

Article

Measuring up: Assessing the Progress in Water Demand Management in British Columbia, Canada

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Abstract

Amid growing water stress in British Columbia caused by climate change, population growth, and rising demand, local governments in Canada are adopting water demand management and conservation policies as part of broader climate adaptation efforts to promote sustainable water use and optimize efficiency. Our objective was to understand the actions local governments are taking to address climate-related impacts on the water sector. Thus, the study assesses the implementation status and progress of water demand management in British Columbia by surveying water managers from 94 local jurisdictions across the province. Our analysis focuses on four key dimensions: prioritization, planning, investment, and implementation of water demand management policies. Results reveal that 84% of surveyed jurisdictions have water efficiency/conservation plans, and 55% of household water connections are metered. Commonly implemented measures include mandatory water restrictions, volumetric pricing, leak detection, and public education campaigns, with regional policies proving more prevalent than municipal-level initiatives. Despite notable progress, implementation remains uneven, with gaps in resource allocation and many household connections still without water meters. Tracking the progress of implementing best practices in water conservation is an essential part of local climate adaptation.

Keywords: British Columbia; climate adaptation; conservation; water demand management

1. Introduction

As part of climate adaptation efforts, Canadian local governments are adopting water demand management practices to conserve and optimize water usage [1,2]. Water demand management (WDM) refers to a suite of approaches intended to ensure efficient/productive use, to reduce wasteful use/losses, to ensure fair distribution and billing, and to recover water costs [1]. It involves a mix of measures and strategies, including efficient water dispensers, price reforms, regulations, and public education to promote conservation and reduce usage [1,3]. Across the Province of British Columbia (BC), local jurisdictions are adopting various measures and policies, including water-use restrictions/rationing, water-saving campaigns, metering and volumetric pricing, efficient technologies, system retrofitting, financial (dis)incentives, and rainwater harvesting [4]. These actions are partly based on the Living Water Smart Plan of 2008. The plan sets targets of 33% water-use efficiency and 50% of new municipal water needs to be met through conservation by 2020,



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supported by measures such as metering, pricing reforms, and agricultural efficiency [5]. While the plan influenced major policy developments, including the Water Sustainability Act, this target was not fully achieved. However, it motivated individual municipalities to implement conservation measures, including educational campaigns, water metering, and changes to plumbing codes to reduce water use. For instance, the city of Kamloops reports a 50% decline in peak demand over two decades [6]. Although the province does not have a comprehensive target, jurisdictions such as the City of Vancouver are aiming for a 15% per capita reduction by 2030 [7]. The province motivates and encourages local governments to take action towards these targets, providing a seven-step water conservation planning process to guide communities in developing or revising their plans (*ibid*). Given this guidance, about 40% of local governments had developed and implemented water efficiency and conservation plans by 2013 [4]. These policies and programs can help ensure productive and efficient water use, fair distribution and billing, and reduce wasteful use and system losses. Drought and water scarcity management plans are other measures local governments adopt to help conserve water in the province [5,8]. Given these policies and plans, it is evident that most (if not all) local jurisdictions in BC are aware of the threats of drought and may be taking various measures to reduce demand and conserve water resources.

Meanwhile, there is no comprehensive synthesis or academic research on the status and progress of WDM implementation in the province. Apart from the 2016 BC Municipal Survey, which assessed the implementation of residential metering [9], no known study has reported on the status of implementation for the other WDM measures. There is broad interest in understanding how local governments respond to climate change [10] and water scarcity [11,12]. The case of BC is particularly interesting because the region is often considered relatively water-rich. Thus, the objective of the study was to understand the extent to which local governments are responding to climate-related water scarcity challenges. In the context of climate change adaptation, this manuscript examines the status and progress made by local governments in implementing WDM policies from the perspective of water managers in BC, Canada. Providing up-to-date provincial information on the implementation of WDM measures. In doing so, we tracked how jurisdictions prioritize, invest, and implement WDM. Such findings can reveal gaps or identify patterns in how jurisdictions anticipate and aim to respond to droughts and future water scarcity. Overall, jurisdictions are taking deliberate steps to prepare for potential water insecurity incidents and to mitigate climate impacts. We conceive “progress” similarly to how past studies conceptualize and use the term, referring to the planning and implementation of WDM policies, as well as the consumption-reduction potential of various WDM policies (e.g., see [2,13]. In assessing the consumption-reduction potential of WDM policies in four European cities: Berlin, Copenhagen, Tallinn and Zaragoza, Stavenhagen et al. [2] found that the most effective policies were water systems maintenance, regulations, individual meters, and education campaigns. Learning from these studies, we used indicators such as how jurisdictions prioritize, plan for, invest in, and implement various policies, as reported by water managers themselves. As a result, we examined (a) how jurisdictions prioritize WDM and conservation, (b) what measures are being adopted, (c) the association between prioritizing WDM and developing/implementing water-use efficiency plans, and (d) the level of investment in various measures in terms of personnel and financial resources.

The manuscript is structured as follows: Section 2 provides an overview of WDM policies in BC and the factors pushing jurisdictions to manage demand. Section 3 describes the methodology, including the research questions, data collection, and participant recruitment. In this section, we have also illustrated the descriptive and inferential analyses of the survey data. In the results, Section 4, we describe the patterns and characteristics of

the data, followed by analytic tables and charts showing how jurisdictions prioritize, plan, and adopt various WDM policies. We also present analyses of the association between water efficiency planning and the implementation of WDM policies. We then discuss the implications of these results in relation to existing literature and policy practice in Section 6. We summarize key insights of the manuscript and offer recommendations for water managers to enhance policy practice.

2. Water Demand Management in British Columbia

Water management in Canada is fragmented across the provinces, resulting in varying levels of responsibilities and challenges. Water management generally is a provincial responsibility, but local jurisdictions such as regional districts, municipalities, cities, and towns manage water treatment and other aspects within their service areas (This is, however, not the case in First Nation communities; see [14,15]). For instance, the provincial *Water Sustainability Act* (adopted in 2016) provides guidelines and regulations on water rights licensing, collaborative watershed governance, groundwater protection and water quality standards and monitoring, while regional (water) districts build infrastructure and sell treated water to other lower-level jurisdictions in most cases [16]. Local jurisdictions manage water supply within their service areas, including redistributing water to end users and setting water rates. Their mandate also includes implementing WDM policies and compliance with provincial or federal governments' water regulations and laws. WDM policies are measures at the demand side of the supply-demand equation aimed at changing water-use behaviour and modifying infrastructure to reduce losses or ensure efficient and productive water use [17].

First Nation communities were not included in this research, even though Indigenous residents may certainly be among the populations served by these jurisdictions. Given the distinct realities in First Nation communities, related to differences in land ownership, governance arrangements, legal systems, and jurisdictional authority under Canadian law compared with settler jurisdictions, applying conventional research and analytical frameworks could result in misleading interpretations and conclusions. While we acknowledge the importance of incorporating First Nations perspectives on water demand management and conservation in the province, a dedicated research project could be required to fully address these complexities and water governance issues. For example, we know that First Nations still do not have full and legal access to water rights, adequate drinking water, and full governance authority within their jurisdictions [14].

Nonetheless, we ought to highlight how First Nations interact, especially with BC's *Water Sustainability Act* (the Act) and other jurisdictional policies and plans. The Act has introduced several new measures, including protections for stream health, groundwater regulation, drought management, and enhanced water co-governance to advance sustainable water management in the province. In relation to Treaty First Nations and People on Reserves, the Act has made considerable provisions for First Nations' use of water, including the right to establish water reservations, fee and rental exemptions for water use on Reserves and Treaty lands, and the incorporation of traditional ecological knowledge into Water Sustainability Plans. While these steps aim to improve the relationship between the Crown and Indigenous peoples regarding water governance and protection, we cannot say with certainty the level at which these provisions are being enforced.

Additionally, the water issues in First Nations communities are multifaceted, arising from a combination of aging and inadequate infrastructure, chronic funding and capacity constraints, source-water contamination, shortages of certified water operators, and the limited recognition of Indigenous water rights and decision-making authority within existing governance frameworks. Kehinde et al. [15] argue that legislative reforms and

infrastructure investments, while necessary, are insufficient on their own to address the persistent inequities in access to safe drinking water. Instead, achieving sustainable and equitable water security requires long-term operational funding, enhanced source-water protection, capacity-building initiatives, and the meaningful integration of Indigenous laws, knowledge systems, and principles of self-determination into water governance and management frameworks [15].

Many local jurisdictions across BC are adopting WDM policies to mitigate multiple challenges. First, the province experiences increasingly frequent and intense climate-related water challenges, including summertime droughts and low spring rainfall and snowfall, which contribute to reductions in freshwater resources and overall water scarcity [18]. For example, as of 18 August 2023, about 19 of the 34 water basins were experiencing *Drought Level 5*, which meant that adverse impacts to socio-economic and ecosystem values were *almost certain*. The province has categorized drought levels into five (5), each level with its anticipated impact on socio-economic and ecosystem values and the prescribed actions, including a total ban on outdoor water use. Drought level 1 is the lowest and 5 is the highest. The water basins experiencing *Drought Level 5* during this time included Finlay, Fort Nelson, North Thompson, Parsnip, and South Peace. Second, erratic weather events such as floods, wildfires, and storms are increasingly polluting water sources, complicating treatment processes and increasing the cost of water provision in most jurisdictions. The province is also experiencing abnormally high temperatures during the summer months (up to 46.6 °C in 2021), leading to unprecedented heat waves and increased water demand for cleaning and cooling [18,19].

Third, the province has one of the highest water consumption rates in the country, as measured by per person per day of population served. About 274 litres of water is the average daily residential use per capita of the population served in the province [20]. This figure is higher than the country's average daily residential per capita use for the population served (215 L) [20]. It is also the third-highest among provinces in the country. According to a report by Metro Vancouver [4], high temperatures and heat waves have doubled the daily water demand/use during summertime within its service area. Fourth, population and economic growth in some cities are rising, and given average affluence and lifestyles, this is also driving up water consumption [1]. These pressures can negatively affect the capacity of some jurisdictions to sustainably manage water resources to meet current and future demand.

In response, the province and its local jurisdictions are designing and implementing WDM and conservation measures to mitigate the effects of drought. Following severe summer droughts in 2003, among others, the government outlined various mitigation measures for jurisdictions by developing the *British Columbia Drought and Water Scarcity Response Plan* in 2010, which has since been updated regularly to keep pace with emerging drought-related issues [7,8,21]. For example, while the 2021 edition revised the definitions and criteria for drought levels to align with federal and North American drought-monitoring frameworks, the 2025 edition introduced a new approach to monitoring drought conditions and impacts. Particularly for drought mitigation and preparedness, this plan outlines guidelines for water conservation planning, including descriptions and classifications of drought levels, as well as recommended actions and measures to adopt. For example, at *Drought Level 4*, many jurisdictions, including the Sunshine Coast Regional District, ban outdoor water use—lawn watering, car washing, washing driveways and sidewalks, and filling swimming pools [22]. The penalties for violating these restrictions range from CAD\$200 to CAD\$500 for drought levels 1 to 4. After the 2015 drought, in which the Sunshine Coast came within 30 days of running out of water, over 50 water managers met at the University of British Columbia to discuss lessons learned. At that workshop,

participants agreed that more attention was needed to collect better water use data to build drought preparedness [23].

Jurisdictions across the province implement various WDM policies, such as residential water metering, leak detection, incentives for the use of efficient water devices/appliances, and conservation campaigns to promote water conservation and optimize usage. For example, approximately half of the local jurisdictions within the Metro Vancouver Water District, including Richmond, Surrey, Langley, Burnaby, and New Westminster, have metered all single-family homes and charge rates according to actual consumption [4]. The Sunshine Coast Regional District offered up to \$1000 per property owner to install a minimum of 9000 litres of new rainwater storage in January 2023 under the Rainwater Harvesting Rebate Program. The district has also installed residential meters in the Pender Harbour, Halfmoon Bay, Egmont, Earls Cove, Roberts Creek, Elphinstone, and West Howe Sound areas since 2014 to measure and bill water according to actual consumption, effective in 2018 [21].

Despite these examples, there is little to no comprehensive, province-wide information/data on the progress of implementing WDM measures across the province. Of course, the levels of implementation of WDM measures are unlikely to be uniform across all types of jurisdictions. This information is either absent, incoherent, or scattered across different sources (e.g., peer-reviewed papers, websites, reports), making it difficult to track and understand the overall progress the province has achieved so far. For example, individual localities have isolated studies and reports on the implementation status of WDM measures within their service areas (see, for example, [4,22]). In the academic literature, Brandes and Ferguson [1] have provided a comprehensive report outlining the overarching reasons, benefits, and recommended strategies for implementing WDM policies effectively. Lepsoe [24] investigated the drivers and patterns of water consumption, as well as conservation efforts, in two BC Mountain resort communities—Rossland and Invermere. The author found that climate impacts on water resources, hot weather, and seasonal demand increases due to tourists in these areas [24]. The study recommends scaling up WDM and conservation measures as the most effective way to accommodate a community growth of 2500–5000 people without increasing the drinking water supply (ibid). An historical review of Vancouver's drinking water supply describes how the metropolitan region has grown to have an admirable water system but falls short on water efficiency, with the average resident in Vancouver consuming 20% more water than residents in Seattle, despite sharing a similar climate.

More recent research by a University of British Columbia graduate student examined the political climate for implementing residential water metering in selected jurisdictions [25]. The authors found high interest and support for residential water metering among elected officials within the Metro Vancouver area. The BC Municipal Water Survey 2016 also found that 26% of all residential connections across the province have individual water meters to measure and charge volumetric rates [9]. Our study builds on these pieces of information and insights to examine the status and implementation progress of WDM measures in BC.

3. Materials and Methods

3.1. Data Collection

We surveyed 94 (out of 162) local jurisdictions (municipalities, cities, towns/communities, and villages) in BC via the Qualtrics online platform to assess the status of WDM implementation and conservation practices in the province. This represents 58% of local governments and 68% of the provincial population when computed using Statistics Canada 2020 population estimates. We were unable to include all 162 jurisdictions in the survey for several reasons. Ju-

risdictions were included only if they maintained an independent water management system; those reliant on neighbouring systems were excluded. Some jurisdictions were difficult to reach, as multiple email attempts were undelivered, indicating the absence of active online contact systems. We adopt the working definitions of municipalities, cities, and towns as self-governing local authorities established under the Local Government Act. These jurisdictions are classified by population size and land area; however, all possess comparable powers and responsibilities for the provision of local services and governance.

The survey comprised 18 questions on how jurisdictions prioritize WDM and water conservation issues, plan for water efficiency/conservation, and how they invest in and implement various WDM policies. For the implementation variable, we presented a sample list of eight (8) WDM measures (see Figure 1) to participants to select those being implemented in their jurisdiction up to the year 2020. This grouping was based on past studies (see [2,24]) and for convenience. Regional districts were not included in the survey since they supervise the activities of lower-level jurisdictions. The target participants were water managers, including mayors, chief administrative officers, and public works officers (e.g., engineers, directors of operations, utility supervisors/managers). For ease, we refer to these diverse respondents collectively as *water managers*, even though their roles vary. While mayors and council members are political figureheads, chief administrative officers supervise the day-to-day administration of their jurisdictions, and public works officers directly operate and maintain the water systems [26]. Despite their varied roles, each of these officers is involved at some stage of the WDM and conservation process, including decision-making, planning, consultation, funding allocation, engineering, and implementation. As a result, all were deemed to be knowledgeable about WDM and conservation policies and thus were deemed appropriate to respond to the survey. The questions were framed to seek participants' water management-related views and experiences, and not their personal opinions. The use of "key informants" or "proxies" to collect data for groups or institutions is not new in social sciences (see, e.g., [27]). Since responses were aggregated across three distinct roles and jurisdictions with varying capacities and authorities, this could affect the variability and comparability of our findings.

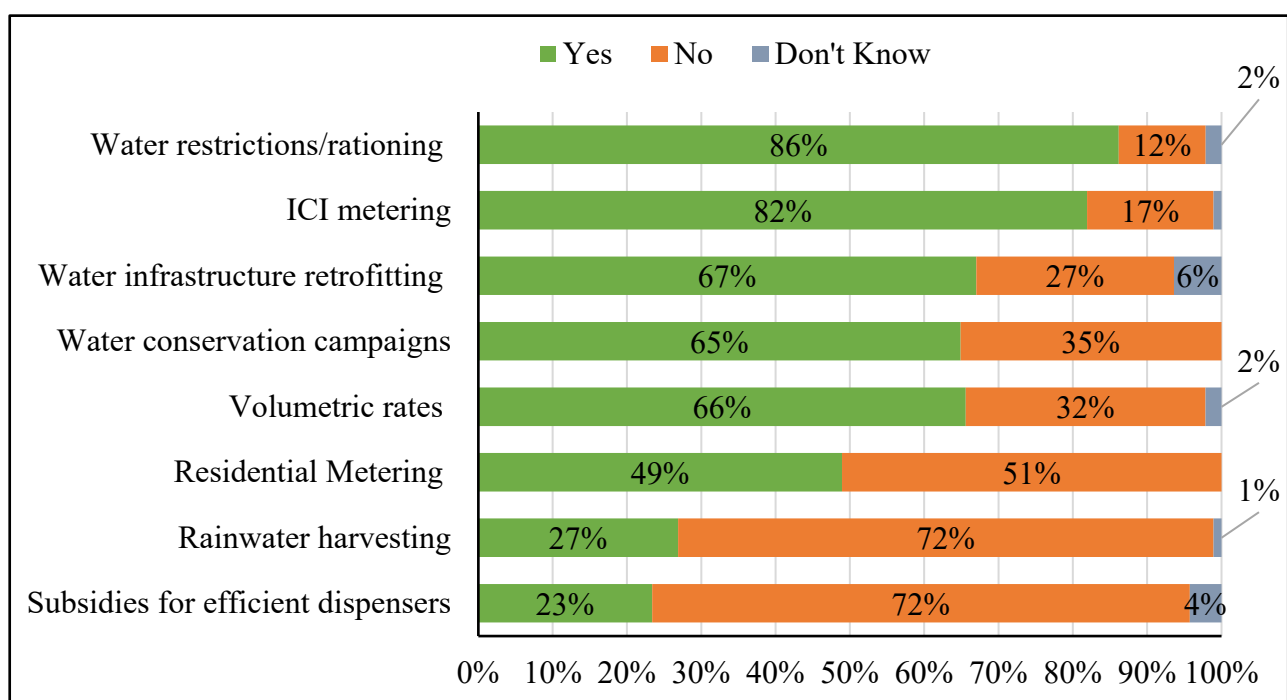


Figure 1. The proportions of jurisdictions implementing WDM policies in the Province of BC.

3.2. Data Analysis

We used the IBM Statistical Package for the Social Sciences (SPSS) Version 29 to organize and analyze the survey data, since SPSS is frequently used to assess WDM [28,29]. Our analyses centred around four survey variables: how jurisdictions (i) *prioritize WDM*, (ii) *plan for water efficiency*, (iii) *invest in*, and (iv) *implement WDM and conservation policies*. We conducted inferential analyses, including crosstabulations, Chi-squares, and the Fisher test, to examine the relationships and significance among these survey variables. In doing so, we first developed a single index for all eight (8) WDM policies together to cross-tabulate with the other variables (e.g., *jurisdiction type*, *prioritize*, *plan*, and *invest*). This analysis shows, on average, the number of policies implemented by each jurisdiction, particularly those with WDM/conservation plans. Specifically, we tested for the significance of the relationship between (a) *having a conservation plan and implementing it among various jurisdictions*, (b) *prioritizing WDM/conservation and developing a plan for it*, and (c) *prioritizing WDM/conservation and investing in it*. We also tested for the relationship among all variables taken together as an illustration/evaluation of the implementation progress of WDM policies.

We also analyzed and compared variables within each jurisdiction type. For example, we calculated the proportion of *municipalities* in the province with efficiency/conservation plans. We were unable to compare WDM implementation progress across jurisdictions due to unequal participant counts by jurisdiction type. For example, more than 50% of participants are from municipalities, and only 26% are from cities. However, to assess progress in WDM/conservation, we primarily compared our results with past province-wide surveys, including the BC Municipal Water Survey 2016 [9]. These figures for all sampled jurisdictions were computed using Statistics Canada 2020 population estimates. We occasionally used jurisdictional data, where available, to provide more context and, in some cases, more detailed examples. For example, we use water-efficiency and conservation plans from the Sunshine Coast Regional District to illustrate how local governments are planning for water conservation.

4. Results

Our results are based on jurisdictions that responded to the survey, and not all BC jurisdictions. Results reveal that 84% of surveyed jurisdictions have water efficiency/conservation plans, and 55% of household water connections are metered. Furthermore, we find that (1) 88% of surveyed jurisdictions are prioritizing water supply and WDM issues, (2) most of the surveyed jurisdictions are implementing multiple policies, (3) those that develop *WDM/conservation plans* are more likely to implement them, and (4) there is considerable progress in adopting WDM/conservation policies across the province. Further details and interpretation of these results are provided in the following sections.

4.1. Patterns and Characteristics of the Data

We recorded a 58% response rate to the survey. Thus, we received responses from 94 local governments, representing 58% of local jurisdictions in the province and 68% of the provincial population (using the 2021 population estimates). Fifty-four percent ($n = 51$) of survey respondents were from municipalities, 28% ($n = 26$) were from cities, and 18% ($n = 17$) were from communities/towns. The higher proportion of respondents from municipalities in the survey will likely have some implications for the analysis, especially when comparing survey variables across jurisdictions. Of the 80 survey respondents who provided their job titles, 17 were mayors, 32 were chief administrative officers, and 31 were in the public works department. The average years of on-the-job experience was 7 years. It is reasonable to say that participants had sufficient experience and information on water management to provide well-informed survey responses.

4.2. Prioritizing and Planning for WDM

Most surveyed jurisdictions prioritized drinking water (88%) and WDM issues (81%) when developing official community plans. We conducted inferential analyses to assess whether there is a relationship between prioritizing WDM issues and the actual development or implementation of a water-efficiency/conservation plan. The SPSS chi-square analyses used the number of valid cases for each variable (Prioritizing WDM, Conservation plans, and jurisdiction type) in the crosstabulation, since each was a separate question. Therefore, cases with missing data on either variable included in the chi-square test were excluded, which explains the mismatch between the total number of valid cases reported earlier for jurisdiction type and those shown in Table 1. The statistical results show a significant association between *prioritizing WDM/conservation issues* and *developing an efficiency/conservation plan* only in Cities. Thus, for *cities*, the Likelihood Ratio is slightly high ($p = 0.075$), but the Pearson Chi-Square and the Linear-by-Linear Association tests show a significant relationship between the two variables. However, the analysis shows no association between the variables in Communities and Municipalities, suggesting the two variables are independent (Table 1). We also found that 79 surveyed local governments had developed water-efficiency/conservation plans, and 89% of those with plans are implementing them.

Table 1. Relationship between prioritizing WDM and conservation plan by jurisdiction type.

Jurisdiction Type		Value	df	Asymptotic Significance (2-Sided)
Community	Pearson Chi-Square	10.578 ^b	4	0.032
	Likelihood Ratio	8.496	4	0.075
	Linear-by-Linear Association	4.363	1	0.037
	N of Valid Cases	17		
	Missing proportion (%)	0.0		
City	Pearson Chi-Square	0.451 ^c	3	0.930
	Likelihood Ratio	0.581	3	0.901
	Linear-by-Linear Association	0.143	1	0.705
	N of Valid Cases	25		
	Missing proportion (%)	3.8		
Municipality	Pearson Chi-Square	7.836 ^d	4	0.098
	Likelihood Ratio	6.567	4	0.161
	Linear-by-Linear Association	0.108	1	0.742
	N of Valid Cases	49		
	Missing proportion (%)	3.9		
Total	Pearson Chi-Square	7.215 ^a	4	0.125
	Likelihood Ratio	7.451	4	0.114
	Linear-by-Linear Association	1.035	1	0.309
	N of Valid Cases	91		
	Missing proportion (%)	3.2		

Superscripts a, b, c, and d denote SPSS-generated Pearson chi-square test notes for the total sample and the jurisdiction-specific analyses for community, city, and municipality, respectively. The chi-square values were calculated separately using the valid cases available in each crosstabulation.

4.3. Investing and Implementing Demand Management Measures

Our survey shows that the dominant WDM measures being implemented among surveyed jurisdictions are mandatory water restrictions (86%), institutional, commercial,

and industrial (ICI) metering (82%), educational campaigns (65%), and system maintenance (67%). Approximately half of the surveyed jurisdictions sampled (49%) are metering residential water supply (all or partial connections). On the other hand, fewer jurisdictions are practicing rainwater harvesting and offering subsidies for efficient water technologies. Figure 1 shows the full list, indicating the proportions of responding jurisdictions that implement each WDM measure.

We also asked water managers to rate the level of resource investment in terms of finances and personnel commitment their jurisdictions have made in implementing the various WDM measures. Eight (8) measures were listed, and participants were asked to rate each policy on a scale of 1–5, with 1 being the least investment and 5 being the most investment. Residential water metering is the WDM measure in which surveyed jurisdictions spend the most resources, followed by infrastructure retrofits and commercial metering. In contrast to these items, rainwater harvesting and subsidized water dispensers are reported to have received less investment (See Figure 2).

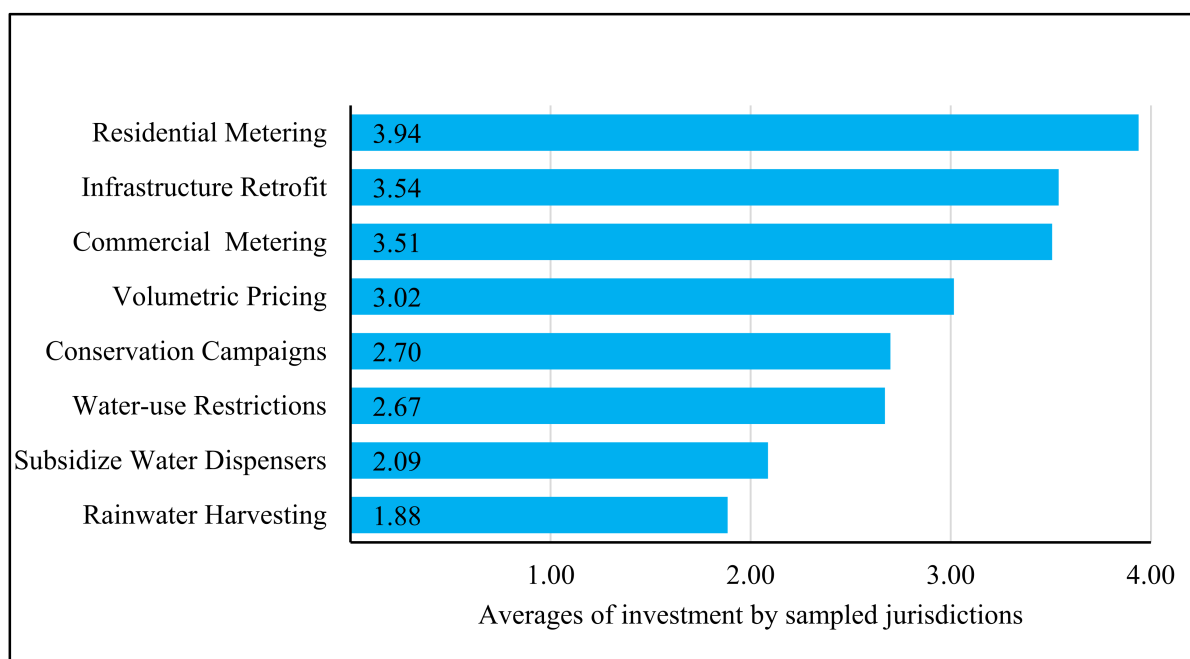


Figure 2. Resource investment (funds and personnel) in WDM by surveyed jurisdictions.

The range of WDM measures adopted by various jurisdictions is relatively even across all types of jurisdictions. However, unsurprisingly, *cities* and *municipalities* tend to adopt more measures than *communities/towns*. While multiple reasons could account for these disparities, several possibilities include resource constraints, study biases against communities/towns, and the possibility that some communities/towns are nested within regional water management. Figure 3 details the average number of policies adopted by various jurisdiction types.

We computed the relationship between developing a water-efficiency/conservation plan and adopting various policies. The crosstabulation analysis shows that *having an efficiency/conservation plan* is associated with implementing various WDM policies. For instance, we found that, on average, between 64% and 86% of surveyed jurisdictions with plans were implementing five (5) WDM measures (Figure 4). The scatterplot (Figure 4) shows a positive relationship between the two variables. The position and thickness of the coloured diamonds indicate the number of WDM policies (on the y-axis) adopted by jurisdictions. This result suggests that most surveyed jurisdictions are adopting WDM policies aligned with their efficiency/conservation plans.

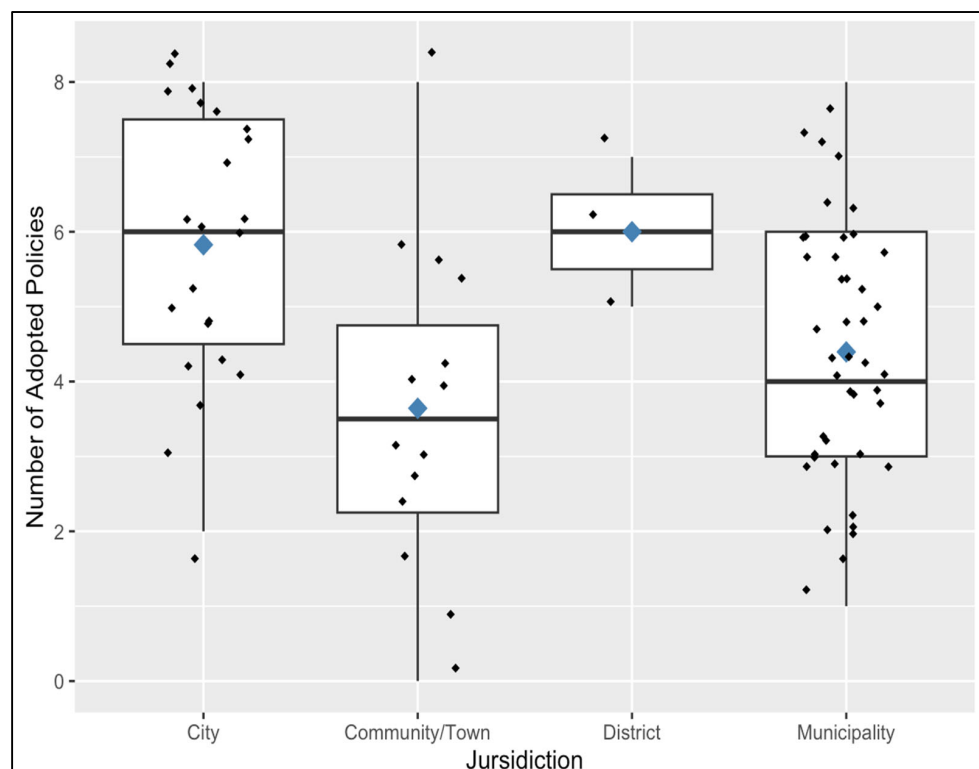


Figure 3. No. of water conservation policies adopted in cities, municipalities, and communities/towns in British Columbia. The boxplots show the distribution of adopted WDM measures; black points represent individual jurisdictions, the horizontal line indicates the median, and the blue diamond represents the mean for each jurisdiction type.

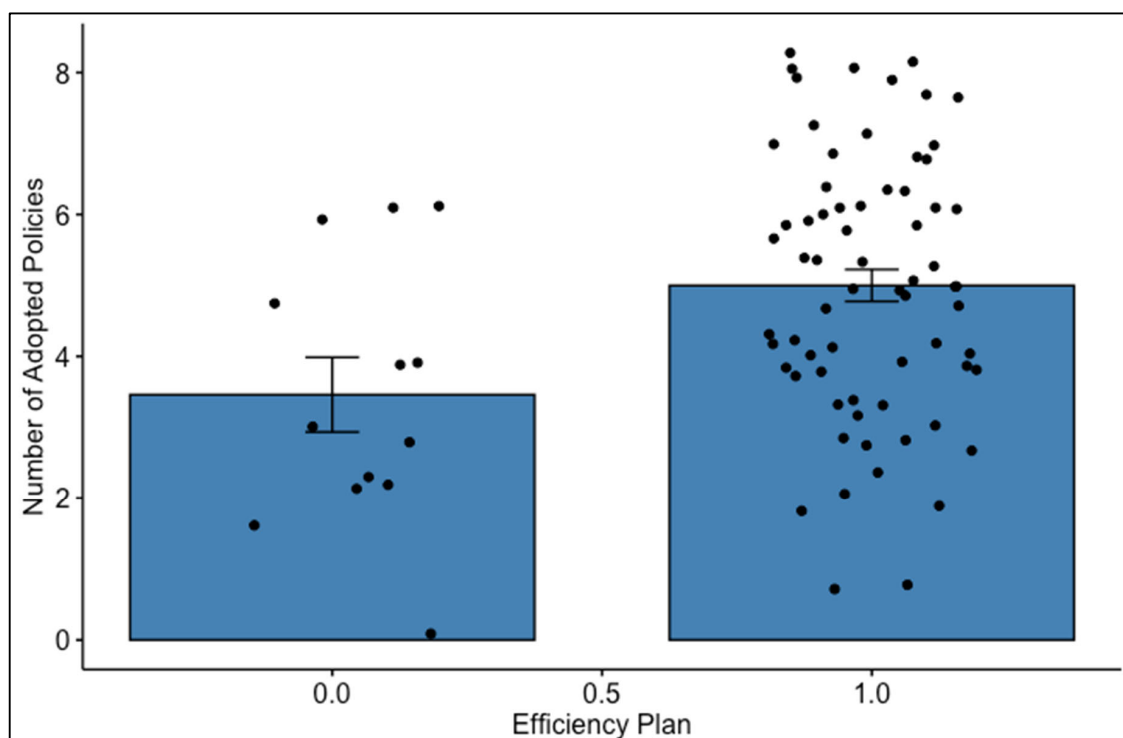


Figure 4. No. of adopted WDM policies by the presence of a water efficiency/conservation plan. “0.0” on the x-axis indicates jurisdictions without a water efficiency/conservation plan, while “1.0” indicates jurisdictions with a plan. Black points represent individual jurisdictions, and the bars show the average number of policies adopted for jurisdictions with and without WDM plans.

4.4. Adopting Residential Water Metering

We find that 48 jurisdictions (out of 94 surveyed) are implementing residential metering in single-family homes, and 54 have meters in multi-family household units. Figure 5 shows the proportions of metered jurisdictions by single-family and multi-family household types. Participants also provided estimates of total metered connections in both single- and multi-family housing unit types, reporting that approximately 296,430 residential household connections are metered, representing 55% of all residential water connections in the surveyed jurisdictions. Regarding the distribution by household type, 58% of single-family connections and 46% of multi-family connections have water meters among responding jurisdictions (Figure 6).

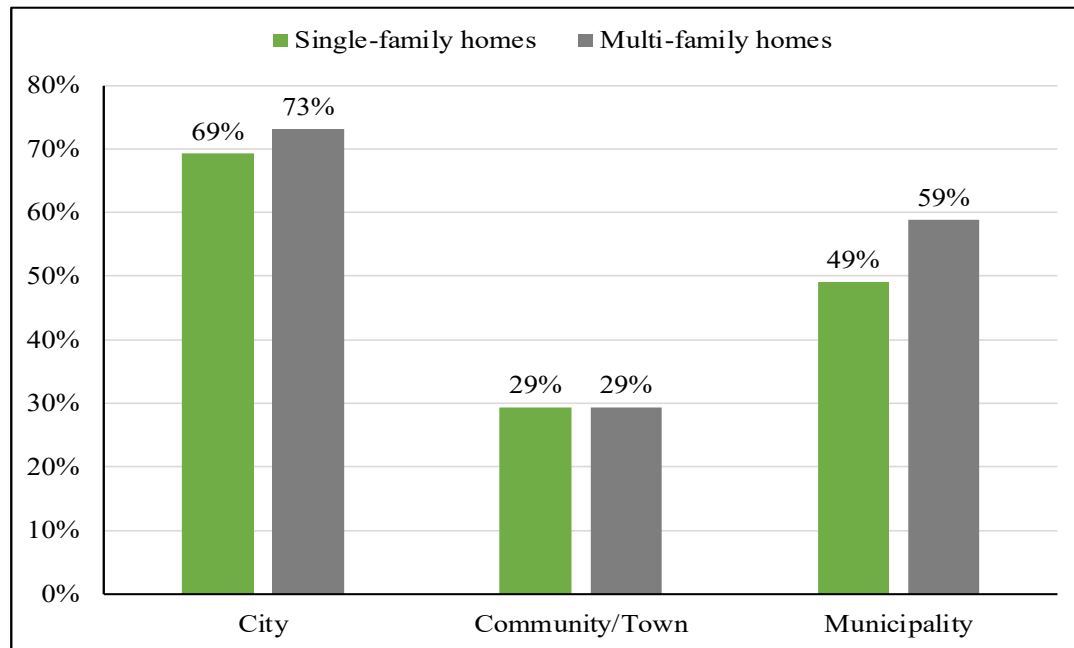


Figure 5. Percent metered households separated by household type and jurisdictions.

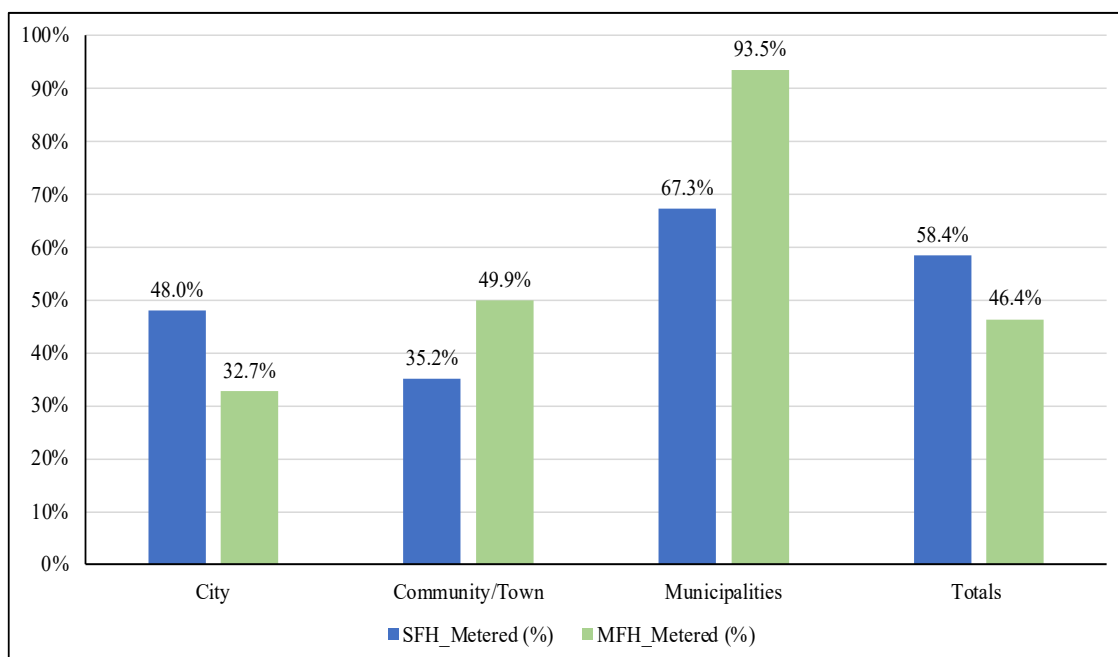


Figure 6. Percentage of metered connections by household type across jurisdictions.

5. Discussion

We highlight that jurisdictions are aware of the drought threat and are interested in managing water demand in the province of BC. In particular, this work highlights that many of the surveyed jurisdictions prioritize WDM and are implementing water-efficiency and conservation plans (84%). Jurisdictions responding to the survey reported investing in residential metering, with metered connections accounting for 55% of residential water connections. The study also indicates that many of the surveyed jurisdictions are taking action to conserve water, considering the positive relationship between having an efficiency plan and implementing WDM policies. These insights are discussed below with reference to the literature and policy practice among BC jurisdictions.

5.1. Planning and Adopting WDM Policies

Our research has demonstrated that jurisdictions are largely working towards adopting WDM policies to promote water conservation and reduce demand. For instance, the survey results show over 81% ($n = 76$) of surveyed jurisdictions prioritize WDM issues. Moreover, 4 in 5 responding jurisdictions have efficiency/conservation plans to guide the implementation of WDM policies. While direct comparisons are difficult due to methodological differences, earlier figures from 2013 estimated that 40% of jurisdictions had water conservation plans according to the *Water Conservation Guideline for British Columbia* [30]. Water-efficiency and conservation plans explicitly outline strategies and actions, including conservation objectives and financial commitments to implement WDM policies [4]. These practices align with past recommendations for the conscious planning and implementation of various water management frameworks to sustainably manage water resources [31]. Additionally, intentionally prioritizing and planning for efficient water use and conservation are part of fundamental principles of sustainable resource management and development [32,33].

Despite the lack of existing research for comparison, excerpts from jurisdictional reports indicate an increase in the proportion of jurisdictions adopting various WDM and conservation policies. It is also important to note that WDM policies formulated by upper-level governments and passed on to lower-level jurisdictions, such as water restrictions, are the most adopted among the surveyed jurisdictions. These policies are initiated through a legislative bill passed by a Jurisdictional Council or Board and are mandatory for jurisdictions within that water service area. For example, the Greater Vancouver Water District has legislated summertime water restrictions and institutional, commercial, and industrial (ICI) water metering, which all 23 jurisdictions that receive treated water from its service area must comply with [34]. Existing research supports our findings that WDM measures enacted as laws can be easily complied with, given there are penalties for violations and their potential to reduce consumption, especially during droughts [35,36].

Given that more jurisdictions responding to the survey prioritize, plan, and adopt various WDM measures, it is reasonable to assert that the province is advancing its water conservation objectives. For instance, many surveyed jurisdictions now have efficiency/conservation plans and are adopting multiple measures. Take metering, for example, the number of residential metered connections in the surveyed jurisdictions has increased from 26% to 55% between 2016 and 2020. However, we may need more comprehensive or representative data to report on these statistics and draw conclusions with greater confidence.

The literature sometimes describes WDM as a reactive mechanism during drought or water scarcity to temporarily hold up demand until additional supply is secured [1,37]. For instance, research in Cape Town, South Africa, and California, USA, shows that water

restrictions, metering, and efficiency technologies are common practices used to mitigate drought conditions [38,39]. The same cannot be said about the use of WDM and conservation policies in BC. For instance, the high proportion of jurisdictions implementing water-efficiency/conservation plans and their compliance with water restrictions suggest proactive, long-term water conservation planning by the province in response to climate change and rising demand. For example, the province has developed a water conservation strategy since 1998 to guide jurisdictions in supporting and promoting water conservation and efficient use in preparation for critical situations such as droughts and rising demand [40].

The broad trend of jurisdictions to adopt WDM policies may be accelerated by a “looking over the shoulder” effect, in which jurisdictions copy one another and adopt the best practices of neighbouring municipalities. A study that compared water rate structures in the province of BC found evidence that jurisdictions were likely mimicking their neighbours’ policies in designing their water rates [41] and we would expect that if this were happening in pricing, it is likely also happening in WDM.

It is important to note that these plans recommend guidelines for jurisdictions, but it is left to them to adopt what is deemed appropriate given local circumstances. Despite that, the province has, at no time, officially declared a water crisis or emergency. Water conservation and WDM policies are being implemented in preparation for or anticipation of (threats of) drought in the province. Thus, implementing multiple measures to promote efficient water use and conservation can be seen as part of pre-emptive climate change adaptation measures in the water sector.

5.2. Study Limitations

We encountered some methodological and practical challenges that could limit the generalizability and application of our findings. We aggregated responses from individuals in three distinct roles and from jurisdictions with varying levels of capacity and authority. However, due to differences in sample sizes, we could not conduct comparative analyses across jurisdictions. Moreover, we could not compare which type of jurisdiction performs better at implementing WDM and conservation measures due to variations in demographic and exogenous factors, such as population, resource capacities, and geographic locations. Nonetheless, this research presents the first and most up-to-date assessment of WDM progress in BC. Our findings can serve as foundational data to inform more precise investigations into how different types of jurisdictions are adopting WDM policies in the future.

Second, it is reasonable to survey local government officials because they are responsible for critical water decisions, and planning and implementing WDM policies. However, since WDM largely depends on the support and compliance of water users, household-level survey data from residents could give a more robust and different perspective on the progress of WDM and conservation measures. For instance, it can be challenging for water managers to assess the progress of educational campaigns from their perspective, since water users might not be observing the water-saving practices introduced by the water managers.

Finally, while residential metering and household-focused conservation programs are desirable policies, they also raise concerns about shifting responsibility for water security and climate adaptation onto individual households. Such approaches may obscure structural drivers of water scarcity, such as aging infrastructure, industrial demand, and higher-level planning failures, and risk placing disproportionate burdens on households with limited resources or capacity to respond.

6. Conclusions

Local governments in BC are increasingly implementing WDM policies to promote water conservation and ensure efficient use. Most water managers indicate that their jurisdictions prioritize water conservation and, relatedly, have developed efficiency/conservation plans to guide the implementation of WDM measures. The high proportions of jurisdictions implementing water restrictions; institutional, commercial, and industrial (ICI) water metering; and water conservation campaigns also indicate progress in line with the types of efforts the provincial government recommends. More specifically, non-financial policies and those determined by upper-level governments are commonly implemented across all jurisdictions. Thus, policies such as mandatory restrictions and water-saving campaigns determined at broader regional or provincial scales have had higher implementation rates over the years. Moreover, these policies have been initiated or enacted as bylaws of regional districts and are therefore often compulsory for lower-level jurisdictions.

Even though other regions implement WDM and conservation measures following water crises, such as drought or water shortages, we suggest that BC local jurisdictions are being proactive by adopting WDM policies. Thus, localities are attentive to climate change and its consequential impacts and are increasingly planning proactively through WDM and conservation. That said, it will be helpful to local water managers to conduct further studies into which WDM measures are the most consequential, particularly for different types of jurisdictions, given the levels of investment required and other considerations.

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