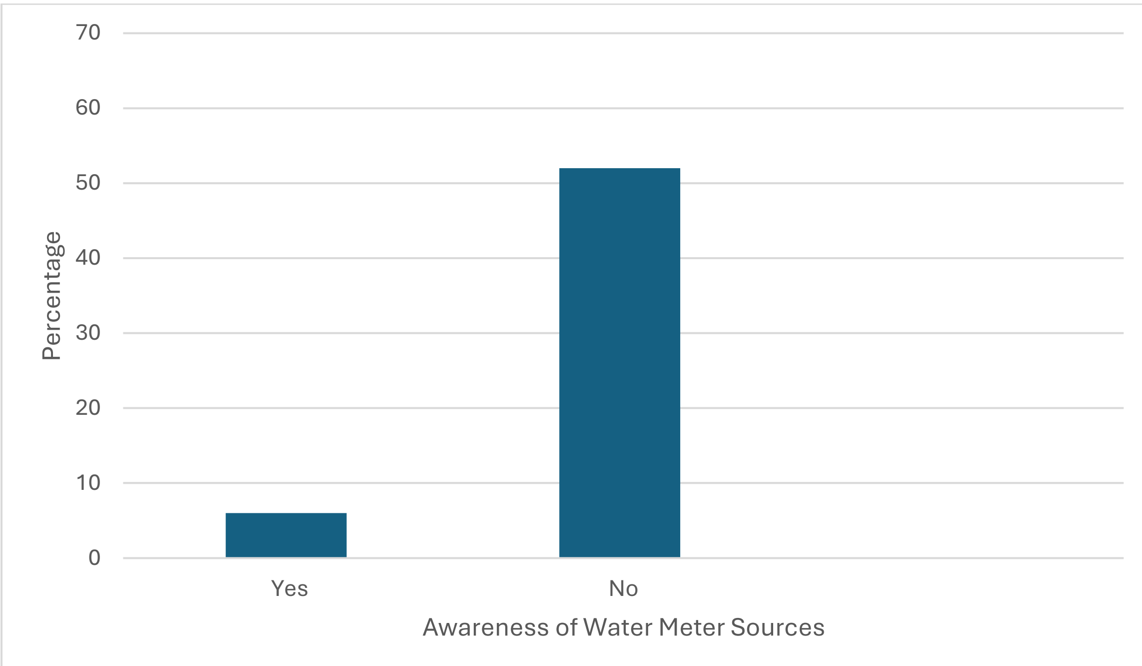


Source: Sample data, 2024

4.3.12 Familiarity with Water Meter Purchase and Installation Sources

Figure 16 shows participants' awareness of where to purchase water meters or find installation services in their locality. The data reveals that a vast majority, 94 percent, are unaware of these sources in their area. Only 6 percent of the survey takers indicate that they are aware of where to obtain these services. This survey findings indicate that the questioned population lacks knowledge about available options for purchasing water meters or accessing installation services.

Figure 16: Awareness of Water Meter Purchase and Installation Sources Among Respondents

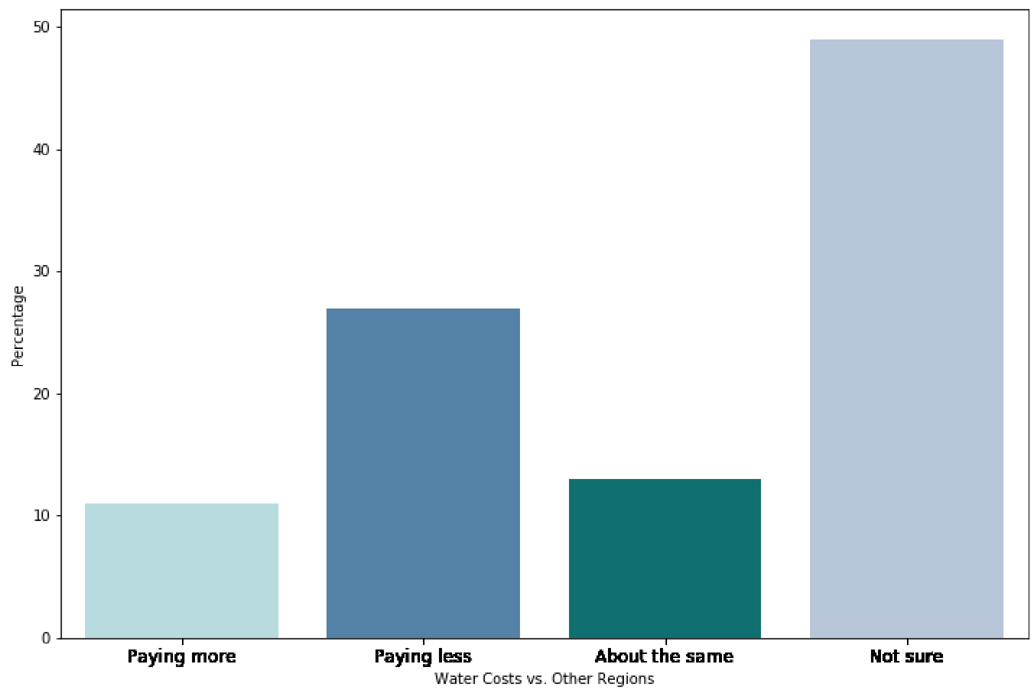


Source: Sample data, 2024

4.3.13 Perception of Water Costs Compared to Other Regions

Figure 17 presents the perception of participants regarding how their water consumption costs compare to other provinces. The visualization groups participating households into four categories: paying more, paying less, paying about the same, and unsure. Each segment shows the percentage of participants who responded to this question. It can be concluded from the sample data that almost half of the participants (49 percent) are not sure how their water consumption costs compare to those in other provinces; 27 percent believed they are paying less, 13 percent think that they are paying about the same, and finally, 11 percent feel they are paying more. Therefore, considering this distribution, it appears that most respondents have a large amount of ambiguity regarding the costs of water in comparison to other regions.

Figure 17: Distribution of Views on Water Costs Compared to Other Areas

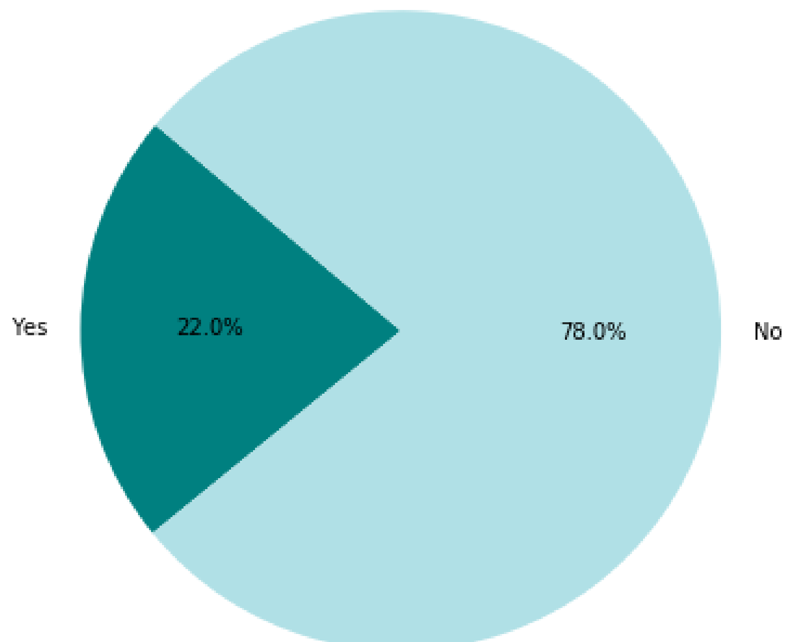


Source: Sample data, 2024

4.3.14 Awareness of High Residential Water Consumption Rates in Newfoundland and Labrador

Figure 18 illustrates the awareness of the participants in this survey about the fact that the province of Newfoundland and Labrador currently has one of the highest average daily residential water consumption rates compared to other provinces in Canada. Each segment represents the percentage of participants who responded to the question. Figure 18 shows a significant majority of participants, 78 percent, are not aware that this province has one of the highest average daily residential water consumption rates compared to other provinces. However, 22 percent of respondents are aware of this fact. The results of this data indicate that the respondents had a severe lack of knowledge about the high water usage rates in this province.

Figure 18: Awareness of High Residential Water Consumption Rates in NL

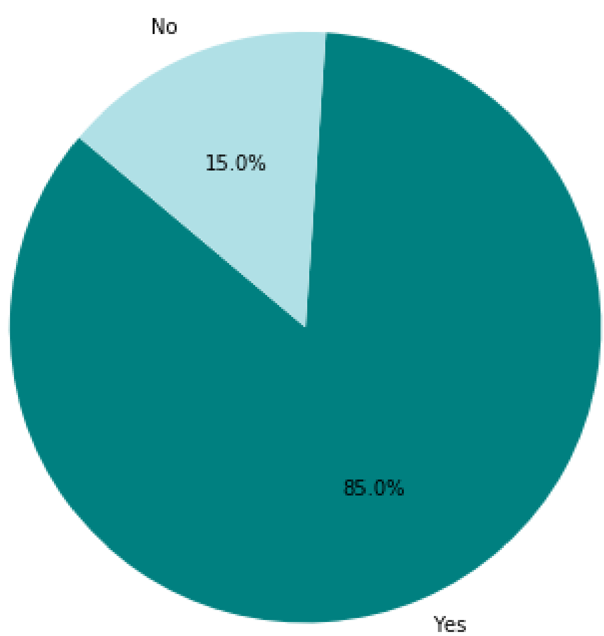


Source: Sample data, 2024

4.3.15 Perceptions of Water Meter Impact on Consumption and Conservation

Figure 19 shows the participants' perspectives on the effects of water meter installation on household water usage and conservation. According to this representation, 85 percent of respondents indicate that setting this metering system could assist in reducing the amount of water that is used in households and promote conservation, while 15 percent do not consider this to be the case.

Figure 19: Breakdown of Views on Water Meter Effectiveness in Conservation

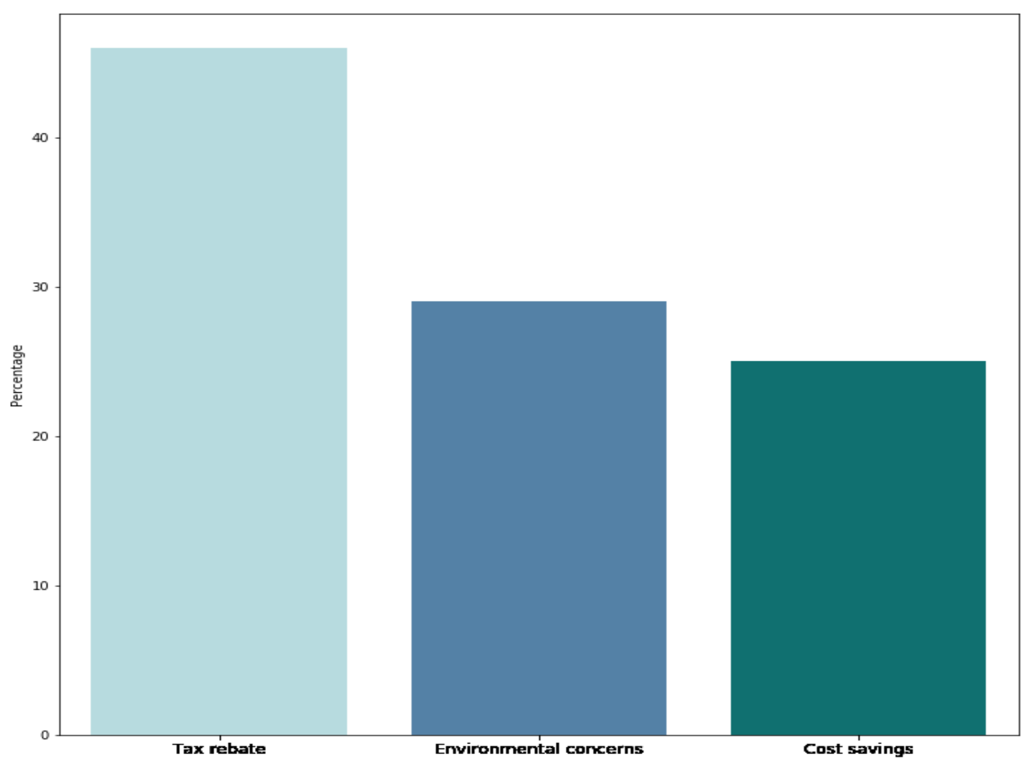


Source: Sample data, 2024

4.3.16 Influential Factors in Water Meter Installation Decisions

The factors influencing water meter installation decisions are summarized in Figure 20, showing categories like government incentives (e.g., tax rebates), environmental concerns, and cost savings along with the percentage for each. As it is observed, government incentives (e.g., tax rebates) emerge as the most influential factor, with 46 percent of the entire participants indicating it as vital in their decision-making process. From the data, 29 percent of households are motivated by environmental considerations, while 25 percent are influenced by the potential for cost savings.

Figure 20: Factors Driving Household Water Meter Installation Decisions

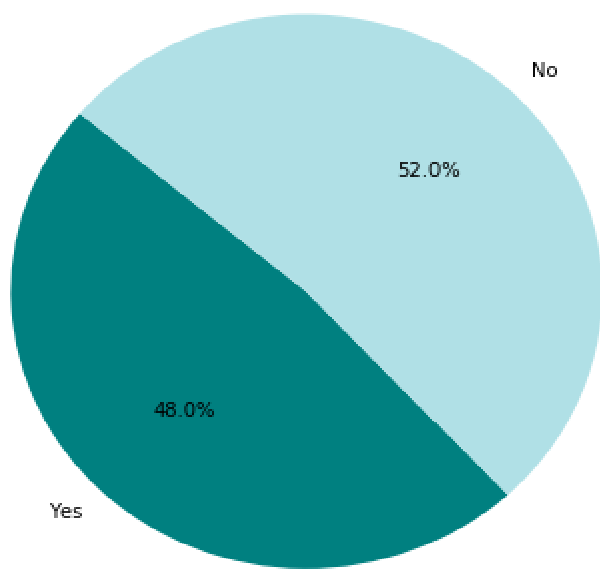


Source: Sample data, 2024

4.3.17 Interest in Water Conservation Programs

Figure 21 shows how willing participants are to join educational programs or campaigns about water conservation and efficient use of water. The answers are split into those who are willing to participate and those who are not. From the data, 48 percent of respondents are interested in being part of these programs, while 52 percent were not. Consequently, it appears that more work may be required to inspire participation from the general public, given that fewer locals expressed an interest in being involved.

Figure 21: Distribution of Willingness to Participate in Water Conservation Education Programs

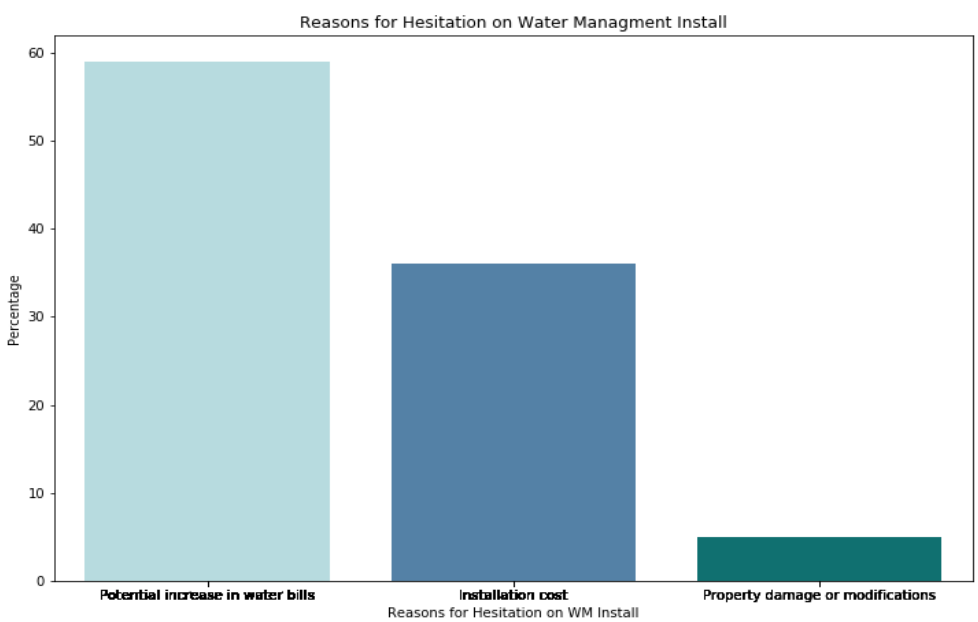


Source: Sample data, 2024

4.3.18 Primary Concerns About Installing Water Meters

Figure 22 displays the main reasons respondents indicated as potential hesitations toward installing water meters in their households. Respondents were given several options and asked to select the one that represented their biggest concern for the question. It can be seen from the data that 59 percent of respondents identify the potential increase in water bills as their primary concern regarding the installation of a water metering system in their household. In addition, 36 percent express their concerns about installation costs, while 5 percent of respondents worry about potential property damage or modifications. The analysis results indicate that households' decisions to install meters are primarily influenced by financial factors, including both the initial and ongoing costs.

Figure 22: Participants' Primary Concerns Over Water Meter Installation

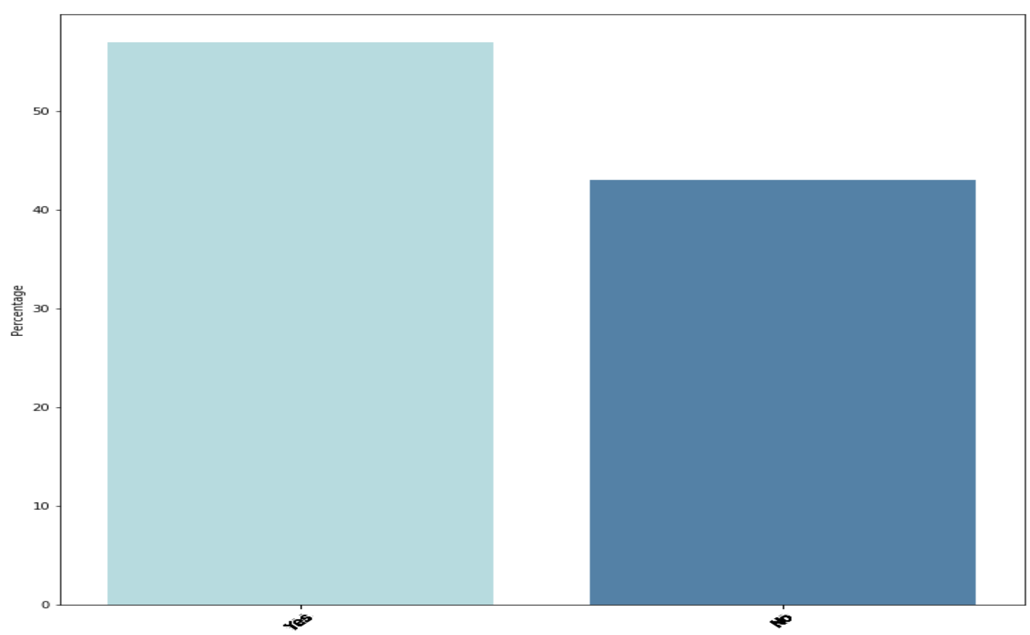


Source: Sample data, 2024

4.3.19 Willingness to Pay for Water Meter Purchase and Installation

According to an in-person discussion with the Corner Brook municipality, the estimated cost for purchasing and installing a water meter comes to about $800 (Corner Brook Municipality, personal communication, May 26, 2023). This cost serves as the baseline for analyzing participants' willingness to invest in water metering systems, as represented in Figure 23. Participants' willingness to spend about $800 on the purchase and installation of a metering system in their properties is represented in Figure 23. Data show that 57 percent of respondents are ready to participate financially in installing water meters, while 43 percent are not. This result underscores the need for customized incentives.

Figure 23: Willingness to Contribute Financially for Water Meter Purchase and Installation

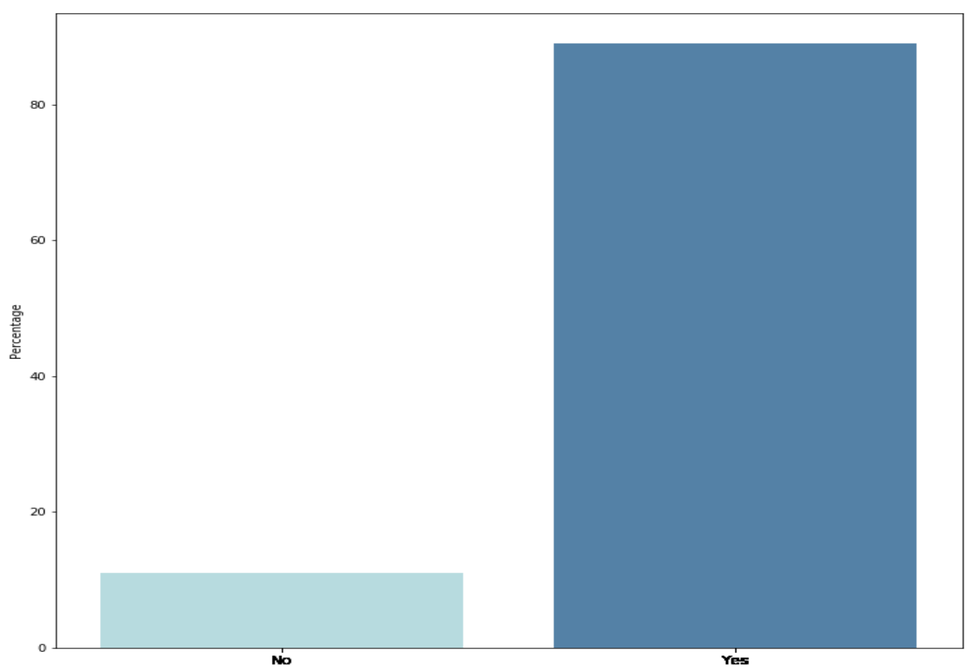


Source: Sample data, 2024

4.3.20 Satisfaction with the Current Water Pricing System

Figure 24 shows how participants feel about the current water pricing in Corner Brook. The answers are either "satisfied" or "not satisfied." Out of 100 participants, 89 say they are satisfied, while 11 say they are not. This shows that the pricing works for most people, and only a small number are unhappy with it. This may mean that, for most residents in this city, the water pricing seems fair and acceptable.

Figure 24: Distribution of Satisfaction with Current Water Pricing System in Corner Brook

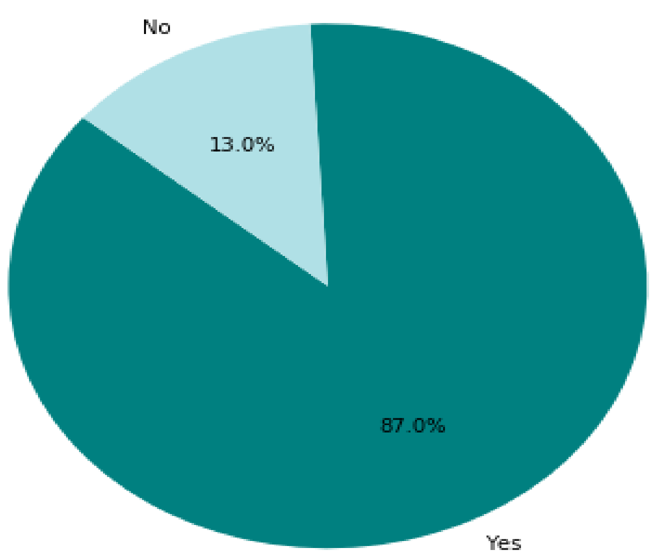


Source: Sample data, 2024

4.3.21 Participant Views on the Government Incentives for Water Meters

Figure 25 summarizes participants' opinions on whether the government should provide incentives for water meter installation to encourage broader adoption among households. Responses are categorized into Yes and No, showing the percentage distribution for each response. As can be seen from Figure 25, the majority opinion was in favour of the government incentives for water meter installation. The results show that 87 percent of respondents believe in government incentives for water meter adoption, whereas 13 percent are opposed. This preference highlights respondents' perception of the advantages in government-supported initiatives to increase water meter installations.

Figure 25: Opinions on Government Incentives for Water Meters

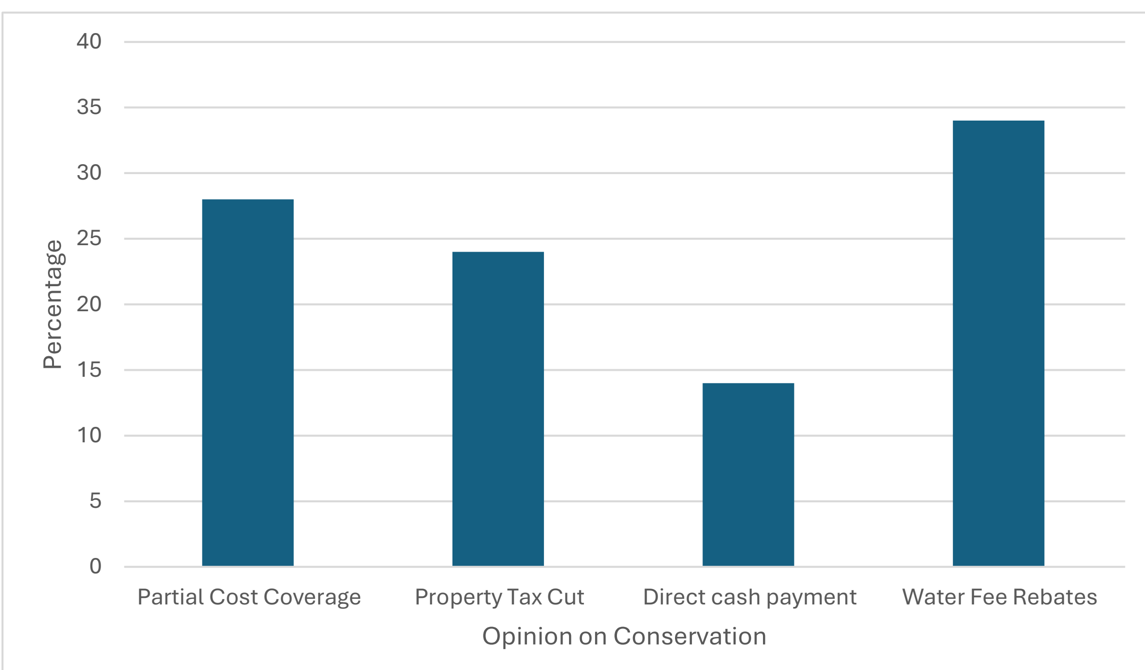


Source: Sample data, 2024

4.3.22 Opinions on Government Incentive Types for Water Meter Adoption

Figure 26 shows respondents' preferences regarding government incentives for water meter installation. Participants selected their preferred type of incentive from several options, which were categorized into partial coverage of purchase and installation costs, property tax reduction for the following year, direct cash payment, and rebates or subsidies on water usage fees. As it is shown in Figure 26, the preferences of respondents regarding government incentives for the installation of water meters are somewhat diverse. From the provided choices, 34 percent prefer rebates or subsidies on water usage fees, 28 percent are in favor of covering a portion of the purchase and installation costs, 24 percent are interested in property tax reductions, and 14 percent prefer direct cash payments. Designing incentives with an emphasis on rebates and subsidies could increase support and involvement in water conservation initiatives, as implied by these findings.

Figure 26: Respondents' Preferred Government Incentives for Water Meter Adoption

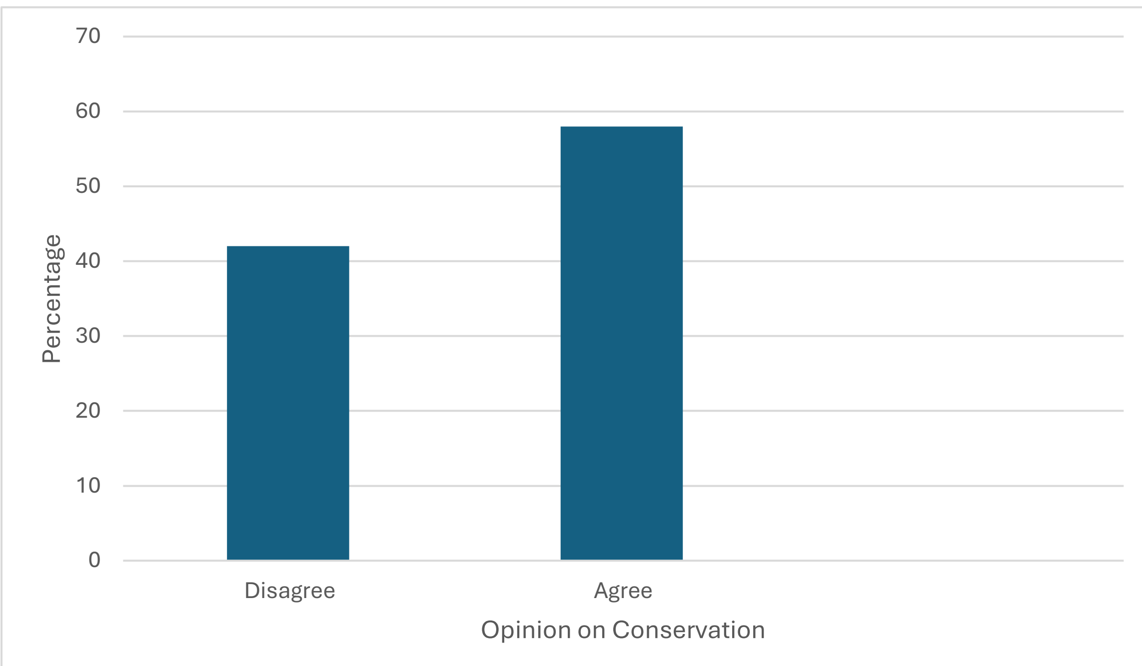


Source: Sample data, 2024

4.3.23 Participants' Views on Water Meters and Water Conservation

Figure 27 shows the responses from participants on their perceptions of water meters and their effectiveness in conserving water. The data indicate that 58 percent of respondents believe installing water meters could help save water, while 42 percent disagree. In other words, the findings suggest that a slightly larger group of people believes that water meters may play a role in water conservation.

Figure 27: Opinions on the Role of Water Meters in Water Conservation



Source: Sample data, 2024

4.4 Application and Explanation of the Logit Model for Water Meter Adoption

A binary response model, as noted by Horowitz and Savin (2001), is a regression model with a dependent variable *Y* that is binary. Commonly used methods, such as logit and probit models, are based on the assumption that the functional relationship between *Y* and the explanatory variables is defined. These two models are commonly used in econometric research, particularly in leading academic journals (Horowitz & Savin, 2001). Recent studies have demonstrated the application of the binary logit regression model in socio-economic research. For instance, Tehupeiory et al. (2023) use binary logit regression to study the factors affecting urban communities' willingness to transition to apartment living in Jabodetabek. Tehupeiory et al. (2023) emphasize in their study how sociodemographic factors influence individuals' likelihood of paying for an apartment. Similarly, Zhang et al (2023) utilize binary logit regression to evaluate how respondents' socioeconomic characteristics impact their willingness to spend money on buying electric vehicles.

There are also some studies that used the binary logit regression model, such as Bekabil (2022), which examined factors affecting farmers' willingness to adopt conservation agriculture practices, and Asfaw et al. (2024), which analyzed household waste management behavior. In this study a binary-choice logit model is applied for parameter estimation to analyze the willingness of households to install water meters in the City of Corner Brook. Given its suitability for binary outcomes, the logit model is employed to analyze 'Yes' or 'No' responses about water meter installation and to estimate how different factors affect Willingness to Accept (WTA) installing residential water meters. This model helps understand better how different factors could affect the probability of a household's decision to install a water metering system on their premises. Hence, this model is proper for predicting probabilities within the range of 0 to 1, which corresponds well with binary outcome variables in this study. Logit regression resembles linear regression in the sense that it can either have a single independent variable or several independent variables (Stoltzfus, 2011). If linear regression predicts continuous values, then logit regression handles binary outcomes (Stoltzfus, 2011; Castro & Ferreira, 2022). Although both models were evaluated for this study, the logit model was chosen due to its suitability for analyzing a categorical dependent variable. One reason this model is important is that it clearly shows how different factors, such as age, household size, or education, can influence someone's decision. For example, it helps find out if older people are more likely to get water meters than younger ones, or if bigger families are less likely to use them. The results, presented as odds ratios, provide a simple way to see how much these factors increase or decrease the chances of adoption. Furthermore, the logit model can also estimate odds ratios, which may be used to interpret in an intuitive manner the impacts of independent variables such as age, education, and employment status on the propensity to adopt water meters. The offered technique is not only reliable for analysis purposes but also useful to policymakers and anyone else interested in crafting strategies and incentives to drive adoption. This method corresponds with well-known ways of studying how people decide to use sustainable technologies, thus it is reliable for looking at residential water meter adoption.

4.4.1 Data Management and Analysis Tools for the Logit Model

This study utilizes Python (version 3.5) for the purpose of data analysis. NumPy, Pandas, and Stats Model libraries are highly useful for statistical analysis and model generation. NumPy works as the main library for scientific work in Python. It gives access to useful data structures and fast tools that are not included in Python's basic packages (Sapre& Vartak, 2020). In addition, Pandas is a library that makes it easier to work with datasets and offers essential tools for building statistical models (Sapre& Vartak, 2020). Stats Models is also a library that is used for statistical and econometric analysis in Python (Seabold & Perktold, 2010). In this study, for data manipulation and preparation, the panda's library is used to ensure that the data is appropriately formatted for analysis. In addition, NumPy is applied for numerical operations, whereas Stats Models are applied for implementing the logit model. Prior to doing the regression analysis, an Exploratory Data Analysis (EDA) is conducted to facilitate storytelling and prepare the data for input into the logistic regression model. By fitting and estimating the logistic regression model according to the hypotheses, all important independent variables are evaluated simultaneously by implication of the Stats Models module in Python. Using Python enables effective data management, model setup, and result visualization. In addition, Python's flexibility, along with the powerful libraries matplotlib and seaborn, facilitates the development of detailed figures and charts to depict the results of this research effectively.

4.4.2. Probability Distribution and Expected Value

The logit model is grounded in the assumption that the dependent variable, the willingness to install a water meter, is distributed according to a Bernoulli distribution. Each respondent's decision is viewed as a Bernoulli trial with a success probability πi that varies across cases. According to this model, the probability of success (π_i) shows the chance that household i will install a water meter. This likelihood is determined by a series of independent variables (X_i) such as income, education, employment status, and environmental considerations of the households. The anticipated value of the binary outcome (dependent) variable γ_i is given by the following formula, which shows the probability that household i will install a water meter in their properties:

$$Pr[\gamma_i = 1] = \pi_i$$

In addition, the variance of the binary outcome variable in this study measures the variability in the probability of installation among households. It is given by:

$$Var(\gamma_i) = \pi_i(1 - \pi i)$$

To keep the probability of success (π_i) within the range of zero to one, the logistic function (Λ) is applied. The probability of success is represented as:

$$\pi_i = \Lambda(\Omega_i) = \Lambda(X_i'\gamma) = \frac{exp(X_i'\gamma)}{1 + exp(X_i'\gamma)}$$

As it is mentioned above π_i is the likelihood of household i installing a water meter. In this formula Λ stands for the logistic cumulative density function. $X_i'\gamma$ is a linear combination of the independent variables X_i and the vector of parameters γ that are unknew and are required to be estimated. Moreover, the log odds represent the ratio of the probability of a household deciding to install a water meter to the probability of not installing one. This ratio is expressed as:

$$\Omega_i = \log\left(\frac{\pi_i}{1 - \pi_i}\right)$$

The likelihood that household i will opt to install a water meter is depicted by πi. Conversely, $(1 - \pi_i)$ indicates the chance that the household will decide against installing a water meter. The log odds, shown as Ω_i, offer a method for connecting this probability to the various influencing factors. In the logit model, the log odds are determined by multiple factors that could affect the choice to install a water meter.

$$X_i'\gamma \;=\; \gamma_{0+}\gamma_1 x_1 + \;\gamma_2 x_2 \;+\; \gamma_n x_n + \varepsilon,$$

As can be seen in the formula below, factors such as income, education level, family size, environmental awareness, and others are included as independent variables X_i. In addition, the baseline probability is shown by the intercept term γ_0. The influence of each factor on the likelihood of installing a water meter is expressed by the coefficients γ_1 through γ_n. Any unexplained variability is accounted for by the inclusion of a random error term. Moreover, the estimated coefficients γ from this logit model provide insights into how each variable affects the probability of installing a water meter. The dependent variable in this model is coded 1 if the respondents showed their willingness to accept installing a water meter (WTA_{IWM}) in their residents and zero otherwise. To estimate the probability of a household's willingness to accept installing a water meter (WTA_{IWM}) in the City of Corner Brook, the following regression model is developed:

$$
\begin{aligned}
WTA_{IWM} = \gamma_0 + \ & \gamma_1 gen2 + \gamma_2\, age2 + \gamma_3\, age3 + \gamma_4\, mari + \gamma_5\, Fsz2 + \gamma_6\, Fsz3 + \gamma_7\, edu2 \\
& + \gamma_8\, emp2 + \gamma_9\, emp3 + \gamma_{10}\, inc2 + \gamma_{11}\, inc3 + \gamma_{12}\, wpfam2 + \gamma_{13}\, wmgmtc2 \\
& + \gamma_{14}\, wmca2 + \gamma_{15} wmsource2 + \gamma_{16}\, costcompare2 + \gamma_{17}\, costcompare3 \\
& + \gamma_{18}\, costcompare4 + \gamma_{19} awusage2 + \gamma_{20} bwmrwc2 + \gamma_{21} infwm2 \\
& + \gamma_{22} infwm3 + \gamma_{23} wcedu2 + \gamma_{24} rhwmi2 + \gamma_{25} rhwmi3 + \gamma_{26} finc2 \\
& + +\gamma_{27} satisfwp2 + \gamma_{28} govincent2 + \gamma_{29} effectivewmc2 + \varepsilon.
\end{aligned}
$$

The results obtained from the analysis of these coefficients make it possible to determine the factors that have a major impact on households' decision to adopt water meters. Policymakers require this information to formulate efficient policies for water management in this city and to tackle the difficulties linked to the implementation of a metered water pricing system.

4.4.3 Descriptions of Variables and Expected Outcomes for Water Meter Adoption

Table 6 describes the dependent and independent variables used in the logit regression model for this study and highlights the anticipated influence of each explanatory variable on the decision to install water meters. This research focuses on what might shape the choices of Corner Brook residents. For example, one idea is that older people are more likely to agree to install water meters than younger ones. In addition, bigger households, like families with two or more people, might be less willing to install them in their units because the costs or effort could seem too much. At the same time, people with higher education might show more interest in water meters. Another thing that seems important is whether someone is working, retired, or unemployed. It is expected that people with jobs are more likely to agree to water meter installation than those who are retired or not working. Being aware of the costs of buying and installing water meters also seems to matter. Residents of this city who know how much it costs might be more willing to install them, compared to those who do not know. Knowing about high water usage in Newfoundland and Labrador could also play a role. People who realize how much water is used every day in the province might feel it is important to install a water meter. On the other hand, in this city, households that are happy with the current water pricing system might not want to change things by adding a water meter. Lastly, people who think water meters are good for saving water are more likely to install one. The idea that meters can help with conservation might inspire them to consider making that choice. This way of thinking makes it easier to see what leads people to install water meters and what factors influence them. More details can be found in Table 6 below.

Table 6: Descriptions of Variables Used in Regression Analysis

Variable Name	Description	Expected sign
WTA IWM	1 if the household was willing to accept installation of water meter, 0 otherwise	____
gen	1 if the participant was male , 0 otherwise	-
age1	1 if the participant was Under 30 years old, 0 otherwise	+
age2	1 if the participant was Between 30 and 65 years old, 0 otherwise	+
age3	1 if the participant was 65 years and older, 0 otherwise	+
marit	1 if the participant was married, 0 otherwise	+
fsz1	1 if the participant was from 1 member family size, 0 otherwise	-

fsz2	1 if the participant was from 2 member family size, 0 otherwise	-
fsz3	1 if the participant was from 3 member family size, 0 otherwise	-
edu	1 if the completed level of education was college or university, 0 otherwise	+
emp1	1 if the participant was Employed, 0 otherwise	+
emp2	1 if the participant was Unemployed, 0 otherwise	-
emp3	1 if the participant was Retired, 0 otherwise	-
inc1	1 if the participant was annual Household Income was Below $54,999, 0 otherwise	-
inc2	1 if the participant was annual Household Income was Between $55,000 and $79,999, 0 otherwise	-
inc3	1 if the participant was annual Household Income was $80,000 or above, 0 otherwise	+
wpfam1	1 if the participant was familiar with Water Pricing Structure, 0 otherwise	+
wmgmtc1	1 if the participant was confident in managing water consumption, 0 otherwise	-
wmca1	1 if the participant was aware of Water Meter Cost, 0 otherwise	+
wmsource	1 if the participant was not aware of water meter source to purchase/install, 0 otherwise	-
costcompare 1	1 if the participant was Perceived that Paying more for water vs Other Regions, 0 otherwise	+

costcompare 2	1 if the participant was Perceived that Paying less for water vs Other Regions, 0 otherwise	-
costcompare 3	1 if the participant perceived paying about the same for water as other regions, 0 otherwise	-
costcompare 4	1 if the participant was not sure that Paying more or less that Other Regions for water, 0 otherwise	-
awusage	1 if the participant was aware of NL's High Water Usage, 0 otherwise	+
bwmrwc1	1 if the participant was not believed that water meter reducing household, 0 otherwise	-
infwm1	1 if the participant saw government incentives as a factor for water meter installation, 0 otherwise	+
infwm2	1 if the participant saw environmental concerns as a factor, 0 otherwise	+
infwm3	1 if the participant saw cost savings as a factor, 0 otherwise	-
wcedu	1 if the participant was not open to Water Conservation Education, 0 otherwise	-
rhwmi1	1 if the participant saw potential bill increase as a reason to hesitate, 0 otherwise	-
rhwmi2	1 if the participant saw installation cost as a reason to hesitate, 0 otherwise	+
rhwmi3	1 if the participant saw property damage or modifications as a reason to hesitate, 0 otherwise	-

finc	1 if the participant was not willing to contribute financially for water meter, 0 otherwise	-
satisfwp	1 if the participant was satisfied with current water pricing system, 0 otherwise	-
govincent	1 if the participant did not believe in government incentives for water meter installation, 0 otherwise	+
effectivewmc	1 if the participant was believed in effectiveness of WM for W Conservation, 0 otherwise	+

Source: Sample data, 2024

4.5 Data Analysis

4.5.1 Overview of Variables

Table 7 gives a detailed explanation of the variables used in this study. In this table, information such as the frequency, mean, and standard deviation of the variables used in the model is presented.

Table 7: Summary statistics

Variable Name	Frequency	Mean	S.D.
Gender			
gen1 (Female)	52	0.52	0.5021
gen2 (Male)	48	0.48	0.5021
Age			
age1 (Under 30 years old)	20	0.2	0.4020
age2 (Between 30 and 65 years old)	67	0.67	0.4726

age3 (65 years and older)	13	0.13	0.3380
Marital Status			
marit1 (Single)	51	0.51	0.5024
marit2 (Married)	49	0.49	0.5024
Family Size			
fsz1 (1 member)	22	0.22	0.4163
fsz2 (2 members)	35	0.35	0.4794
fsz3 (3 members or more)	43	0.43	0.4976
Education			
edu1 (Completed High School or lower)	44	0.44	0.4989
edu2 (Completed College or University degree)	56	0.56	0.4989
Employment Status			
emp1 (Employed)	82	0.82	0.3861
emp2 (Unemployed)	6	0.06	0.2387
emp3 (Retired)	12	0.12	0.3266
Annual Household Income			
inc1 (Below $54,999)	24	0.24	0.4292
inc2 (Between $55,000 and $79,999)	17	0.17	0.3775
inc3 ($80,000 or above)	59	0.59	0.4943
Familiarity with Water Pricing Structure			
wpfam1 (No)	71	0.71	0.4560
wpfam2 (Yes)	29	0.29	0.4560
Confidence in Managing Water Consumption			

wmgmtc1 (No)	28	0.28	0.4513
wmgmtc2 (Yes)	72	0.72	0.4513
Awareness of Water Meter Cost			
wmca1 (Yes)	8	0.08	0.2727
wmca2 (No)	92	0.92	0.2727
Knowledge of WM Purchase/Installation			
wmsource1 (Yes)	6	0.06	0.2387
wmsource2 (No)	94	0.94	0.2387
Perception of Water Costs Compared to Other Regions			
costcompare1 (Paying more)	11	0.11	0.3145
costcompare2 (Paying less)	27	0.27	0.4462
costcompare3 (About the same)	13	0.13	0.3380
costcompare4 (Not sure)	49	0.49	0.5024
Awareness of NL's High Water Usage			
awusage1 (Yes)	22	0.22	0.4163
awusage2 (No)	78	0.78	0.4163
Belief in WM Reducing Household Consumption			
bwmrwc1 (Yes)	85	0.85	0.3589
bwmrwc2 (No)	15	0.15	0.3589
Influential Factors for WM Installation			
infwm1 (Government incentives (e.g., tax rebate))	46	0.46	0.5009
infwm2 (Environmental concerns)	29	0.29	0.4560
infwm3 (Cost savings)	25	0.25	0.4352

Openness to Water Conservation Education			
wcedu1 (Yes)	48	0.48	0.5021
wcedu2 (No)	52	0.52	0.5021
Reasons for Hesitation on WM Installation			
rhwmi1 (Potential increase in water bills)	59	0.59	0.4943
rhwmi2 (Installation cost)	36	0.36	0.4824
rhwmi3 (Property damage or modifications)	5	0.05	0.2190
Willingness to Contribute Financially to WM			
finc1 (Yes)	57	0.57	0.4976
finc2 (No)	43	0.43	0.4976
Satisfaction with Current Water Pricing System			
satisfwp1 (No)	11	0.11	0.3145
satisfwp2* (Yes)	89	0.89	0.3145
Government Incentives for WM Installation			
govincent1(Yes)	87	0.87	0.3380
govincent2 (no)	13	0.13	0.3380
Effectiveness of WMs for Water Conservation			
effectivewmc1 (disagree)	42	0.42	0.4960
effectivewmc2 (agree)	58	0.58	0.4960
interested in installing WM			
WTA IWM (Interested in installing WM) (Yes)	31	0.31	0.4648
WTA IWM (Not interested in installing WM) (No)	69	0.69	0.4648

Source: Sample data, 2024

4.5.2 Logit Regression Results and Key Findings

4.5.2.1 Control Variables and Model Setup

To estimate the parameters of regression models employing cross-sectional data, it is important to avoid multicollinearity by selecting a reference category for each categorical variable in the survey questionnaire. This reference serves as a baseline which makes the interpretation of coefficients relative to the omitted category. One of the response options is thus removed from each category in order to address this issue. For example, with gender, "female" is taken as the baseline, while "under 30 years old" is used as the reference for age. When looking at marital status, the model is set up to compare responses to "single." In terms of family size, the reference is "one member," and for education, the baseline is "completed high school or lower." This model uses "employed" as the reference for employment categories and sets "below $54,999" as the baseline for income. When considering familiarity with water pricing, those who answered "no" became the reference group." Not confident" is used as the reference point for assessing confidence in managing water use. In terms of awareness about water meter costs, "yes" was the baseline for comparisons, while knowledge of where to buy water meters was measured against "no." When considering perceptions of water costs compared to other areas, the model used "paying more" as the reference. The model takes "yes" as the reference for comparing awareness of high water usage in NL, and the belief that water meters could decrease home water use is assessed against "yes", as a reference category as well. When looking at reasons for water meter installation, "government incentives" is used as the reference. In this setup, "yes" is used as the reference for figuring out how open participants are to learning about saving water. The reasons for hesitating to install a water meter are compared to "potential increase in water bills." For willingness to pay for water meters, "yes" is the point of comparison, while satisfaction with the current water pricing system is benchmarked to "no." For the effectiveness of water meters in conservation, "disagree" is used as the baseline. Table 8 presents the estimation results of the logistic regression model. It is worth mentioning that household surveys are time-specific and data-specific. Therefore, the estimation results should be interpreted cautiously. The collected data reveal that age, family size, education, employment status, awareness of purchasing and installation cost of water meters, awareness of high water consumption rates in the region of the study, satisfaction with water pricing, and the belief in water meters' effectiveness for conservation, are significant at different levels.

Table 8: Estimation Results

Variable Description	Variable Name (Model)	Estimate (p-value)	Change in Probability (p-value)
Gender_2	gen2	0.0208 (0.793)	0.0197 (0.793)
Age_2**	age2**	0.4457 (0.044)	0.4225 (0.023)
Age_3**	age3**	0.9914 (0.034)	0.9397 (0.017)
Marital Status_2	marit2	0.0281 (0.855)	0.0267 (0.856)
Family size_2 ***	fsz2***	-0.4617 (0.008)	-0.4377 (0.001)
Family size_3 **	fsz3**	-0.2770 (0.050)	-0.2626 (0.024)
Education_2***	edu2***	-0.4596 (0.003)	-0.4357 (0.000)
Employment Status_2	emp2	-0.2804 (0.245)	-0.2658 (0.228)
Employment Status_3**	emp3**	-0.3713 (0.072)	-0.3520 (0.046)
Annual Household Income_2	inc2	-0.0728 (0.638)	-0.0691 (0.636)

Annual Household Income_3	inc3	0.0669 (0.630)	0.0635 (0.629)
Familiarity with the W Pricing Structure_2	wpfam2	0.1575 (0.295)	0.1493 (0.280)
Confidence in Managing W Consumption_2	wmgmtc2	0.0935 (0.336)	0.0887 (0.322)
Awareness of WM Cost _2*	wmca2*	0.4122 (0.122)	0.3907 (0.096)
Knowledge of WM Purchase/Install-2	wmsource2	-0.1974 (0.486)	-0.1872 (0.480)
Perception of W Costs vs. Other Regions_2	costcompare2	-0.1756 (0.299)	-0.1665 (0.285)
Perception of W Costs vs. Other Regions_3	costcompare3	0.0542 (0.866)	0.0514 (0.866)
Perception of W Costs vs. Other Regions_4	costcompare4	-0.1053 (0.490)	-0.0999 (0.485)
Awareness of NL's High W Usage_2***	awusage2***	0.4176 (0.013)	0.3959 (0.002)
Belief in WM Reducing W Consumption_2	bwmrwc2	0.3923 (0.186)	0.3719 (0.161)
Influential Factors for WM Install_2	infwm2	-0.0612 (0.526)	-0.0581 (0.520)
Influential Factors for WM Install_3	infwm3	-0.1589 (0.276)	-0.1507 (0.257)
Openness to W Conservation Education_2	wcedu2	-0.1896 (0.132)	-0.1798 (0.107)
Hesitation for WM Install_2	rhwmi2	0.1015 (0.315)	0.0962 (0.300)
Hesitation for WM Install_3	rhwmi3	-0.2893 (0.251)	-0.2743 (0.235)
Willingness to Contribute Financially_2	finc2	0.1917 (0.140)	0.1818 (0.117)
Satisfaction with the W Pricing System_2**	satisfwp2**	-0.6468 (0.055)	-0.6131 (0.032)
Government Incentives for WM Install_2	govincent2	0.669 (0.377)	0.6342 (0.372)
Effect of WM on W Conserv_2*	effectivewmc2*	0.2039 (0.092)	0.1933 (0.068)

Dependent Variable: WTA IWM (Interested in installing water meter)

Number of observations: 100

McFadden R-squared (Pseudo R–squared).: 0.5986

LR Chi-square: 72.272

Log-Likelihood: -24.228

Degree of freedom: 29

Note:*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level;

Source: Sample data, 2024

4.5.2.2 In-Depth Analysis of Significant Variables

This section provides an in-depth analysis of the significant variables identified in the regression model. Comparisons with relevant survey responses for each variable enable the exploration of patterns and relationships within the data. Therefore, these comparisons provide a more comprehensive view of the results by showing how different groups, characterized by significant variables responded to additional survey questions.

4.5.2.2.1 Age and Willingness to Install Water Meters

The hypothesis of this study proposes that individuals from older age groups are more likely to be open to installing a water meter compared to younger respondents. Table 8 shows that those respondents in the 30-65 category of age (Age_2) are 42 percent (p-value 0.023) more likely to agree to the installation of a water meter in their properties rather than those in the under-30 age bracket (Age_1). The coefficient for Age_2 suggests a positive correlation with the likelihood of water meter installation relative to respondents younger than 30. In addition, respondents who are 65 years and older (Age_3) are 94% more likely to install a water meter than those under 30 years old, showing a stronger positive correlation with the likelihood of willingness to install a water meter relative to the reference age group (p-value 0.017). The coefficients demonstrate that willingness to install a water metering system rises with age. Thus, the null hypothesis that age has no significant effect on willingness to install a water meter is rejected.

For this significant variable, a more in-depth analysis is presented to provide further insights. Among the 100 survey participants, 80 individuals are over the age of 30. Of these, 75 percent (60 individuals) expressed no interest in installing a water meter while 25 percent of them are interested. In this age category, of the 72.5 percent (58 participants) of respondents who feel confident in managing their household's water usage, only 16 are willing to install a water meter, while the majority (42) are not. Additionally, 27.5 percent of the respondents over 30 years (22 participants) are not confident in their ability to manage water consumption; out of this age group, only 18.2 percent (4 participants) of the respondents, who feel confident in monitoring their water usage, were interested in installing a meter, while 81.8 percent are not interested at all. Notably, 46.3 percent of this survey respondents aged over 30 express a willingness to engage in educational programs or campaigns about water conservation and efficient water use, whereas 53.7 percent (43 participants) of them are not interested. The results highlight the importance of specific initiatives aimed at older residents, who may show greater willingness to engage in water conservation education and install water meters. Highlighting benefits like cost savings and easier water management could help the municipality address concerns about adoption. As a result, the municipality might benefit from targeting this age group to increase water meter installations.

4.5.2.2.2 Family Size and Willingness to Install Water Meters

According to the research hypothesis, residents from larger households are less inclined to install a water meter than those who live alone. According to the regression analysis, individuals in two-person households (Family_Size_2) are 44% less likely to adopt water meters than those living alone, with a p-value of 0.001. In addition, individuals in households with three or more members (Family_Size_3) exhibit a 26% lower likelihood of installing a water meter compared to those who live by themselves (p-value 0.024). The likelihood of installing a water meter is much lower in houses with three or more people than in single-person households, according to the coefficient for Family Size 3. As a result, the null hypothesis that family size does not significantly affect the desire to install a water meter can be rejected. The data shows that bigger families are much less likely to put in water meters than people who live alone.

This significant variable is examined in more depth to provide additional context for the findings. The findings say that 78% of the people surveyed are homeowners with households of two or more members. Of these 78 percent of the respondents, 37.2 percent show a willingness to install a water meter, while 62.8 percent are not interested at all. Moreover, out of the 78 percent of respondents with larger families, 53.8 percent are willing to participate in water conservation education, while 46.2 percent are not. The further analysis illustrates that within this category (78 persons), 34.6 percent of the respondents express a preference for receiving governmental rebates or subsidies on their water usage fees. Another 26.9 of these households consisting of two or more members show interest in having part of the purchase and installation costs covered, while 24.4 percent of these respondents prefer a property tax reduction for the following year. Finally, 14.1 percent of them are more interested in a direct cash payment as a governmental incentive to accept installing the water meter. The results suggest that providing financial incentives, such as rebates or subsidies, may motivate larger households to install water meters in their homes. In addition, it can get more convenient for larger families to implement water meters is offering financial benefits which could reduce the impact of installation costs.

4.5.2.2.3 Education and Willingness to Install Water Meters

Regarding the education variable in this model, it is expected that people with higher education would show greater interest in installing water meters, leading to a positive coefficient sign. However, the results show that people with a college or university degree (Education_2) are 44% less likely to install a water meter than those without higher education (p-value 0.000). According to the coefficient for this category, adopting water meters is less likely among individuals with a university degree than residents with a high school education or less, which is different than from what we expected. It is normally expected that people with higher education degree care more about the conservation of natural resources, especially water consumption and as a result they are more willing to install water meter in their properties. This estimation results are in contradiction of what we thought. Consequently, the findings of this study should be interpreted cautiously, as noted earlier, given that this research is both time-specific and data-specific.

Additional insights are provided for this significant variable through further in-depth analysis. The statistical results indicate that among the survey participants, approximately 56 percent of the respondents have a college or university education, while 44 percent have a high school education or less. Out of these 56 percent of respondents with college or university degrees, 48.2 percent show their interest in participating in environmental conservation programs, while 51.8 percent are not interested. Additionally, further analysis shows that out of these survey participants with higher education, 57.2 percent are mainly concerned about the potential increase in water bills as a result of installing water meters. Among this category, 33.9 percent are worried about the installation costs, and only 8.9 percent are concerned about potential damage caused by the meter installation. On the other hand, 85.7 percent of participants with higher education levels believe that water meter installation may encourage water conservation and decrease home water consumption, while just 14.3 percent of them disagree, according to the data analysis. In addition, 50 percent of these individuals with higher educational degrees consider government incentives, such as a tax rebate, as the most important factor that has an impact on their decision to accept the installation of water meters. 28.6 percent of them choose environmental concerns and only 21.4 percent select cost savings. The impact of government incentives on residents' decisions to install water meters is clearly significant. Among individuals with a high school education or less, who make up 44 percent of respondents, 47.7 percent are interested in participating in environmental conservation education programs, while 52.3 percent are not interested in participating. In addition, of the respondents with high school degrees and lower, 61.4 percent say the likely increase in their water bills is their main reason for not installing a water meter, while 38.6 percent cite the cost of installation.

4.5.2.2.4 Employment Status and Willingness to Install Water Meters

The hypothesis of this research is that employed people are more willing to install a water meter than those who are unemployed or retired. The regression analysis results partially confirm this hypothesis. The data in Table 8 says retired participants (Employment_3) are 35% less willing to install a water meter than those who are employed, with a p-value of 0.046. This result suggests a statistically significant negative association between retirement and the likelihood of water meter installation.

Additional insights are revealed through a detailed analysis centered on this significant variable. Within this group, 12 percent are retirees, 6 percent are unemployed, and 82 percent are employed. Out of the 12 percent of retired participants, 41.7 percent indicate a preference for water usage fee rebates or subsidies, 25 percent select property tax reductions, another 25 percent prefer partial coverage of installation costs, and just 8.3 percent of respondents chose direct cash. It should be noted that not a single one of the retirees knows how much it would cost to buy and install a water meter in their home. Also, only 8.3 percent of the retirees know where to provide water meters in this city, and 91.7 percent of them have no idea about the location. It is significant to mention that 75 percent of surveyed retirees are aged over 65. Among the employed participants, 35.3 percent consider rebates or subsidies on water usage fees as the most desirable government incentive, while 29.3 percent prefer partially covering the cost of purchase and installation. Additionally, 24.4 percent express interest in reducing their property taxes for the following year, and only 11 percent prefer to receive direct cash payments from the government. Further analysis reveals that, out of the 82 percent of respondents who are employed, 92.7 percent are unaware of the cost associated with purchasing and installing a water meter, and only 7.3 percent are informed. Among the 6 percent unemployed respondents, 66.6 percent choose direct cash payment, 16.7 percent select property tax reduction for the next year, and 16.7 percent choose partially covering the cost of purchase and installation. 66.7 percent of unemployed respondents are unaware of the cost associated with purchasing and installing a water meter, while 33.3 percent are aware.

4.5.2.2.5 Awareness of Purchasing and Installation Costs and Willingness to Install Water Meters

The hypothesis of this study proposes that people who are aware of the cost of providing the water meter and its installation are more likely to accept the installation of a water meter in their unit. As can be seen in Table 8, respondents who have knowledge about purchasing and installing a water meter (Awareness of WM Cost _2) are 39% more likely to be willing to install water meters (p-value 0.096). In addition, the coefficient for this category indicates a positive association with the likelihood of installing a water meter compared to people without such knowledge. Thus, the null hypothesis for this variable, which stating that residents' awareness of buying and installing residential water meters does not influence their decision, can be rejected. Therefore, it is concluded that individuals who are aware of cost of water meters and their installation are more likely to install water meters compared to those without related information.

To provide more information, further analysis is undertaken for this significant variable. 92 percent of respondents in this survey have no knowledge of the associated cost of water meter adoption, while 8 percent indicate that they have this information. Among these respondents with no knowledge of associated costs, 70 percent of individuals are not interested in installing a water meter. However, 30 percent of them are inclined to adopt to this installation. Moreover, 42 percent of these participants, who have no knowledge regarding the associated cost of having a water meter and, at the same time, are not interested even in installing a water meter, are open to participating in educational programs about water conservation and efficient water usage. However, 58 percent have no interest in participating in such programs. In addition, among these 42 percent, 90 percent had no idea where they could provide water meters, and only 4 percent have this information. Moreover, 78% of these respondents, who have no knowledge of water meter cost and were not interested in installing water meters but are inclined to participate in educational programs, are not aware that Newfoundland and Labrador currently has one of the highest average daily residential water consumption rates compared to other provinces in Canada. Also, at this category, 70 percent are not familiar with the current water pricing structure in their city. On the other hand, out of those respondents who have no information regarding water meters and are not interested in installing water meters in their units, 34 percent are more inclined to install a water meter if the government offers financial support like Rebates or subsidies on water usage fees. Also, 31 percent prefer property tax reduction, 22 percent choose partially covering the cost of purchase and installation, and only 13 percent opt direct cash payment as interested government incentives.

4.5.2.2.6 Awareness of High-Water Usage in NL and Willingness to Install Water Meters

The study hypothesizes that people who are aware of the high daily residential water consumption per capita in western Newfoundland are more likely to install a water meter than those who are not. According to the result of this study, those respondents who are aware of the province's high average daily residential water consumption rates (Aware_of_NLs_High_W_Usage_2) are 40 percent more likely to be willing to install a water meter compared to those who are not aware (p-value 0.002). In addition, the significant positive coefficient indicates that greater awareness of elevated water consumption rates is associated with an increased probability of willingness to adopt water meter installation. As a result, the null hypothesis that awareness of high-water consumption has no notable effect on the willingness to install a water meter can be rejected. The results confirm the hypothesis that knowledge of high-water consumption rates increases the likelihood of adopting water meters.

Additional information is presented for this significant variable through extended analysis. This awareness is found to influence the willingness of households to install water meters. According to the data analyzed, out of the 100 survey respondents, 78 percent are not aware of the high-water usage in the province, while the remaining 22 percent are aware of this issue. Of those not aware (78 respondents), only 25.6 percent express a willingness to install a water meter, while 74.4 percent had no interest. On the other hand, among the 22 percent of respondents who are aware of the high water consumption, 50 percent are willing to install a water meter, and the other 50 percent are not. The further analysis shows that 43.5 percent of the 78 percent who do not know about the province's high water use are interested in joining conservation education programs, while the others are not. These results emphasize how water awareness can impact residents' choices about water meter installation and conservation. This analysis highlights the importance of targeted education programs to increase awareness about water use and its effects.

4.5.2.2.7 Satisfaction with Water Pricing and Willingness to Install Water Meters

The hypothesis of this study suggests that, in the city of Corner Brook, residents who are satisfied with the existing pricing system are less likely to install water meters than those who are dissatisfied. Table 8 indicates that respondents satisfied with the pricing system (Satisfaction with W pricing_2) are 61 percent less likely to install a water meter compared to those who are dissatisfied (p-value 0.032).

More insights are provided for this significant variable through extended examination. Among the respondents, 89 percent are satisfied with the water pricing system in Corner Brook, while 11 percent are not satisfied. Of the 89 percent satisfied group, 67.4 percent are not interested to install a water meter in their home, while 32.6 percent of them are in favor of it. Upon closer examination of the data, we find that among this 89 percent group, 24.7 percent prefer partially covering the cost of purchase and installation as a government incentive, 25.8 percent prefer property tax reduction for the next year, 13.5 percent prefer direct cash payment, and a notable 36 percent individuals favor rebates or subsidies on water usage fees. An analysis of residents' awareness of water meter costs and locations revealed that, among the 89 percent who express satisfaction with the current water pricing system, 91.1 percent of respondents are unaware of the purchasing and installation costs, while 8.9 percent are informed. In addition, it is found that 93.3 percent of respondents are not aware of the location to obtain a water meter, while only 6.7 percent had this information.

4.5.2.2.8 Belief in Water Meter Effectiveness and Willingness to Install Water Meters

Table 8 shows that those respondents who are convinced that water meters help conserve water resources (Effectiveness of WM for Conservation_2) are 19 percent more likely to install a water meter than those who do not believe this (p-value 0.068). This hypothesis is clarified by the insights gained from the regression analysis results. In addition, the coefficient for Effectiveness of WM for Conservation_2 (Strongly Agree) reflects a positive relationship with the probability of installing a water meter relative to those who strongly disagree. The findings show that people who are strong advocates of the conservation benefits of water meters are more likely to install one.

More information is offered for this significant variable by expanding the analysis. The results show that whereas 42 percent of people surveyed do not think that water meter installation would aid in water conservation, 58 percent did. Among those 42 percent who do not think that installing water meters helps with water conservation, 35.7 percent express an interest in taking part in campaigns or educational programs that promote effective water use and conservation. However, 64.3 percent have no interest in such programs. In addition, while 58 percent of people believe that water meter installation could help save water, 43.1 percent of those people were not inclined to take part in campaigns or educational programs that promote water conservation and efficient usage, while 56.9 percent support participating in such programs.

Chapter 5

5. Major Findings and Policy Recommendations

5.1 Introduction

In this chapter major findings of this research study are summarized in section 5.2 with the particular focus on understanding the influencing factors on the willingness of households in the City of Corner Brook to install water meters in their own units. The policies that encourage water meter adoption are discussed in section 5.3, which is followed by section 5.4 that includes future research ideas and the study's limitations.

5.2 Major Findings

The City of Corner Brook, located in western Newfoundland and Labrador, faces significant challenges with water management, mainly because of the unstructured water pricing system in this area. In other words, residents are charged an annual water and sewage tax fee determined by their property category, not by the amount of water they consume. Fairness is an issue with this setup, since households consuming more water are not paying higher rates, while lower-usage households are still taxed equally. The way the current system is set up complicates water management for the municipality and creates obstacles for conservation. Even with these difficulties, no studies have focused on residents' willingness to install water meters in this region. This research, therefore, aims to fill that gap. A thorough understanding of residents' water consumption habits is vital, and a fair, usage-based billing system could assist the city in managing costs while encouraging more responsible water use and conservation. The research aimed to examine the factors that could influence homeowners' willingness to install water meters, focusing on fairness and encouraging more responsible water consumption. This study analyzed data from a telephone survey of 100 households, using a binary logit regression model to examine demographics, household attitudes, and factors related to water conservation.

The results show that certain factors make people more likely to consider installing a water meter. For example, older age, the knowledge of water meter installation cost, public awareness on water-use per capita at the provincial level and believing that the installation of water meters help with saving water all had a positive impact. Despite this, other factors seem to reduce the willingness of the Corner Brook residents to go forward with this adoption. Larger families, higher education levels, being retired, and satisfaction with the current pricing system are linked to lower interest in installing meters. It seems like bigger families might see meters as an extra expense, while people with higher education levels might even think that dealing with water conservation is a job for the government, not something they should have to take on themselves. The study concludes that while certain factors encourage water meter installation, barriers still exist that need to be addressed. The insights from this study could assist policymakers in expanding water meter coverage across the city, which would, in turn, encourage smarter residential water use and address specific water challenges in the region.

5.3 Policy Recommendations

Based on this study's results, policy recommendations have been created to aid policymakers and relevant decision-makers. These suggestions are intended to support the adoption of water meters in Corner Brook. The results of this study show the key factors that affect residents' choices, giving a good base for creating strategies to increase water meter use across the region of the study. The results of this study show the key factors that affect residents' choices, giving a good base for creating strategies to increase water meter use across the region of the study. The proposed recommendations are intended to address important barriers and promote adoption in an effective way. The proposed recommendations are:

(*i*) Targeted Outreach for Older Residents

This study reveals that, compared to younger age groups, people aged 65 and older are much more likely to adopt water meters. It is suggested that policymakers or the municipality work closely with older residents, especially those 65 and older, to promote the benefits of water meters, like simplified water monitoring and potential cost reductions. Therefore, this adoption rates between the people at this age category might be raised with customized content that could be relates to their concerns and values.

(*ii*) Support and Incentives for Larger Households

This study shows that people in large families are less interested in installing water meters than those who live alone. To address this, the government could offer subsidies or incentives to bigger families or discounts on water meter installations. Another strategy to overcome opposition to water meters is to educate people on how they can assist larger households monitor their water use and save money.

(*iii*) Educational Campaigns Highlighting Water Usage Awareness

The survey results show that awareness of the residents of western Newfoundland on high average daily residential water consumption rates is positively associated with the willingness to install water meters. It is recommended that the municipality launch campaigns to educate residents on water use in the region and the environmental harm caused by overuse. Increasing public awareness can assist policymakers inspire more responsibility in residents, resulting in more people getting water meters.

(*iv*) Addressing Concerns Among Highly Educated Residents

The findings show that knowing about Newfoundland and Labrador's high water consumption rates is connected to a higher likelihood of installing water meters. Therefore, this study recommends that the municipality launch campaigns to raise public awareness on water use in the region and the environmental harm caused by overuse.

(*v*) Incentives for Residents without employment

The findings from this study indicate that employed people are generally more willing to install water meters in their homes compared to those who are not working. Financial help, which includes subsidies, could be introduced by the municipality to make installation more affordable for people without employment at this time, whether they are retired or unemployed. At the same time, it would be a good idea to create programs that explain how water meters can lead to lower water bills over time. This kind of information could be more appealing to people who are in this category and might help them decide to adopt this system.

(vi) Educational Programs to Raise Awareness of Water Meter Costs

Awareness about the costs of buying and installing water meters is a significant factor in whether the respondents decide to install them or not. The study, which shows that 92 percent of respondents did not know about these costs, points to a real barrier. Policymakers could address this with educational programs that include clear, useful information on where to buy a water meter, the cost, and how to arrange installation. It would be useful to highlight that this province is among the highest in Canada for average water consumption, which makes managing water use a top priority. Increasing this kind of awareness would really help residents feel more comfortable with the idea of installing water meters, especially if they see the long-term benefits in both savings and water conservation.

(vii) Revising the Current Water Pricing Structure

The findings show that satisfied residents with the current water pricing system in this city are less likely to install water meters. Small pricing adjustments by the city could support conservation efforts. For example, charging extra for high water use might encourage residents to install meters and manage their water usage better. Additionally, sharing clear and simple information about how meters can save money and how much they cost could close the gap in awareness. Therefore, the municipality could provide some financial incentives as an encouragement offer, like decreased water bills or aid with installation expenses to get residents more interested in cooperating with such water conservation programs.

(viii) Encouraging Water Conservation by Using Meters

The study results indicate a positive connection between residents' belief in the conservation benefits of water meter installation and their likelihood of choosing to install one. By emphasizing these benefits, municipalities or policymakers could foster adoption, especially among environmentally conscious individuals.

In general, these policy recommendations outline strategies that the municipality or policymakers can use to encourage more Corner Brook residents to install water meters. By focusing on the factors that affect residents' willingness to adopt water meters, the decision makers would be able to initiate some related programs that not only promote water conservation but also ensure a smooth and successful whole coverage of the City of Corner Brook with water meters.

5.4 Limitations of the research and areas for future study

5.4.1 Limitations of the Research

This study is extensive; there are, however, several limitations that must be pointed out. One of the major limitations of this study pertains to how the data were collected. As it has been mentioned, the primary data were collected via telephone surveys. These surveys, that are cost-effective and broad in scope, may still result in biased outcomes. As an illustration, those more inclined to participate in this survey might hold different views on the installation of water meters than non-participants. In addition, social desirability bias can influence participants' responses, leading them to provide answers that seem more socially acceptable rather than reflecting their genuine opinions, which may affect the reliability of findings in environmental conservation research (Vesely & Klöckner, 2020).

The geographic scope of this study was the City of Corner Brook, located in western Newfoundland, which limits the generalizability of the findings to other areas within the province. The unique island setting and local perceptions of water abundance in this city might shape residents' attitudes towards water meter installation differently from other provinces in the country. These findings need careful consideration when applied to regions with different geographical features, but they still provide valuable insights for local policymakers. Conducting a comparative analysis in mainland areas might help uncover more about what affects acceptance of water meter installations.

5.4.2 Areas for Future Research

The results of this study provide a strong base, and more research could help find new areas to study and better ways to conserve water. Additional studies could focus on evaluating the feasibility of adopting Advanced Metering Infrastructure (AMI), which directly transmits data regarding water usage to the utility at predetermined intervals, in the City of Corner Brook. A thorough cost-benefit analysis comparing Automated Meter Reading (AMR) and AMI should be part of this research. Furthermore, the research must examine the necessary infrastructure and the cost implications of using sophisticated metering technology. A comparative analysis between regions using AMI and those AMR can identify best practices and areas for improvement. Understanding how water management practices vary regionally will help in developing solutions that are customized for the city. Economic research could look into the long-term financial benefits of advanced metering technologies. Future research could also assess user satisfaction with smart meters in regions where they are currently used. The impact of features like real-time data access and leak detection on user behavior and the adoption of smart meters needs to be studied. Given the limited research on willingness to adopt water meters, future studies should also explore other factors influencing residents' decisions or undertake more exploratory research to better understand this issue. As a result, advancing water conservation and resource management requires persistent related research to develop effective strategies.

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