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ICLEI Local Governments for Sustainability
Les gouvernements locaux pour le développement durable
CANADA

SUPPORTING RESIDENTS DURING FLOODS

WHAT MUNICIPALITIES NEED TO KNOW ◗◗ PART OF THE **LIVING WITH WATER PROJECT**

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Land Acknowledgement

ICLEI Canada's work happens across Turtle Island which has traditionally been and is home to many diverse First Nations, Inuit, and Métis peoples since time immemorial. We are committed to strengthening relationships with Indigenous groups and knowledge keepers, knowing that truth and reconciliation require ongoing learning, unlearning, reflection, and action. We endeavour to listen to and learn from Indigenous Peoples on an ongoing basis in the process of our work.

Tools

Several tools referred to in this guide are available only in French; they are followed by a mention to that effect in parentheses.

Disclaimer

This report reflects the opinions of ICLEI Canada experts, which have been carefully formulated based on ICLEI's professional competence. The report, as well as the methodology, assumptions, techniques and procedures used to develop it, should be interpreted within the context of the Living With Water Project. The report must also be considered as a whole; no portion of it should be taken out of context. In accordance with existing legislation, ICLEI Canada is not responsible for third parties' use of the report or any part thereof (i.e., communication, publication, reference, citation, dissemination or footnote), or decisions made or actions taken based on this report.

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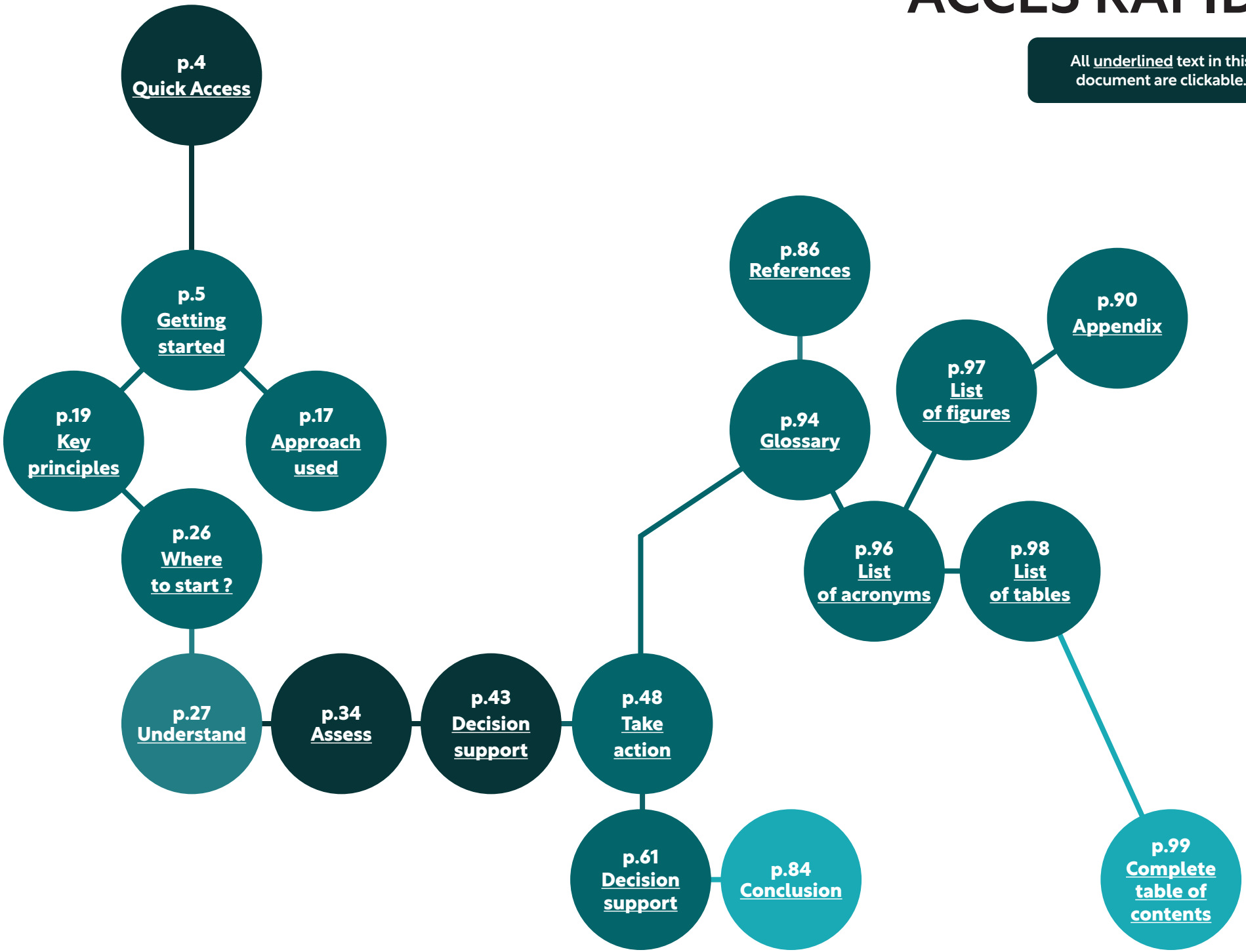

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GETTING STARTED

1. GETTING STARTED

1.1 Why a guidance document ?

This guide has been produced as part of the Living With Water Project, which aims to promote the large-scale adoption of construction and retrofit practices adapted to all flooding types across Canada. This project involved the Quebec government, municipalities, professional architecture associations, and the insurance industry. Outcomes will fuel the development of training programs tailored for various audiences as well as decision-making tools that will help to increase residential buildings' resilience to flood risks. Residences will be less vulnerable to the effects of flooding, which will increase occupant safety, reduce property and structural damage, and minimize repair costs and efforts after flooding.

The Living With Water Project is led by Architecture Without Borders Quebec (AWBQ), in collaboration with the Cité-ID LivingLab of the École nationale d'administration publique and ICLEI Canada, and is carried out with the contribution of Écohabitation, the Université de Sherbrooke, the National Research Council Canada, the Institut national de la recherche scientifique (INRS), and the cities of Longueuil, Montreal, Laval and Quebec.

This project is funded as part of the Building for the Future cycle of the Canada Mortgage and Housing Corporation (CMHC) Housing Supply Challenge. It also benefits from the collaboration of the Government of Quebec, through the participation of the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, the Ministère des Affaires municipales et de l'Habitation, the Société québécoise des infrastructures and the Société d'habitation du Québec.

1.2 How is this document meant to be used ?

This guide does not follow a linear structure. At each stage, municipalities are invited to choose the options that best suit their situation. We recommend skipping to different sections as you see fit instead of reading the document from cover to cover.

In each of section, the resources mentioned are briefly described and directly accessible via a hyperlink. In Section 4.3 (Taking Action), the examples of initiatives are listed first by category and then in alphabetical order by the cities or regions that have implemented them.

1.3 Who is this document intended for ?

This guide has been designed for small and medium-sized municipalities in Canada and is intended for municipal staff and stakeholders involved in municipal flood planning and management.

The focus is primarily on riverine and pluvial flooding, though some tools also apply to coastal flooding. It is intended to inform the development of programs to support or promote adapting existing residences.

More specifically, it aims to help small and medium-sized Canadian municipalities to:

01 Assess their level of flooding knowledge and preparedness;

02 Identify their needs and opportunities in their community to adapt residences.

1.4 Why is this document important for municipalities ?

Annual precipitation has increased over the last few decades in many regions of Canada. The IPCC (2022) also notes that climatic hazards related to hydrological changes, such as extreme rainfall and storms, are expected to intensify in the future. Total annual precipitation in Canada will likely continue to increase and be more concentrated during extreme events, which will increase the risk of flooding in towns and villages across the country (Environment and Climate Change Canada, n. d.; Pörtner et al., 2022). Rainfall patterns are shifting dramatically due to climate change.

For example, the high emission scenario predicts that Toronto, Edmonton and Calgary will see their annual probability of very rare rainfall increase from 1% to 15% by 2100 (Ness et al., 2021).

THE INCREASE IN PRECIPITATIONS OBSERVED IN RECENT DECADES WILL CONTINUE.

Relying on historical data is no longer sufficient to predict the likelihood of future events. As is illustrated in Figure 1, climate projections indicate total precipitation will increase in several Canadian provinces. However, the average increase in annual precipitation cannot be considered alone, since it represents only one type of climate data that impacts the occurrence of flooding.

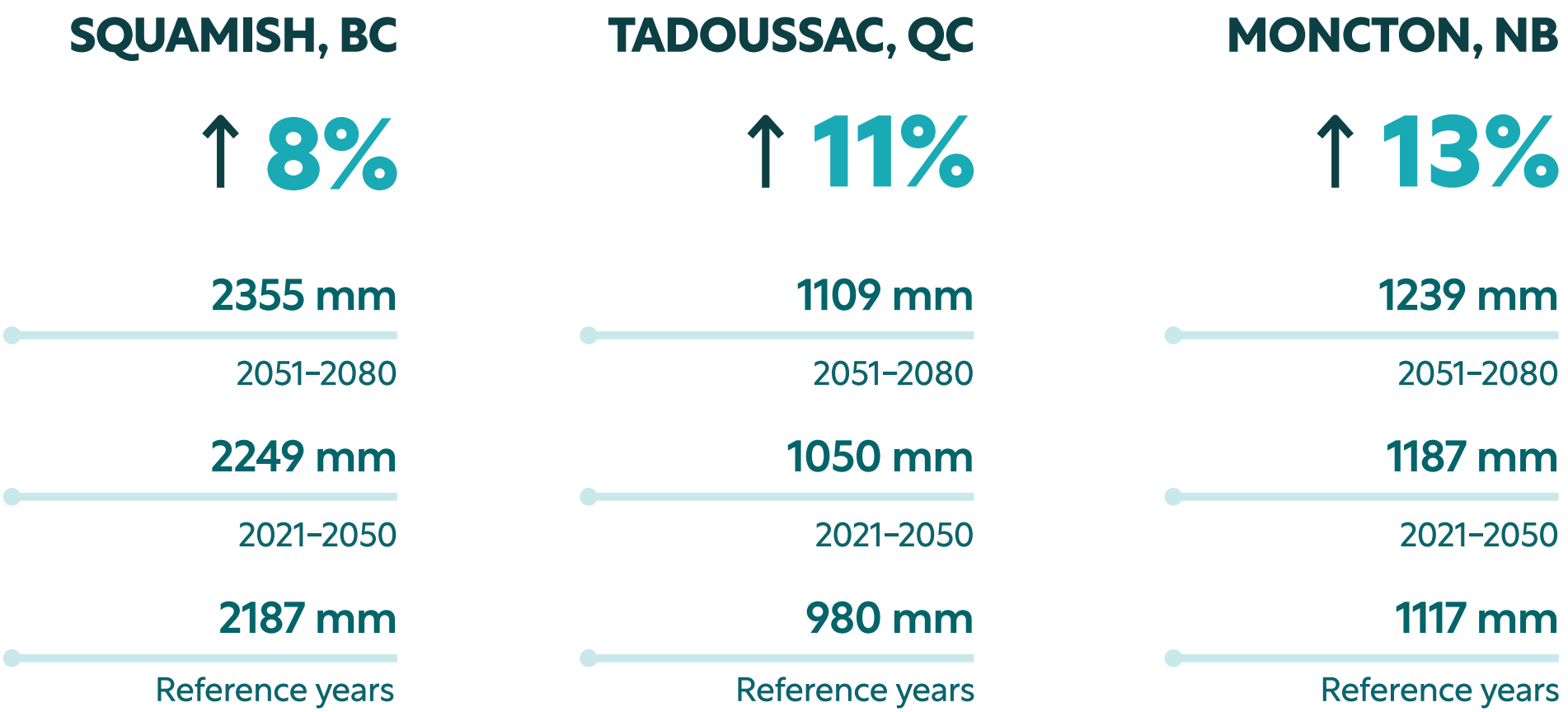

Figure 1: Rainfall projections for three Canadian cities. Source: Climate Atlas – High emission scenario

When there is a lack of permeable surfaces, heavy rainfall overloads storm sewer systems and causes flooding, water infiltration, and damage to buildings and homes.

In addition, damage to infrastructure has cascading effects on socio-economic and natural systems, including lower economic performance and risks to the health, well-being, and the livelihoods of local residents.

THE COST OF FLOODING DUE TO INTENSE PRECIPITATION IS RISING.

As listed below, flooding has multiple impacts (see Figure 2) regardless of its type and whether it occurs on its own or in combination with other climatic hazards.

Direct economic losses include

01 Damage to properties, businesses, and grey and green infrastructure;

02 Increased wear and tear to assets which results in higher maintenance costs and reduced asset life span;

03 Service interruptions;

04 Loss of property value;

05 Increased spending on emergency services;

06 Impacts on physical health (e.g., unsanitary buildings, illnesses related to mould exposure) and mental health (e.g., home evacuation, loss of possessions, claims and compensation, etc.);

07 Damage to ecosystems.

Indirect economic losses include

01 Impeded access to critical services caused by road and business closures;

02 Inability of workers to get to work due to damaged transportation networks;

03 Higher insurance premiums for flooded buildings;

04 Long-term impacts on physical and mental health;

05 Loss of revenue for businesses that work with those directly affected by flooding;

06 Devitalization of a neighbourhood or area;

07 Urban scattering caused by potential relocations.

Flooding is considered by some to be "the greatest climate threat in Canada" (IBC, n. d.) because of its frequency and associated costs and property damage (Eyquem & Monnerat, 2024). Insurance premiums for damage due to extreme weather have more than doubled every five to ten years since the 1980s (IBC, 2019). For the period 2003 to 2012, damage attributed to extreme precipitation in urban areas in Canada was estimated to be valued at over **$20 billion** (Kovacs & Sandink, 2014). The Intact Centre on Climate Adaptation (ICCA) now estimates the annual cost of residential flooding (all causes combined) to be **$2.9 billion in Canada**, and 89% of this amount is attributable to the properties that are most at risk, which represent only 10% of Canadian homes (Eyquem & Monnerat, 2024; IBC, 2019). Canada is facing a significant deficit in terms of public infrastructure and asset spending, and recent estimates to maintain existing infrastructure range **from $110 billion to $270 billion** (Ness et al., 2021).

CANADA IS FACING A SIGNIFICANT DEFICIT IN TERMS OF ASSET & SPENDING PUBLIC INFRA-STRUCTURES.

In Quebec alone, the government spent nearly $70 million annually in response to flooding from 1991 to 2013. In 2017 and 2019, flooding cost $360 million and $438 million, respectively, in financial assistance paid to victims, but these amounts do not cover all the damage suffered (Ouranos, n. d.). Preliminary estimates suggest that, in August 2024, Tropical Storm Debby alone caused more than **$2.5 billion in insured damage**. In 2024, the financial institution Desjardins decided it would no longer offer mortgages to buyers of homes in areas prone to flooding every 0–20 years, which makes it virtually impossible to sell some historic homes (QMI, 2024).

The Canadian Climate Institute predicts that flood damage in Quebec could reach $210 million annually (Canadian Climate Institute, n. d.). Figure 3 shows the annual cost of inland flooding[1] that could be incurred across Canada under two different emission scenarios. It is even more alarming to note that the most recent floods could cause these projections to be revised upwards, especially considering the significant increase in construction costs—of around 30 to 40% in Quebec—in recent years (UMQ, 2024).

Figure 2: Main types of damage caused by flooding

TYPES OF IMPACTS

Grey and green infrastructure **damage**

Loss of life and water-transmitted diseases or caused by infrastructure damage

Property **damage**

Economic losses : building damage, transportation problems and business closures

[1] Inland flooding occurs when precipitation over land accumulates locally or runs off and elevates the water level in rivers, streams, and other inland water bodies. It can manifest as either fluvial flooding or pluvial flooding. Source: Ryan Ness, Dylan G. Clark, Julien Bourque, Dena Coffman and Dale Beugin. Under Water: The Costs of Climate Change for Canada's Infrastructure. 2021. Canadian Institute for Climate Choices. Ottawa, Ontario.

Municipalities lack funds and are faced with a growing number of responsibilities.

Figure 3 shows the annual costs of inland flooding that could be incurred across Canada under two different emissions scenarios.

It is all the more alarming to note that the most recent floods could cause these projections to be revised upwards, especially considering the significant increase in construction costs in recent years, on the order of 30 to 40% in Quebec (UMQ, 2024).

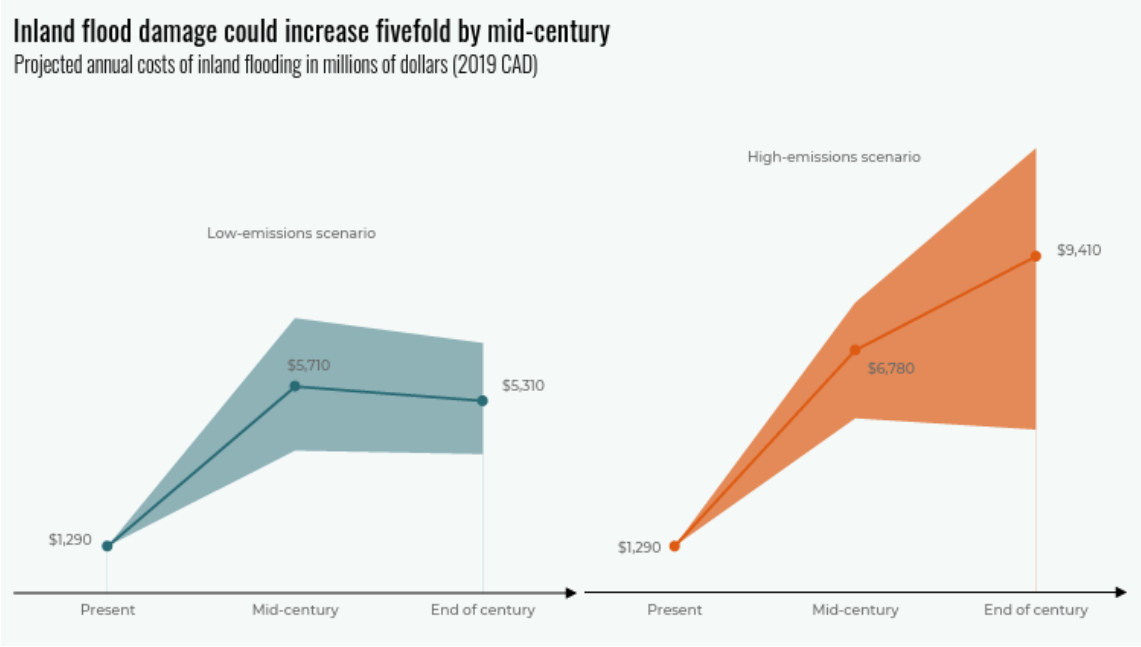

Figure 3: Damage caused by flooding, from Ness et al., 2021, p. 33.

Municipal governments are now in charge of a much larger proportion of infrastructure than they were historicallty. Municipalities own approximately 60% of public infrastructure in Quebec—many of which are aging, resulting in a maintenance deficit of $2 billion per year (Gosselin et al., 2022)—while they receive only 10% of the tax base (IBC & FCM, 2020; UMQ, 2023). Municipalities alone cannot cover the water infrastructure upgrades required to help prevent flooding of the magnitude mentioned above. The UMQ estimates that nearly $45 billion would be needed for these upgrades (Fortier, 2024; UMQ, 2024).

In addition, many indirect costs are not taken into account in the estimates of costs related to climate change, including disruptions to municipal services, supply chains, transportation, and commercial operations, as well as power outages, water and food shortages, and other significant non-market costs. FCM had requested $10 billion over 10 years to help its members adapt to climate change. However, the federal government has granted only $530 million through the Green Municipal Fund, which indicates how creatively local governments must work to fund the adaptation of their communities (Thurton, 2024). In the face of the climate crisis, waiting is not an option. Municipalities must be supported now to strengthen their capacity to catalyze and promote adapting housing to all types of flooding.

Photo credits : Radio-Canada/Trevor Lyons

Savings that can be achieved through adaptation.

Investments in disaster risk reduction can offer a return of **400% or more** on the amount allocated to adaptation. For example, the $665 million expansion of the Red River Floodway in Manitoba saved $12 billion in recovery costs (ICB, n. d.; Kovacs & Sandink, 2014).

In Hamilton, Ontario, the restoration of a wetland complex costing approximately $15.3 million will provide various services valued at up to $44.2 million. In addition to helping to limit flooding, this nature-based solution represents a significant saving compared to an artificial solution that would have cost around $28.5 million (Eyquem et al., 2022).

The ICLEI Canada Cost of Doing Nothing toolkit provides additional information and resources to assess the costs of doing nothing within a local context, and makes building a business case for climate adaptation as easy and simple as possible. In short, cities are facing a growing threat with limited human and financial resources. This document aims to help them guide their residents toward the best adaptation choices according to their situation and means.

1.5 The role of municipalities

Cities are particularly vulnerable to the impacts of climate change because they exacerbate existing chronic and acute stresses, such as population growth, aging infrastructure, and extreme weather. Adding to these sources of stress is the pressure that is placed on municipal employees to respond quickly during crises caused by various climatic hazards.

Cities can play a key role in the transition to a low-carbon and more climate-resilient future.

For example, cities are :

01 Both major GHG emitters and most likely to be affected by climate change since most of Canada's population lives in urban areas;

02 Hubs for key climate action players – business centres, federal and provincial governments, private sector insurers and lenders, innovation centres, community organizations, residents, etc.;

03 Directly familiar with local needs and capacities, and thus well positioned to inform investments and identify successful practices on the ground

04 Important actors in managing natural and built infrastructure and promoting flood protection at the property level.

Flooding affects municipalities at multiple levels, since floodplain maps impact municipal regulations in most provinces. Municipalities are responsible for creating drainage facilities and ensuring the safety of residents during an emergency, and many of them own or manage protection works.

They therefore have a major interest in adapting to the growing risk, especially since they must bear a large part of the direct and indirect costs of flooding (Dottori et al., 2018; ICLEI Canada, 2022).

The high concentration of valuable assets in cities requires mechanisms to facilitate their replacement in the event of a disaster, including the use of existing and available insurance (IBC, n. d.), but above all, to prepare the population to minimize or even avoid damage (IPCC, 2022). Regulatory and fiscal frameworks can facilitate adaptation.

Why do cities have a responsibility to inform residents about the flooding situation?

Because they are often the first to be called upon by flood victims, cities must act proactively to help residents understand the risk and adapt to it. International and local experience shows that, if they are not aware of the individual risk they face, residents are not motivated to take the steps necessary to protect themselves against flooding.

And to reach residents, studies show that the message must be repeated several times (IBC, 2019). A variety of channels must be used to increase awareness, and contexts specific to renovation—such as permit issuance—can be good opportunities to share information. Public consultation during zoning map implementation can also be crucial for managing residents' expectations.

CITIES ARE THE FIRST TO BE CALLED UPON BY FLOOD VICTIMS.

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APPROACH USED TO PRODUCE THIS DOCUMENT

2. APPROACH USED TO PRODUCE THIS DOCUMENT

This document has the following objectives :

01 Help municipalities to support residents in flood-resilient construction and retrofit projects;

02 Highlight existing municipal flood prevention initiatives;

03 Advance the national discussion on flood resilience.

In the context of the Living With Water Project, ICLEI Canada and several collaborators (including AWBQ and ENAP) carried out a review of the literature and existing tools pertaining to flooding.

This made it possible to identify inspiring Canadian flood support initiatives for residents. Following the literature review, ICLEI Canada conducted semi-structured interviews to assess municipalities' needs to be able to support residents in completing renovations and new construction that are resilient to riverine and pluvial flooding.

A total of 16 Canadian municipalities of various sizes and geographic locations were interviewed. Some of them experience frequent flooding, while others, despite a flood risk, must deal with significant droughts.

These interviews not only provided a better understanding of the issues municipalities experience in relation to flooding but also helped to identify and understand the tools that are used to address flooding and their shortcomings. A synthesis of these interviews highlighted recurring issues and inspiring practices.

Elements that emerged from the interviews:

01 Municipalities are not all at the same level in terms of their understanding and regional management of flooding;

02 Pluvial floods are less well understood and therefore have less impact on the public's perception of flood risk;

03 Many cities still see a need to communicate flood risk and educate their residents;

04 Smaller municipalities often lack expertise and human resources;

05 Many municipalities acknowledge it is necessary to rely on an external resource to supplement internal knowledge and expertise;

06 Residents appreciate "one-stop shopping" to obtain assistance in choosing appropriate adaptations, particularly for construction work;

07 Municipalities like thematic "toolkits" but need information that is specific to their territory;

08 Partnerships are beneficial at all stages of flood adaptation, from awareness campaigns to the funding of actions;

09 Funding remains a challenge when it comes to both infrastructure and incentive programs for residents.

Based on these findings, it seemed relevant to:

01 Guide municipalities toward tools that are tailored to their needs;

02 Avoid certain pitfalls and reproduce successes by presenting the approaches that have been adopted by some Canadian municipalities.

GATHERING KNOWLEDGE

This guide aims to **bring together** a body of relevant knowledge in order to offer municipalities tailored support to better help their residents adapt to residential flooding and **provide various starting points** according to their respective level of progress and needs.

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KEY PRINCIPLES TO REMEMBER

3. KEY PRINCIPLES TO REMEMBER

3.1 The six questions municipalities should ask themselves to support their residents

The following questions provide input for reflection and help identify the most relevant sections of this guide based on each municipality's needs.

01 What is the municipality's goal?

Although the ultimate goal is better flood adaptation, cities are not all at the same stage in this process. It may be important to identify an initial intention to be sure realistic goals are set and, above all, avoid maladaptation. Municipalities are encouraged to consult the decision-support pathways set out in Sections 4.3 and 4.5 of this document for help identifying achievable goals based on the actions they have already taken with regard to flooding. The pathways provide a comprehensive overview of preparatory or concrete adaptation initiatives that others have taken.

02 At what scale or through which lens should an initiative be deployed? t

Although residents can benefit directly or indirectly from the protection of various types of assets that exist within in a municipality, this document focuses mainly on the protection of residential buildings. If a spatial or thematic lens is being used to determine which areas of the municipality to prioritize, mapping can be a valuable tool because it provides a clear picture of the situation in the territory.

For example, it is possible to focus first on the most vulnerable populations by identifying the most heavily affected people in the community using the method proposed by Partners for Action or some of the tools presented in Section 4.2.3. It is also possible to start with the most exposed buildings by using flood-prone area maps or basin maps, detailed in Section 4.2.1. Whichever lens is chosen must be consistent with the municipality's priorities.

03 What datasets will be used?

- Which external services and partners should be involved?
- What are the best sources available?
- Are they applicable to my local situation?
- Can I replicate the data in the area/region?
- Is the data easy to understand?
- Who can help me interpret the data?

Sections 4.1.1, 4.2 and the list of resources in the Appendix 3 provide information about data sources that can be applied generally or specifically to a territory.

04 What are the existing capacities and constraints?

List the city's strengths and weaknesses in relation to this exercise. How will they influence the course of its operations? For example:

Time permitted to implement flood adaptation solutions

- Depending on climate forecasts and the level of risk the municipality is exposed to

Budget and available funding

- Ppportunity to provide financial incentives for adaptation measures
- Possibility of introducing water-related surcharges

Green and grey infrastructure, and ecosystem services

- Presence in the area/region, target and peripheral areas, and state of aging

Human resources and qualifications

- Staff available to respond to residents' concerns, implement programs, and carry out the research and preliminary data collection that is required

Data already available or to be collected

- Climate projections
- Local historical events
- Traditional knowledge of the community
- Financial information
- Ecological information

Beliefs or cognitive biases of residents, and their trust in the municipality

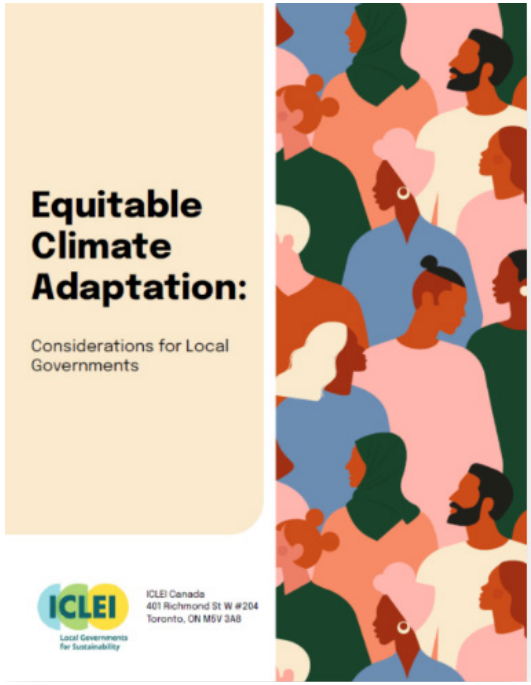
- Ability to convey messages and programs through intermediaries
- **Regulations** that have the potential to limit some adaptation options.

Section 4.2.2 sets out two tools that use the answers to some of these questions to provide suggestions or diagnoses.

05 How can Equity, Diversity and Inclusion (EDI) be integrated?

How will a measure or project benefit the most vulnerable populations?

Even if their actions to promote adaptation are well intentioned, municipalities must pay particular attention to issues related to social inequality and vulnerability in order to avoid maladaptation. For example, grants for residents can sometimes be more beneficial to people who master administrative and financial tools, and leave out a significant proportion of more vulnerable potential beneficiaries.



The Equitable Climate Adaptation resource can help avoid these pitfalls by providing checklists and foundational considerations for each stage of a project.

Similarly, certain flood control solutions that also increase the value of a property or the taxes associated with a specific neighbourhood for aesthetic considerations or other reasons could miss their target of protecting more vulnerable populations. See, for example, the Guide à l'intention des municipalités pour promouvoir un verdissement équitable (in French).

In addition, the City of Ottawa has produced the Ottawa Neighbourhood Equity Index (NEI) tool to help residents, planners, stakeholders and decision-makers identify disparities between neighbourhoods and tackle them in a systematic and organized way.

06 How will success be measured?

There are several ways to measure the effectiveness of adaptation measures at the local level. Qualitative or quantitative indicators are one way to measure success, but they have different levels of complexity. Performance metrics are used to assess adaptation progress over time. They include level of resilience knowledge among municipal employees, number of resilience measures implemented, and level of confidence that studies and assessments will reduce the risk of flooding. In any case, it is best to aim for continuous progress and bear in mind that adaptation is an iterative process.

3.2 Key principles to guide municipal support of flood adaptation

Cities are often on the front lines when it comes to responding to residents' concerns about flooding. In order to work effectively to prevent the worst when supporting their residents, municipalities should rely on the following principles (Figure 4).

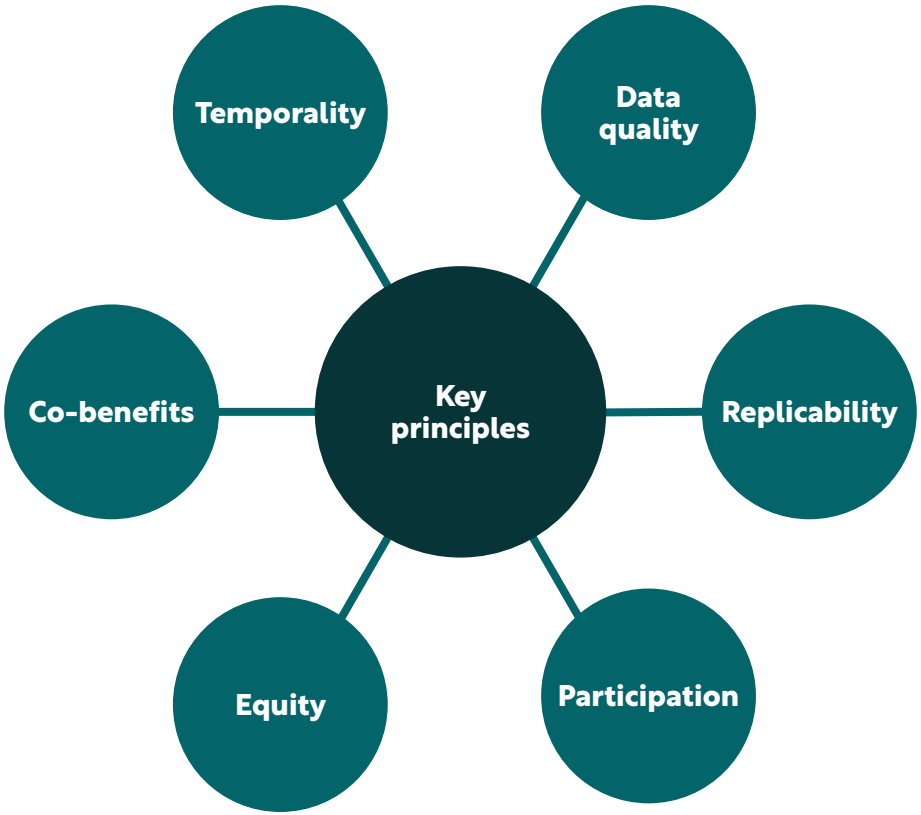


Figure 4: Key principles to support adaptation to flood risk.

01 Data quality: The best data available in the current context, and the clarity of the data

- Ensure that flood risk data is based on historical information, as up-to-date as possible, and incorporates Indigenous knowledge, internal and external experiences, and scientific data.
- Consider different climate projection scenarios.
- Use clear and accessible information, and share it with all partners and stakeholders.

02 Replicability: Applicability to other municipal services or other neighbourhoods

- Clearly indicate how the flood risk assessment can be replicated.
- Identify best practices and examples of them being applied in a variety of contexts.

03 Participation: Inclusion, mobilization, consultation

- Promote collaborative processes when developing adaptation solutions.

04 Equity: Prioritization of vulnerable populations

- Choose measures that take socio-economic inequalities into account and promote their mitigation.
- Use plain language in both communications about the importance of preparing for flooding and instructions or recommendations on how to do so.

05 Co-benefits: Economic profitability, reduced GHG emissions, improved quality of life

- Support the adoption of measures that have not only a positive impact on flood resilience but also other benefits that accelerate the improvement of overall collective well-being.

06 Temporality: Provision of benefits in the short, medium and long term

- Ensure that effects are taken into account on multiple time scales by adopting a variety of measures.
- Anticipate future needs by relying on detailed territorial knowledge and planning.

SEVERAL PSYCHOSOCIAL DETERMINANTS INFLUENCE RESIDENTS' ABILITY TO RENOVATE THEIR HOMES.

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WHERE TO START ?

4. WHERE TO START ?

No matter which stage of the adaptation process that a city is at, resources are available to support it in taking action.

The purpose of this section is to provide quick access to existing tools and to present examples of the tools being applied in various municipalities as a call to take action.

01 Understand : How does flooding occur, and how can we better anticipate it?

- Basic concepts related to climatic hazards and their consequences, especially those for the built environment

02 Assess : What factors determine a residence's exposure to flooding?

- Diagnostic tools to assess the likelihood of riverine, pluvial and coastal flooding
- Social vulnerability assessment tools

03 Take Action : What actions can the municipality take to ensure residences are better adapted to flood risks?

- Regulatory tools: Policies, regulations and guidelines
- Financial incentives: Funding programs for residential interventions
- Communications and resources for residents: Inform residents of the support that is available

4.1 UNDERSTAND

This section focuses on acquiring knowledge about concepts related to flooding. More specifically, it aims to provide a better understanding how flooding occurs locally and how it impacts residences.

4.1.1 Climatic hazards associated with flooding

Several types of extreme weather events are expected to increase in frequency in the coming years due to climate change. Figure 5 shows the hazards that are most strongly correlated with flooding.

The Canadian Centre for Climate Services offers climate data portals that make it possible to visualize the hazards that affect your municipality. It also provides a description of three Canadian portals: ClimateData.ca, which is discussed below, Climate Atlas (Figure 8), and PAVICS, which is designed for climate science experts.

Flooding & climate change

The global climate change has already altered patterns of rainfall, snow, ice, and permafrost melt, exacerbating existing water availability and quality issues, as well as changing the nature and timing of water-related natural hazards, such as floods and droughts.

A flooding is the overflowing by water of the normal confines of a stream or other body of water, or the accumulation of water by drainage over areas which are not normally submerged.

Canada in a Changing Climate
National Issues

Climatic hazards & flooding

Freeze-thaw cycles

Mild winter temperatures

The milder winters that are anticipated will increase the number of winter freeze-thaw cycles in several regions. These cycles can cause damage to infrastructure, for example, by blocking storm sewer drains.

Drought

Climate projections anticipate an increase in prolonged droughts in several parts of the country. Droughts increase the risk of flash flooding by reducing the absorption capacity of the soil.

Heavy rainfall

Increase in total annual precipitation

In some regions of Canada, particularly Quebec and Ontario, IDF curves* are projected to shift and the number of extreme rainfall events is expected to increase.

* Intensity-Duration-Frequency curves relate short-duration rainfall intensity with its frequency of occurrence. They are often used for flood forecasting and urban drainage design. (donneesclimatiques.ca)

Storms

Rising sea levels combined with increased storm surge frequency and intensity will accelerate coastal erosion and increase the risk of flooding.

Figure 5: Key climatic hazards that impact flooding.

Climate Data

Climate Data

The ClimateData.ca portal's Explore by Location option provides historical data and projections based on various climate scenarios for several variables likely to influence flood risk, including ones pertaining to precipitation and droughts:

01 **Total precipitation for a selected period;**

02 **Maximum 5-day or 1-day precipitation;**

03 **Number of wet days with more than 1, 10 and 20 mm;**

04 **Number of periods with more than 5 consecutive dry days;**

05 **Standardized evapotranspiration indices (3 and 12 months).**

Figure 6, which has been reproduced from ClimateData.ca, shows the number of wet days (over 20 mm) per year for a specific municipality and time period based on the median values of the ICMP6, SP5-8.5 higher emission scenario. See the Understanding Shared Socio-economic Pathways (SSPs) section to learn more about the different scenarios and which one to use.

ClimateData.ca offers the option of viewing data by watershed (Figure 7), which may be particularly relevant in a flood prevention context. The Learning Zone section features several topics that provide more information about climate science.

Learn more about the different scenarios.

Climate Portraits

The Ouranos platform, which is specific to Quebec, also popularizes various concepts related to climate models. The platform provides a total liquid precipitation, in millimetres indicator (see Figure 9) that can be viewed by year or by season.

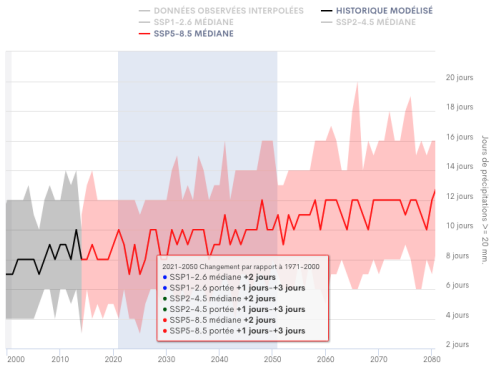


Figure 6: Number of days where at least 20 mm of precipitation falls (Tadoussac, QC).

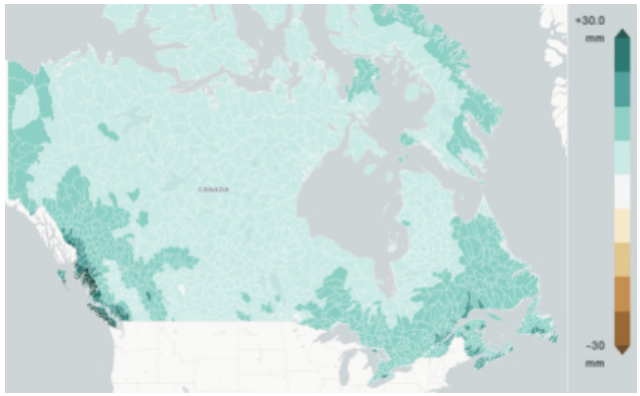


Figure 7: Largest amount of precipitation to fall over 5 consecutive days presented by watersheds (2071–2100) – CMIP5, RCP 8.5.

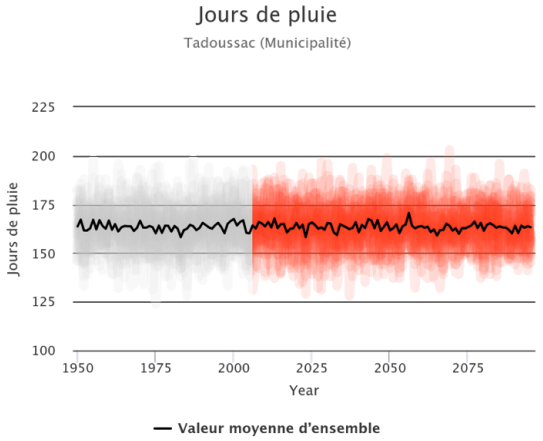


Figure 8 : Climate Atlas graph showing a relatively stable annual number of rainy days in the coming years.

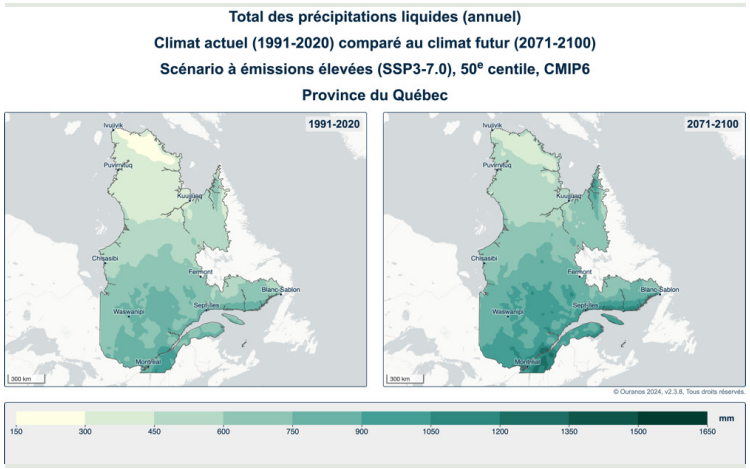


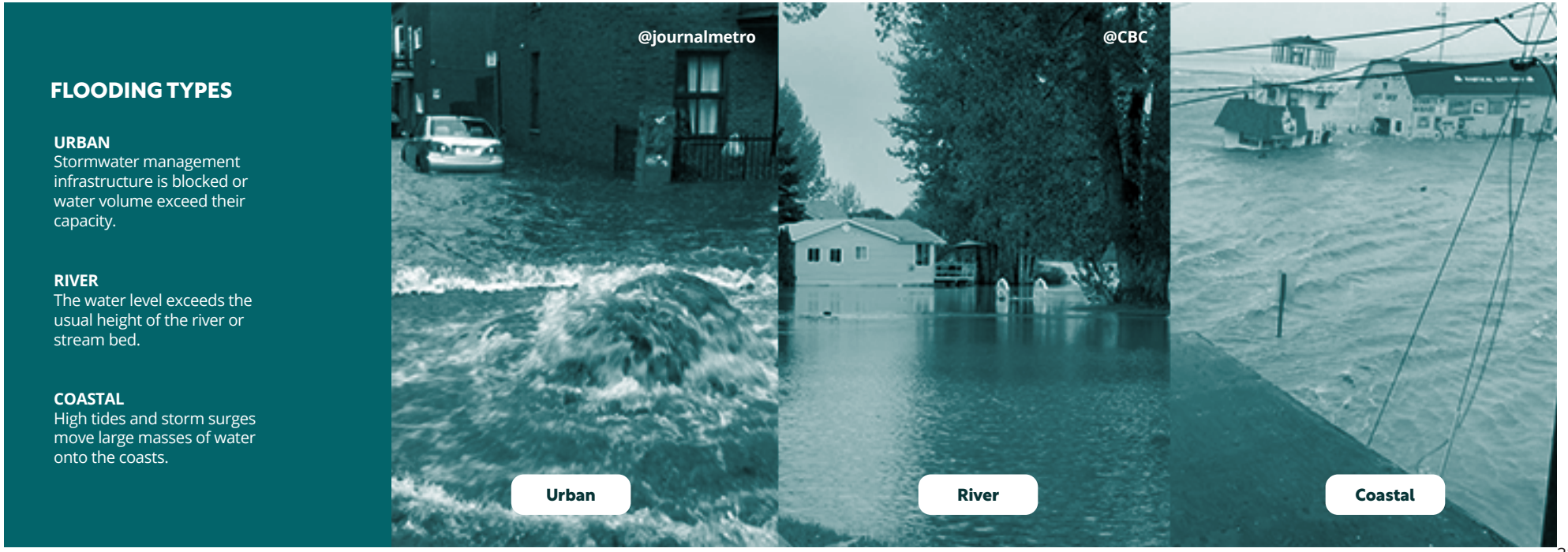
Figure 9: Map preview downloadable on the Ouranos portal.

4.1.2 Types of flooding

Understanding how flooding occurs is important not only for insurers but also when it comes to choosing prevention methods, as the ICLR Focus on Types of Flooding resource explains.

The document warns against the temptation to break flooding down into categories, as several types may occur simultaneously. Nevertheless, three types of flooding that are common in Canada are described below and are included in tools such as the ICCA Municipal Flood Risk Check-Up.

Figure 10 : Les différents types d'inondations en images



01 Pluvial (or urban or overland)

This type of temporary flooding is unrelated to the overflowing of a water body and is therefore likely to occur even in higher urban areas that are far from floodplains or much higher than sea level.

A large amount of rain falling in a short period of time—which is characteristic of this type of flooding—can also trigger groundwater flooding, during which the groundwater level rises to the surface.

In addition, heavy rainfall can overload urban drainage systems and cause backups (Ouranos, n. d.), particularly in homes.

02 Riverine (or fluvial)

This type of flooding can be attributed to heavy rainfall or snowmelt that accumulates quickly in a body of water and increases its flow, or the overflowing of dams or dikes.

Riverine flooding is easier to predict, and its risk is simple to model or map. Residences located in areas at risk of this type of flooding are often more expensive to insure or not insurable at all (IBC, 2019; Public Safety Canada, 2024).

03 Coastal

This type of flooding is generally caused by strong winds and storm surges that push seawater on shore, and it results in the submersion of lower-lying land.

As with riverine flooding, the risk of coastal flooding is generally predictable and able to be modelled. Insurance for this type of risk is still very limited (IBC, 2019; Public Safety Canada, 2024)

RUNOFF, NOT OVERFLOWING RIVERS CAUSED THE MOST DAMAGE.

During Storm Debby, which hit Quebec in August 2024, what caused the most damage was not the overflowing of streams, but rather the runoff, since the networks were unable to contain the **abundant amount of rain** that fell.

Hydrometric stations even displayed flows that were below flood monitoring thresholds, which suggests that this type of flooding is less predictable (IBC, 2019; MELCCFP, 2024).

4.1.3 Possible impacts on residences

The material and human consequences of residential flooding can be particularly devastating for communities. The following resources can provide a better understanding of how different factors affect the type and extent of property damage:

01 A Primer on Severe Weather and Overland Flood Insurance in Canada describes (p. 8) common ways that water can enter a home and some related impacts - see Appendix 1.

02 AWBQ's Living With Water fact sheets (bilingual).

03 Section 3.1 of AWBQ's Cohabiter avec l'eau : État des connaissances en matière d'adaptation des bâtiments aux inondations (2021) provides information about how flooding acts upon and impacts a building (in French).

04 Understanding and Improving Your Residential Drainage pertains to the causes of flooding and residential drainage systems, and provides explanatory diagrams. This document designed by EcoSuperior for the City of Thunder Bay (ON) and its residents contains mostly general information that is also applicable to other Canadian municipalities.

4.2 ASSESS

Back to Quick Access

Now that we have a better understanding of hazards, types of flooding, and their impacts, this section presents some tools that can be used to assess the risk that a municipality, its residents, and their homes face.

The word assess means: "To collect, process, [analyze] potential threat, hazards, risks, resilience, vulnerability, capabilities and associated impact factors" (Public Safety Canada, 2024).

Various criteria can be used to carry out an assessment, including geographical, technical or governance-related criteria. The valuation of natural assets, which can contribute to flood prevention in a municipality through inventory and modelling, could be included in the assessment stage. See Natural Asset Inventory & Ecosystem Service Assessment for the Town of Okotoks for an example.

THIS SECTION PROVIDES A NUMBER OF TOOLS DESIGNED TO HELP YOU ASSESS THE RISK TO WHICH A MUNICIPALITY IS EXPOSED.

4.2.1 Mapping: A key tool

Mapping is an essential tool for identifying flood risks, in particular their probability and potential location. It is useful for both decision-making and raising awareness.

In its document entitled Focus on Flood Mapping in Canada, the IPSC explains what flood maps are and why they are important, and then refers to the following mapping framework from Natural Resources Canada (NRCan).

ACCESSING UP-TO-DATE MAPS IS A DETERMINANT FACTOR IN PUBLIC MOBILIZATION.

NRCan has published a series of flood mapping guidelines (some of which are forthcoming) to help you navigate:

01 Federal Flood Mapping Framework;

02 Federal Airborne LiDAR Data Acquisition Guideline;

03 Case Studies on Climate Change in Floodplain Mapping;

04 Federal Hydrologic and Hydraulic Procedures for Floodplain Delineation;

05 Federal Geomatics Guidelines for Floodplain Mapping;

06 Federal Flood Damage Estimation Guidelines for Buildings and Infrastructure;

07 Federal Land Use Guide for Flood Risk Areas;

08 Bibliography of Best Practices and References for Flood Mitigation.

Examples of maps at different scales.

01 Federal

A Canadian flood susceptibility map shows which areas are the most flood-prone.

02 Provincial

The Alberta government's interactive Flood Awareness Map Application displays flood-prone areas based on several parameters, including the likelihood of occurrence over 30 years, and shows the areas that are expected to be flooded and the areas that are protected by flood berms.

03 Regional

The District Municipality of Muskoka (ON) makes available a Muskoka floodline map that offers useful information such as the roads that become impassable during floods and the difference in elevation between two locations.

A new option makes it possible to visualize the footprint of buildings in 3D and shows the water level that could be reached if the lake overflows. The District also explains in detail the methods that it used for floodplain mapping in its area.

04 Municipal

The City of Montreal conducted a runoff water **retention basin mapping** exercise to better assess its risk of pluvial flooding. Page 3 of the document Analyse de vulnérabilité aux changements climatiques (in French) indicates the methodology that was used to create the map.

4.2.2 How to assess risks to existing infrastructure by region?

The Climate Insight Solution Finder allows you to better understand the risks of various climatic hazards, including flooding, by answering a series of questions. The series of questions pertaining to a municipality's priorities and available resources help to identify an appropriate risk assessment tool.

To find solutions for the hazards identified, another series of questions helps to determine relevant options for infrastructure with the aim of reducing known risks, including to foundation supports, for example, from hydrostatic pressure.

Figure 11 shows an example of a clickstream through the drop-down menus that leads to solutions for municipal stormwater management infrastructure that can contribute to flood prevention for buildings, including public housing.

Perspectives Climatiques
Nous aidons les collectivités à bâtir des infrastructures résilientes et à faibles émissions de carbone

Climate Insight : An essential minicipal platform

Although it focuses on public infrastructures and housing, this platform contains a great deal of resources that can be applied to residences. Climate Insight offers a range of tools for assessing the hazards and impacts of flooding on buildings.

This document's Section 4 : Where to start? is aligned with various tools that are available at no cost on the Climate Insight platform, such as :

01 The Solution Finder

The Solution Finder, which asks a series of questions in order to provide tailored recommendations for building climate-resilient infrastructure.

02 Explore the map

The Explore the Map section, which provides access to climate, socia-economic and infrastructure data from across Canada. This tool can be very useful as it takes into account a social vulnerability index, which can be visualized for all of Canada.

03 Learn

The Learn tab, which contains a series of data sheets with simple visuals that explain key concepts such as risk, life cycle, equity, costs and nature-based solutions.

04 The Library

The Library, which offers plenty of resources categorized by climate consideration (adaptation or mitigation), and type of climate risk, infrastructure, and resource.

Note: Climate Insight does not take into account current funding programs available in Canada.

SOLUTIONS LOCATOR PATH

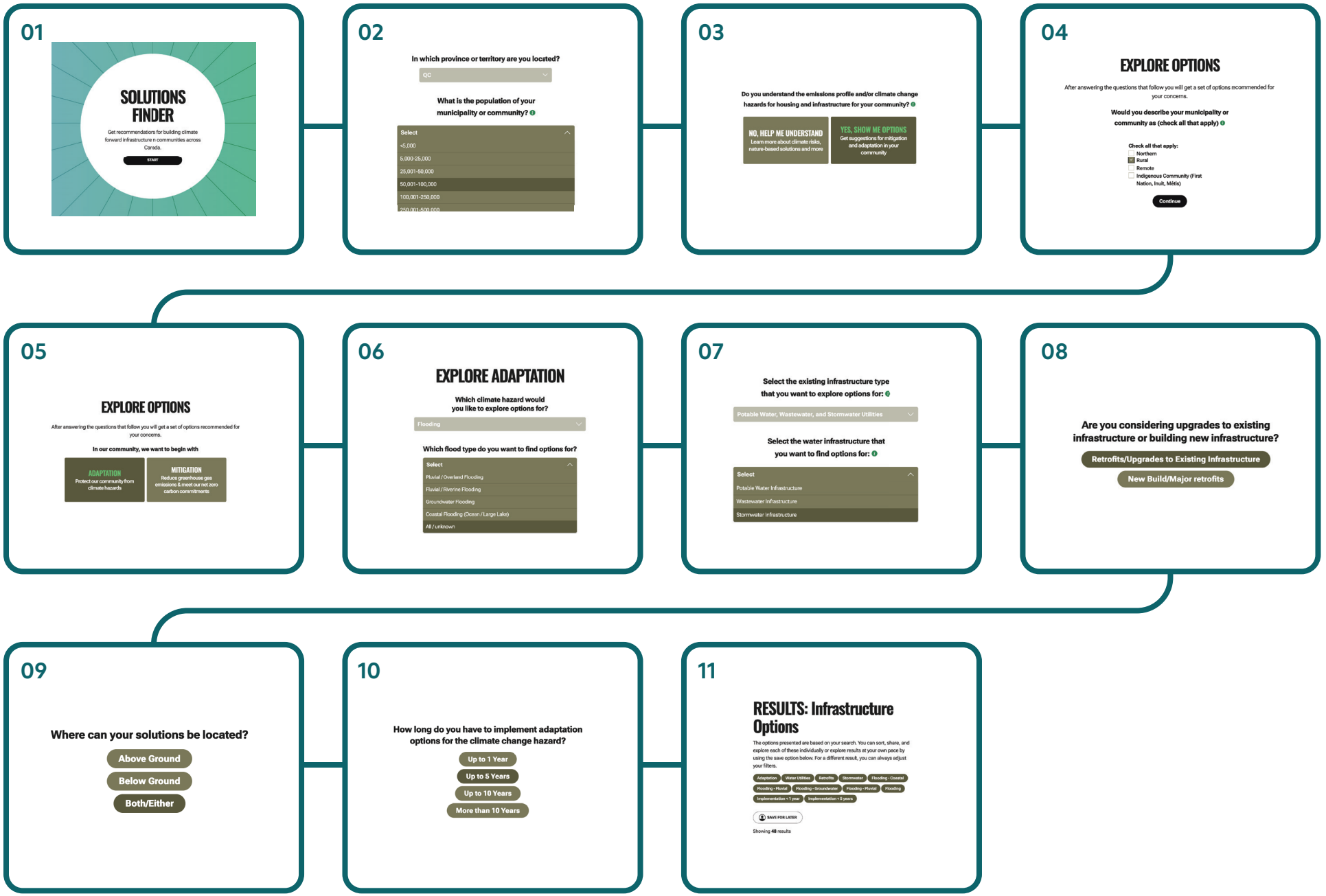


Figure 11: An example of a clickstream leading to adapted infrastructure options on the Climate Insight platform.

Municipal Flood Risk Check-Up

The ICCA's Municipal Flood Risk Check-Up is a self-assessment questionnaire on flood exposure and flood preparedness for municipalities. It takes the form of an Excel worksheet and complements the decision-support pathways set out in Sections 4.3. and 4.5 of this document, which present examples of applications of certain measures listed in the Check-Up.

Answers are analyzed and presented in three results worksheets.

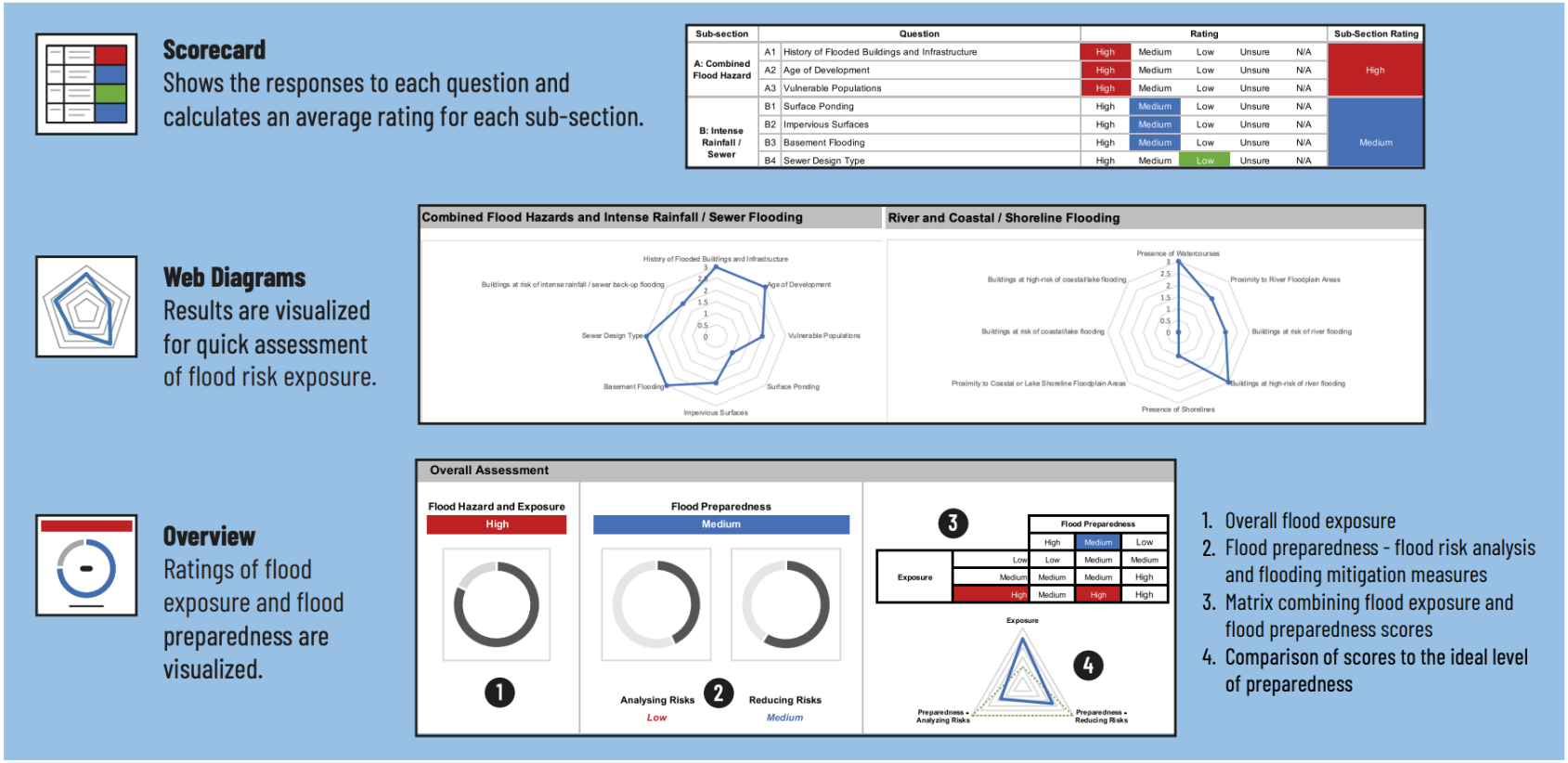


Figure 12: A section of the ICCA's municipal flood risk infographic.

4.2.3 How can we determine where the most vulnerable populations are located?

With its detailed view by neighbourhood, the interactive Healthy Plan City map developed by the University of Toronto, provides insights on 130 Canadian cities' vulnerability to flooding for their entire population as well as several specific categories of vulnerable populations. Healthy Place City, another tool developed by the same research group, uses scores to compare the flood risk of the different areas of the municipalities considered in the tool with other locations in Canada.

01 L'Atlas de la vulnérabilité (in French) is an interactive map of the province of Quebec that shows the distribution of the population's vulnerability to hydrometeorological hazards.

02 The City of Ottawa's Neighbourhood Equity Index is another example of an index that aims to support local planning by considering different categories of vulnerability.

03 Municipalities that are not represented in the above tools can obtain practical tips on assessing social vulnerability and climatic hazards in the University of Waterloo's Inclusive Resilience report.

04 Page 89 of the Territorial Inequities report produced by the Foundation of Greater Montreal and Vivre en Ville (2024) identifies areas of Montreal that are particularly vulnerable to overland flooding by superimposing water-retaining areas maps and disadvantaged areas.

4.2.4 What adaptations can residents undertake themselves?

Every year, the City of Calgary collects and analyzes residents' concerns about climatic hazards. A survey conducted in 2023 showed that far fewer than half of the residents surveyed thought there would be extreme rainfall in the next 10 years, and even fewer had completed flood-specific adaptation measures. These findings show that despite recent events, residents are not taking action. This survey highlights the need for proactive communication about which adaptation measures, plans and tools are most effective to promote residential adaptation to the various hazards that could affect the region.

The Greater Edmonton Region has created a tool that enables residents to explore modifications they can make to ensure their home is better able to cope with various climatic hazards, including flooding. The City of Edmonton's Climate Resilient Home Guide proposes a series of questions (p. 11) residents can ask themselves to get a better picture of their home's vulnerability to flooding.

Promote residential adaptation to regional hazards.

The City of Fredericton has developed a flood-prone homes mapping tool that includes a brief assessment of the flood issues that apply to each address (Figure 13).

The publication of this kind of tool has the advantage of capturing the attention of residents. The tool also includes a Know your System tab that provides residents with tips on how to reduce flooding risk to their home during extreme rainfall.

Empowering risk-aware citizens.

Municipalities may find it beneficial to combine the dissemination of this type of information with financial incentives to empower risk-conscious citizens to implement the suggested prevention strategies.

Figure 13: Results example by selecting a property on the interactive map.

4.3 DECISION-SUPPORT PATHWAYS – UNDERSTAND AND ASSESS

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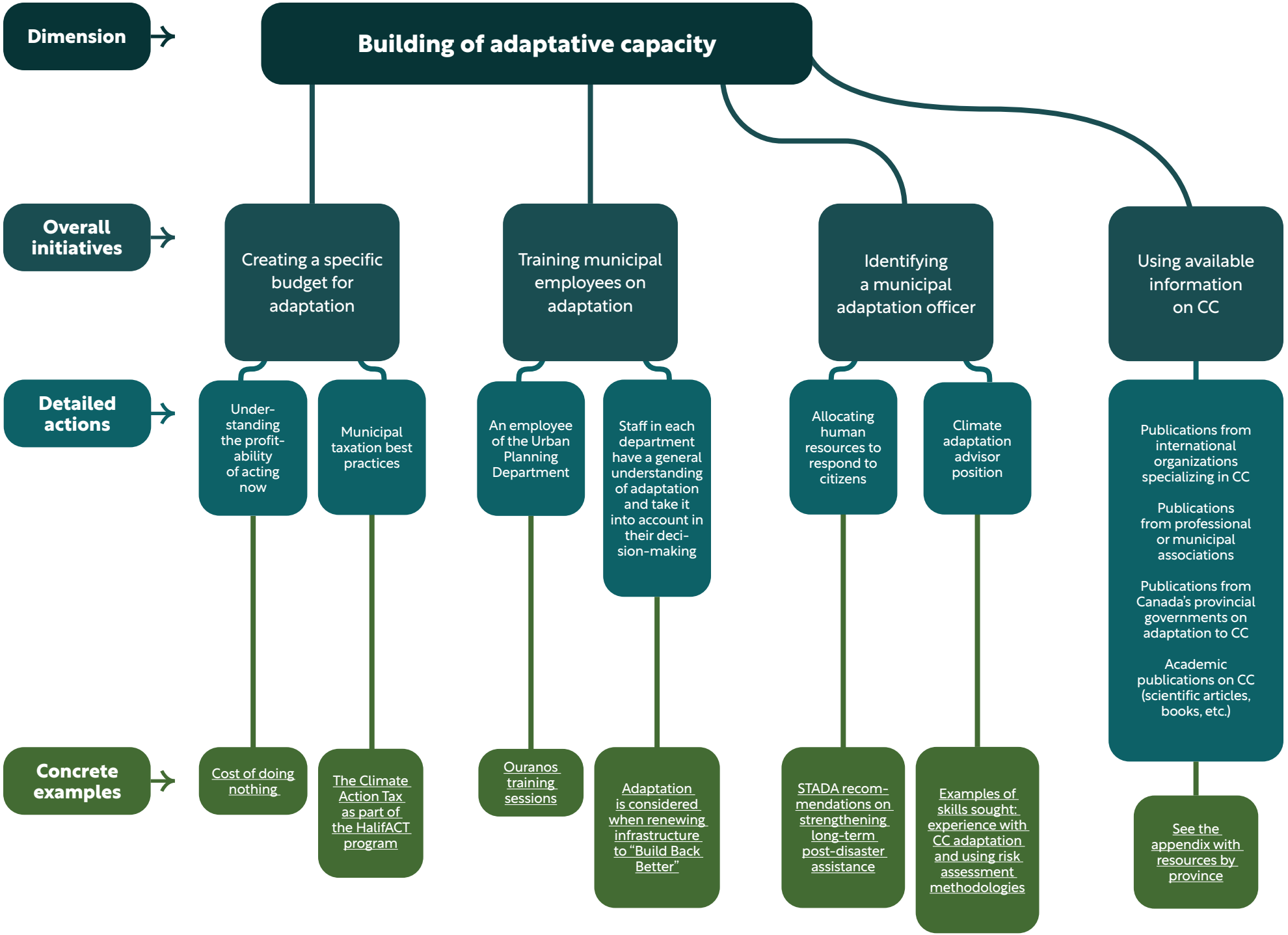
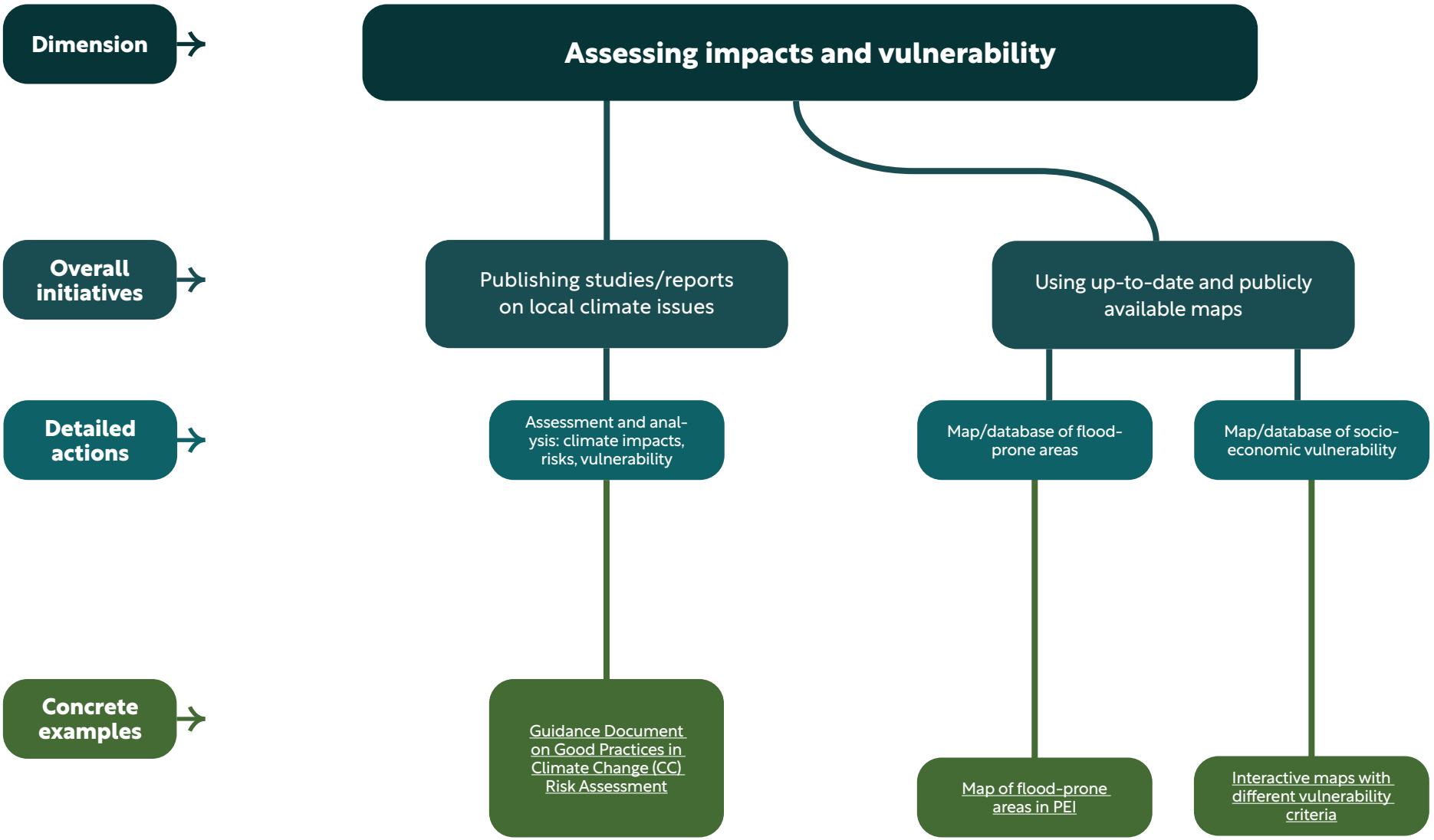
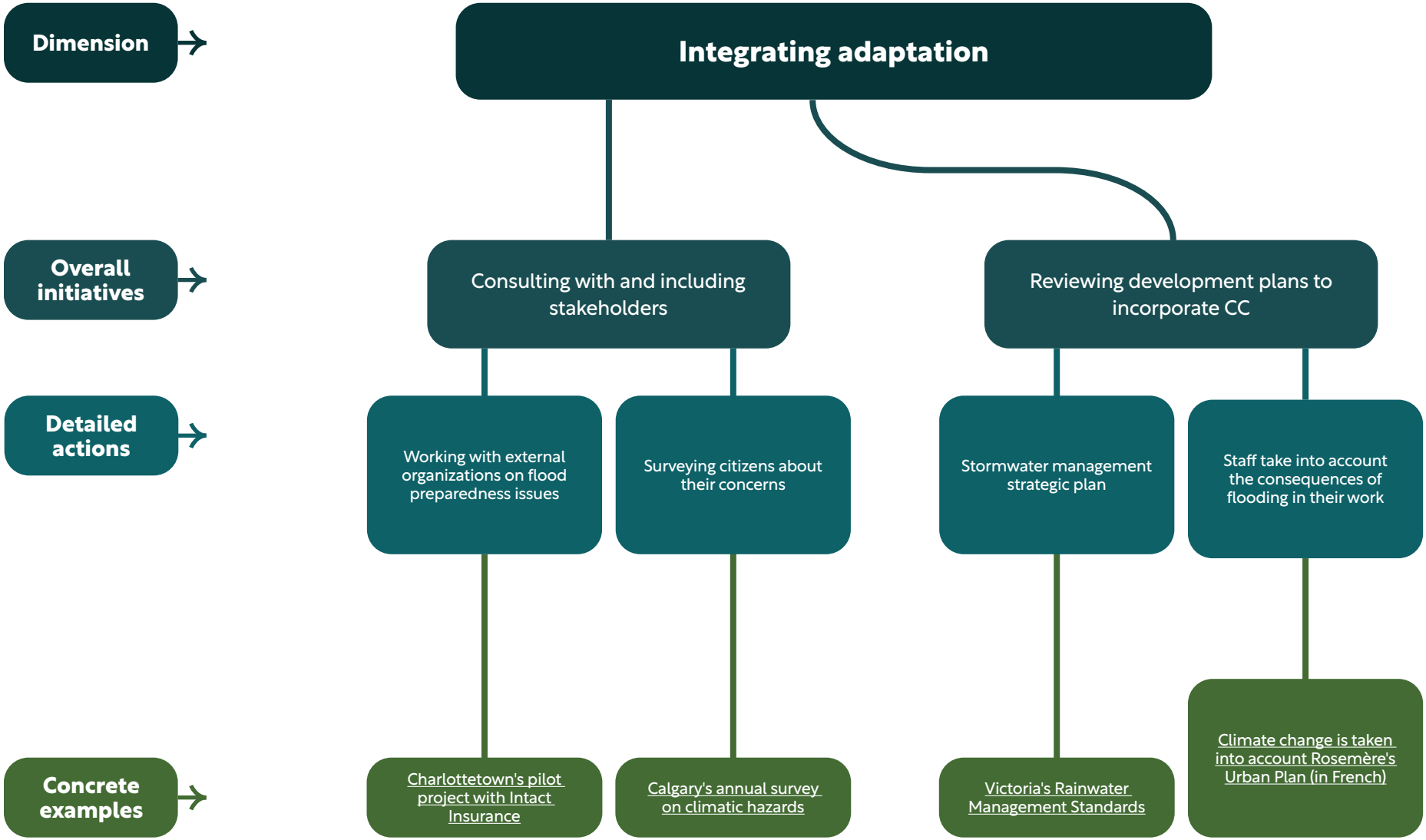
This section covers several of these factors and organizes them in the form of a pathway to inform municipalities on the key factors that should be integrated in an approach to support residents during floods. The pathway presents the concepts in order of increasing specificity (e.g., dimension, overall initiatives, detailed actions, and concrete examples).

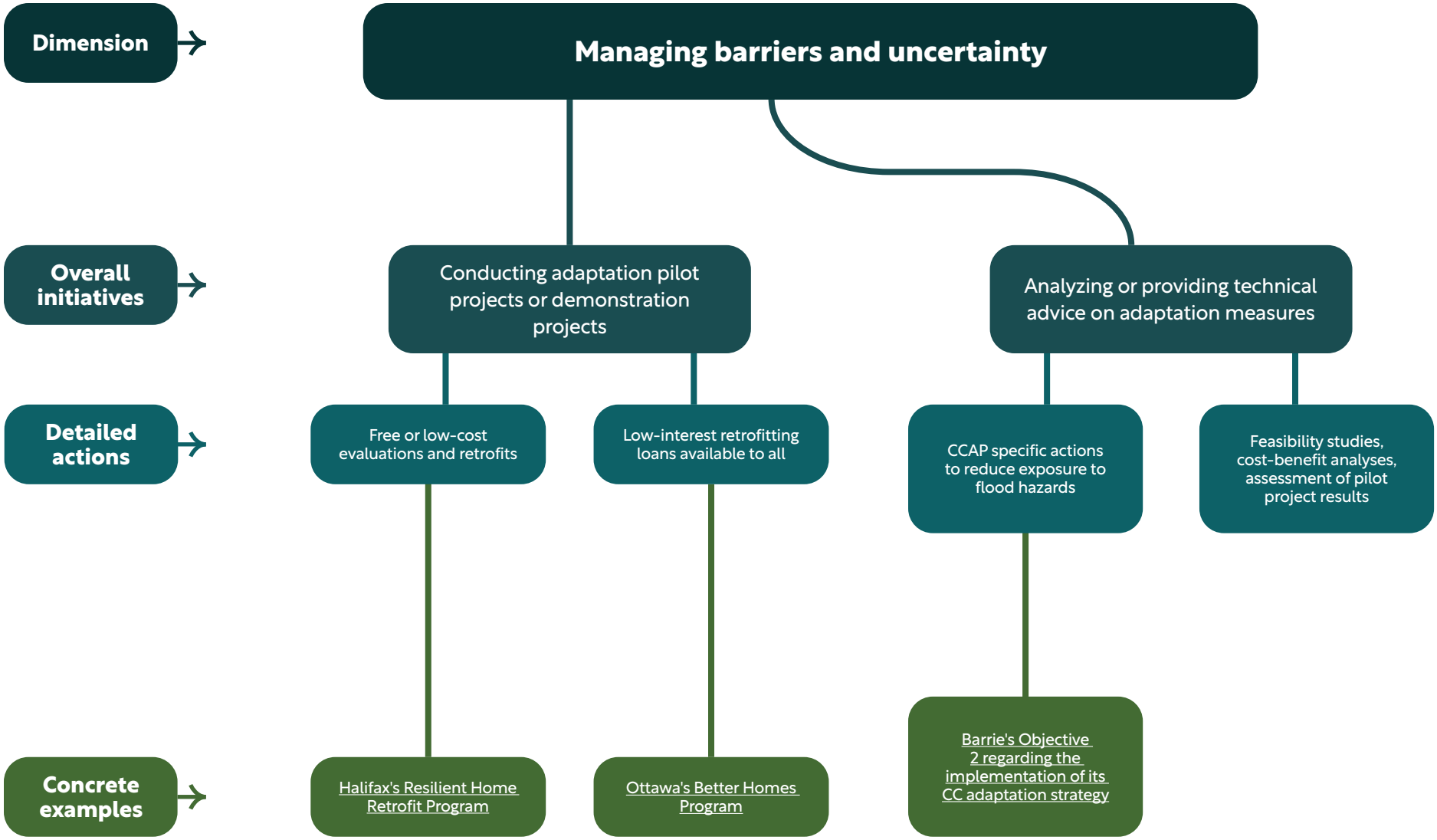
Each example contains a clickable link that takes you to either the appropriate section of this document or the online resource.

The diagrams are inspired by Jacob et al.'s 2022 article entitled Development and validation of an index to measure progress in adaptation to climate change at the municipal level.


Dimension
Building of adaptative capacity
Overall initiatives
Creating a specific budget for adaptation
Training municipal employees on adaptation
Identifying a municipal adaptation officer
Using available information on CC
Detailed actions
Under-standing the profit-ability of acting now
Municipal taxation best practices
An employee of the Urban Planning Department
Staff in each department have a general understanding of adaptation and take it into account in their deci-sion-making
Allocating human resources to respond to citizens
Climate adaptation advisor position
Publications from international organizations specializing in CC
Publications from professional or municipal associations
Publications from Canada's provincial governments on adaptation to CC
Academic publications on CC (scientific articles, books, etc.)
Concrete examples
Cost of doing nothing
The Climate Action Tax as part of the HalifACT program
Ouranos training sessions
Adaptation is considered when renewing infrastructure to "Build Back Better"
STADA recom-mendations on strengthening long-term post-disaster assistance
Examples of skills sought: experience with CC adaptation and using risk assessment methodologies
See the appendix with resources by province


Dimension
Assessing impacts and vulnerability
Overall initiatives
Publishing studies/reports on local climate issues
Using up-to-date and publicly available maps
Detailed actions
Assessment and analysis: climate impacts, risks, vulnerability
Map/database of flood-prone areas
Map/database of socio-economic vulnerability
Concrete examples
Guidance Document on Good Practices in Climate Change (CC) Risk Assessment
Map of flood-prone areas in PEI
Interactive maps with different vulnerability criteria


Dimension
Integrating adaptation
Overall initiatives
Consulting with and including stakeholders
Reviewing development plans to incorporate CC
Detailed actions
Working with external organizations on flood preparedness issues
Surveying citizens about their concerns
Stormwater management strategic plan
Staff take into account the consequences of flooding in their work
Concrete examples
Charlottetown's pilot project with Intact Insurance
Calgary's annual survey on climatic hazards
Victoria's Rainwater Management Standards
Climate change is taken into account Rosemère's Urban Plan (in French)



Opportunity

Conducting regulatory analyses to identify obstacles and barriers

The success of a pilot project can be an additional argument for amending a regulation that acts as a barrier, for example, by limiting public subsidies for residential adaptation projects.

4.4 TAKE ACTION

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This section presents compelling examples of regulatory changes, financial incentive programs for residents, and communication methods that contribute to better residential adaptation to flooding.

4.4.1 Regulations, policies and guidelines

Here are some examples of provincial and municipal regulations, policies, and guidelines that are applicable to stormwater management and the construction, acquisition, or funding of infrastructure.

Stormwater management

Description of the action

Controlling or prohibiting the connection of downspouts (or gutters) to the municipal storm sewer system, whether through the footing drain or by discharging near catch basins, is a popular and effective measure.

Following severe flooding, the City of Windsor (ON) made the disconnection of downspouts mandatory in certain areas of its territory, but offers the service free of charge.

Several cities in Quebec and elsewhere in Canada also have similar regulations throughout their territory, such as the City of Sherbrooke (QC), which applies article 8.1.76 of its bylaw 1300 (in French) to all buildings, regardless of their year of construction.

Stormwater management

Alberta Public Health's guidelines for water reuse and stormwater use explains how to safely implement projects that make use of untreated water from various sources, including stormwater.

The Town of Okotoks (AB) incorporated its stormwater management policy in its Grading and Landscaping Bylaw 37-23. Its policy aims to ensure that 60% of a property's landscaping is permeable (Sections 2.19, 2.26 and 7.4).

Description of the action

Properties' permeability and water retention capacity can also help to reduce the amount of runoff that ends up in public water management infrastructure and thus mitigate the risk of sewer backup.

The Rainwater Management Standards of the City of Victoria (BC) set a citywide rainwater retention target and provide guidelines for implementing various rainwater management methods, such as barrels, cisterns and rain gardens, bioswales, infiltration chambers, permeable paving, green roofs, and education. This technical tool for professionals can help people who want to implement some of these measures on a property.

Construction

Description of the action

Development and retrofitting constraints in flood-prone areas are a means of avoiding exposing residences to a higher level of risk.

The Quebec government's project to modernize the regulatory framework for water environments (in French) is based on a risk management approach that specifically includes people and property. This permanent regime sets out four levels of risk that each permit different types of work.

Section 2.2 of the Okotoks Land Use Bylaw provides a clear example of a constraint applicable to flood-prone areas—the prohibition of basements in new buildings, even in low-current areas.

Acquisition or funding of infrastructure

The City of Fredericton (NB) acquired a large parcel of waterfront land in an effort to promote public access to the river and protect local resiliency. Although this measure does not apply directly to residences, it can have a beneficial effect on the flood risk level.

Description of the action

Purchasing land or properties located in wetlands to preserve the value of the ecosystem services they provide, such as flood prevention due to their high capacity to retain water.

As part of the Getting Ready to Finance Toolkit, participating municipalities identified a series of resilient infrastructure projects that could by financed through private funding. A key element of this program is to connect municipal practitioners with financial experts from the private and public sectors.

Acquisition or funding of infrastructure

The addition of a municipal Climate Action Tax has enabled the City of Halifax (NS) to cover the different in cost between restoring Cole Harbour Park to its original state and building infrastructure to improve resilience to heavy rainfall. Consult Section 4.4.2 of this report for further details.

Description of the action

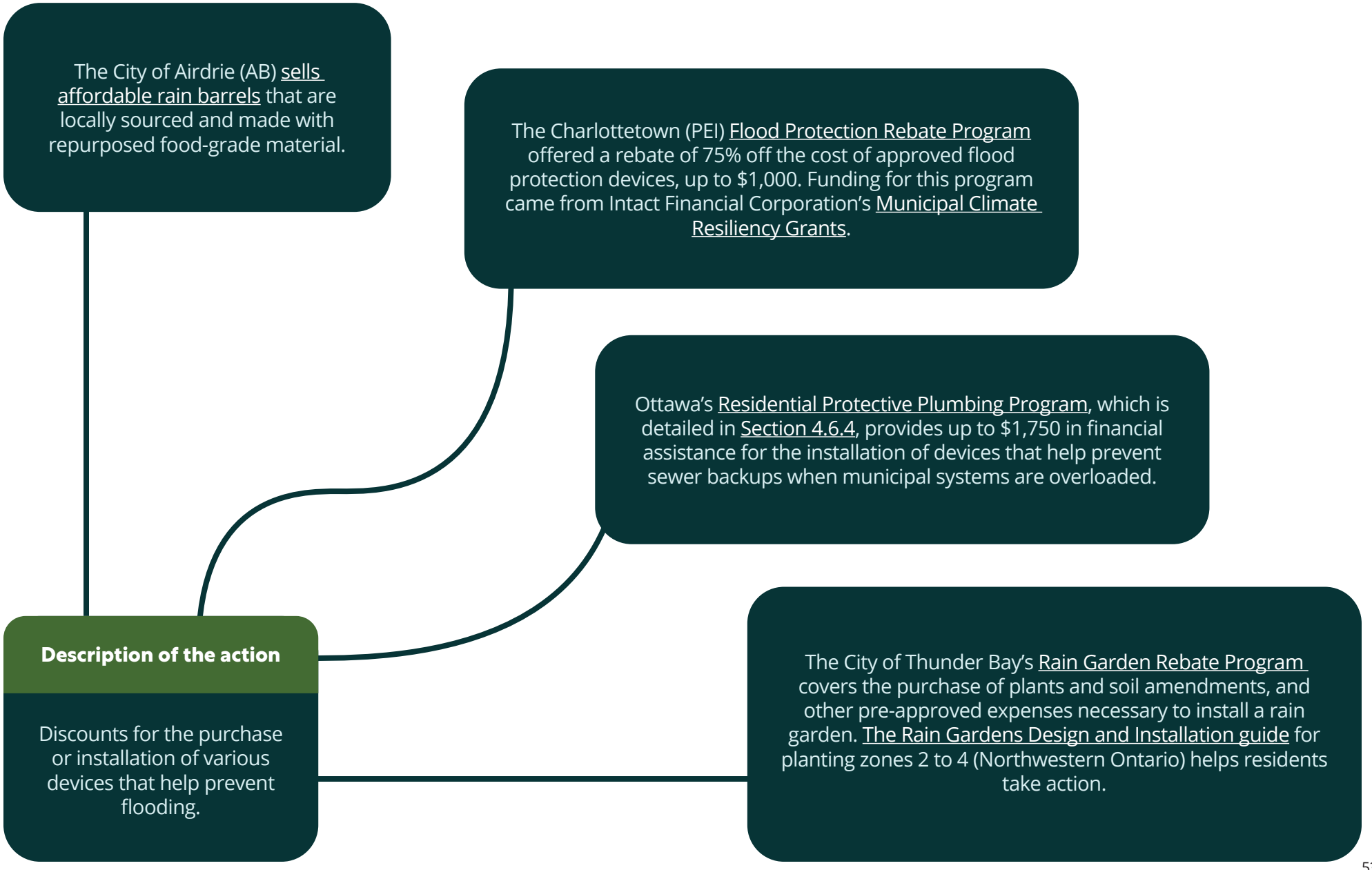
The levying of taxes for climate adaptation and other green taxation measures (in French) are part of the continuum of regulatory and economic tools that can be used by cities for sustainable development (in French), in particular, greater resilience to floods or heavy rains.

In Quebec, the taxation of non-residential parking spaces in cities including Boucherville, Carignan, Gatineau, Laval, Longueuil, Montreal, and Quebec (resources in French for cities other than Laval and Montreal) encourages the demineralization of impermeable areas that contribute to runoff and the overloading of the municipal sewer system during heavy rainfall. This green taxation measure can help fund infrastructure **or incentive programs** and provide numerous co-benefits, such as reducing heat islands, car use and densification (Rettino-Parazelli, 2024).

Taxation even applies to impermeable residential surfaces in some places in British Columbia, Ontario and Saskatchewan, such as Saskatoon, where surcharges were established in 2002 for all types of properties, Mississauga, which followed the examples of Kitchener and Waterloo, and Victoria, Windsor and Ottawa.

4.4.2 Incentive programs

Examples of incentive programs implemented by Canadian cities include:



The City of Thunder Bay (ON) made available to its residents the Residential Drainage Rebate Program promoted by the environmental non-profit EcoSuperior. This program granted eligible owners a rebate of up to $1,750 for the installation of pumps and backwater valves, or the disconnection of footing drains from the municipal system. Certain categories of more financially vulnerable people could also qualify for an additional rebate equivalent to up to 80% of the cost of the work.

The City of Ottawa's Rain Ready Program, which is detailed in Section 4.6.4 of this report, provides financial assistance of up to $5,000 for the implementation of rainwater management projects.

Description of the action

Subsidies or loans for renovation work that facilitates stormwater management.

The City of Montreal's RénoPlex program provides financial assistance for several types of renovation work on buildings with one to five dwellings. Eligible work that could improve flood adaptation includes work on the foundation (e.g., repair of cracks, replacement of a French drain, etc.), the roofing (e.g.,installation of a green roof), the plumbing (e.g, installation of check valves, roof drain diversion, etc.), the garage entrance (e.g., raising the driveway, installing a watertight door, etc.), and the landscaping (e.g., laying of a vegetal surface or honeycomb pavement). The total amount of the subsidies must be minimum $3000. Follow the link to learn more about how the program works.

The City of Windsor provides free downspout disconnection from the municipal sanitary sewer system, explains the benefits of this practice on its website, and even shows residents who want to do it themselves how to do it. As part of its Basement Flooding Protection Subsidy Program, the City also encourages residents to disconnect their foundation drains by reimbursing up to $400 for this measure and provides up to $2,800 in subsidies for all plumbing devices eligible under the program. As indicated in the City's 2020 Sewer and Coastal Flood Protection Master Plan (p. 113), the funding of these programs is estimated to cost $1 billion. The 2024 Budget (p. 561) indicates at least $4.5 million is allocated annually—from the Sewer Surcharge—for all basement flooding reduction measures, including these two programs.

The Better Homes Ottawa pilot program, also detailed in Section 4.6.4, offers low-interest loans to residents who undertake home improvements in a climate change (CC) mitigation and adaptation perspective.

Description of the action

Municipal sewer and water bill rebates.

The City of Victoria's Rainwater Rewards Program offers owners of low-density residences (one to four units) both rebates of up to $1,500 for the installation of targeted rainwater management solutions and a credit of 10% on their annual stormwater utility bill. Owners of larger buildings and IBI may qualify for up to 50% off their annual bill.

The City of Windsor recently published its Stormwater Fee Credit Program Manual, which details how two types of credits applicable to multi-unit and non-residential properties are calculated and administered. The first encourages the installation of structures that control or treat runoff beyond regulatory requirements, while the second is granted for infrastructure that captures runoff from impermeable areas on a property and discharges it directly into the Detroit River or Lake St. Clair.

4.4.3 Communication resources for residents

Whether raising awareness about impacts, assessing risks and vulnerabilities, or implementing actions, the way we have climate conversations is key to inspiring action within our communities. The following are examples of municipal awareness campaigns on stormwater management and flooding.

For municipalities looking to use communications to help implement flood-resilient initiatives, the ICLEI Canada Climate Communications Toolkit is a valuable. This toolkit provides practical strategies, resources, and training opportunities needed to incorporate behavioural insights into climate communications and drive action.

The City of Calgary (AB) made available online a Climate Ready Home Guide for Calgarians, which is specific to the region's unique climatic hazards. The recommendations are organized by hazard, by parts of a house affected, and by times of the year when maintenance should be done.

The City of Charlottetown (PEI) disseminates ICCA infographics such as the one showing the three steps to cost-effective home flood protection.

Description of the action

Guides
for Residents

Landscape Ontario has made available a series of videos explaining how to build a rain garden, which could be useful for other provinces. The association also offers a practical tool that can help you find a professional based on the type of work you are looking to have done.

The Town of Okotoks (AB) makes available on its website the ICLR's guide Protect your home from basement flooding, which explains measures individuals can take to protect their home from basement flooding. Many municipalities in Canada consider this tool to be a useful source of information for residents.

The City of Sherbrooke published an information pamphlet (in French) explaining how to disconnect gutters from the municipal storm sewer system in order to comply with municipal regulations.

In 2019, the City of Airdrie's Water Services increased residents' awareness about water conservation at 10 events and through social media and traditional channels such as newspapers and postcards. Two rain barrel sales drives were successful, with 310 barrels sold (City of Airdrie, n. d.). The communication campaign addressed water use not only outside but also inside the home. Although the measures were mainly implemented to address drought-related issues, they can serve as a model elsewhere in Canada for easing the pressure on infrastructure, including during heavy rains.

Description of the action

Events

Each year, the Town of Okotoks (AB) organizes a very successful open house to inform residents about flooding and emergency procedures. This is an excellent means of communicating with residents given how well-attended it is.

Calgary has also built a web platform that helps residents to better understand its river flood history by popularizing flood recurrence concepts with several explanations and interactive maps, various tables and diagrams, and photos of past floods in the area.

The Resilience projects tab of the interactive map made available by the City of Fredericton (NB) provides an overview of various adaptation projects the municipality has undertaken to prevent flooding. A filter function makes it possible to view them by category. This type of communication resource is useful for increasing public awareness of the efforts the city has made and encouraging residents to do their part by adapting their yards and homes.

The section of the City of Ottawa's website that features its interactive map of flood-prone areas is preceded by a section that describes the map's objectives and the regulatory and climatic contexts that make it relevant, and, more importantly, answer frequently asked questions that address residents' recurring concerns the value of their property may decrease.

Description of the action

Interactive websites and maps

In a context where messages coming directly from the municipality are poorly received, collaboration with third parties can facilitate the transmission of information to the public.

The City of Thunder Bay's Adopt a Storm Drain program administered by EcoSuperior invited residents to select a storm drain to adopt by keeping it clean of debris and obstructions. Drain selection was done using a map of the City of Thunder Bay. Even though the initiative did not generate much interest, it was still useful for educating residents and increasing public awareness.

The City of Prince George (BC) published its Integrated Stormwater Management Plan guiding document that includes a public engagement plan (p. 331).

The National Collaborating Centre for Environmental Health issued A Guide to post-flooding community-level psychosocial response and recovery in Canada, which highlights the importance of building trust and maintaining long-term relationships.

The City of Victoria (BC) developed a communication plan for the implementation of its stormwater utility in 2016. While the utility fees were initially met with opposition, the campaign gave residents a better understanding of the role of stormwater infrastructure and the importance of funding it. The City offered a water bill credit of up to 10% to organizations that helped to educate their employees and the public by posting signage or holding information sessions to explain the stormwater management methods they use. For more information on rainwater surcharges, see Section 4.4.3.

Description of the action

Communication campaigns

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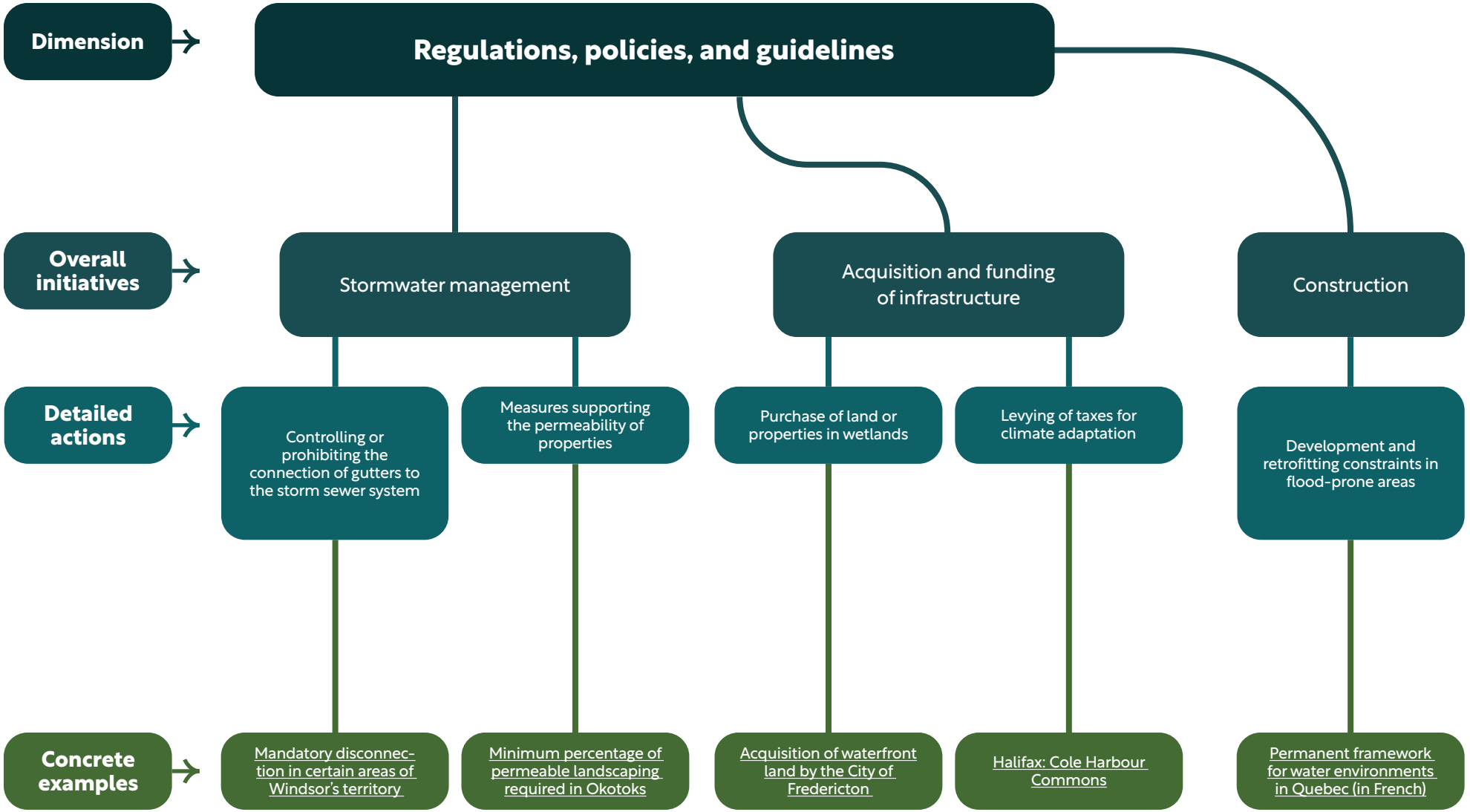
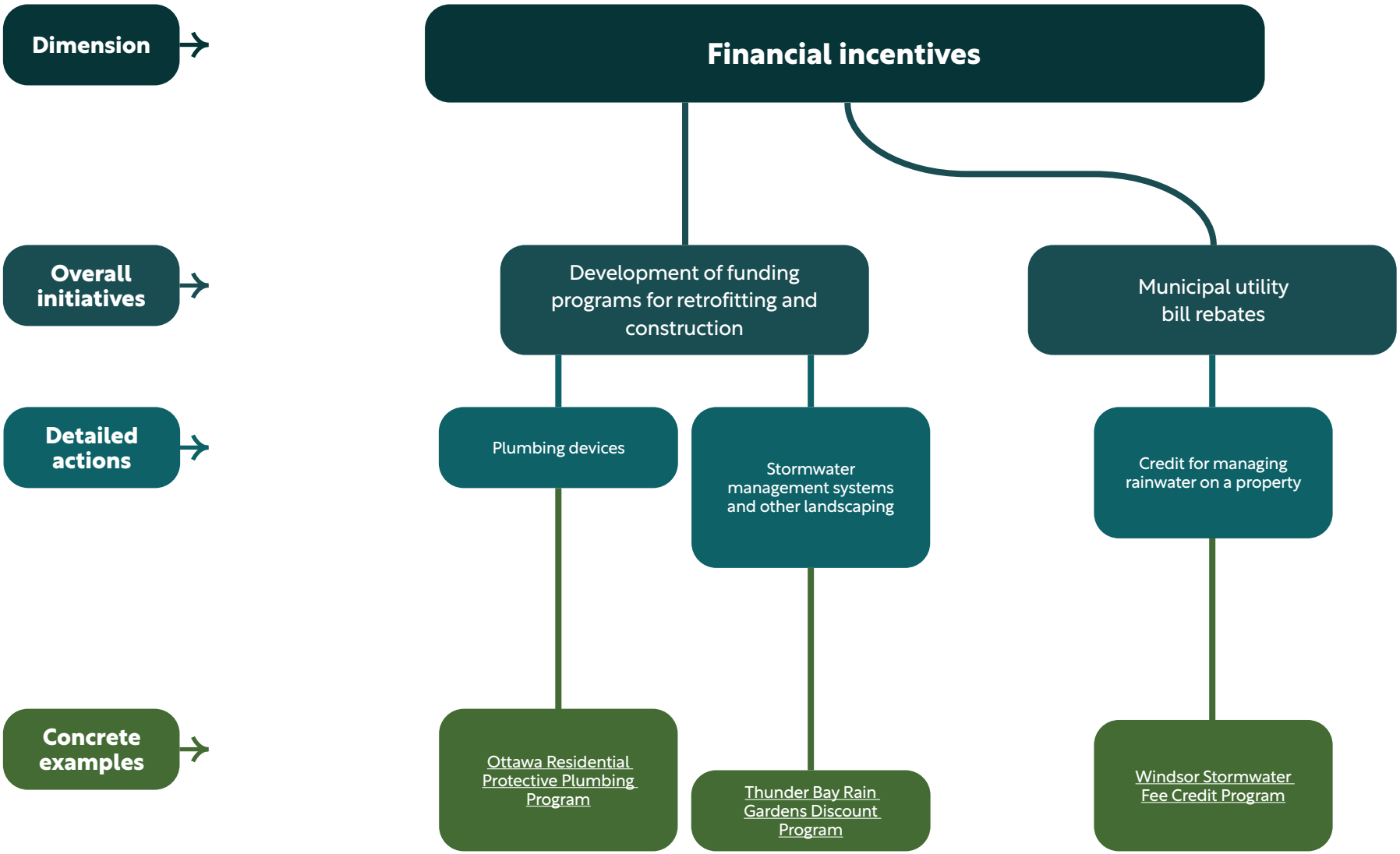
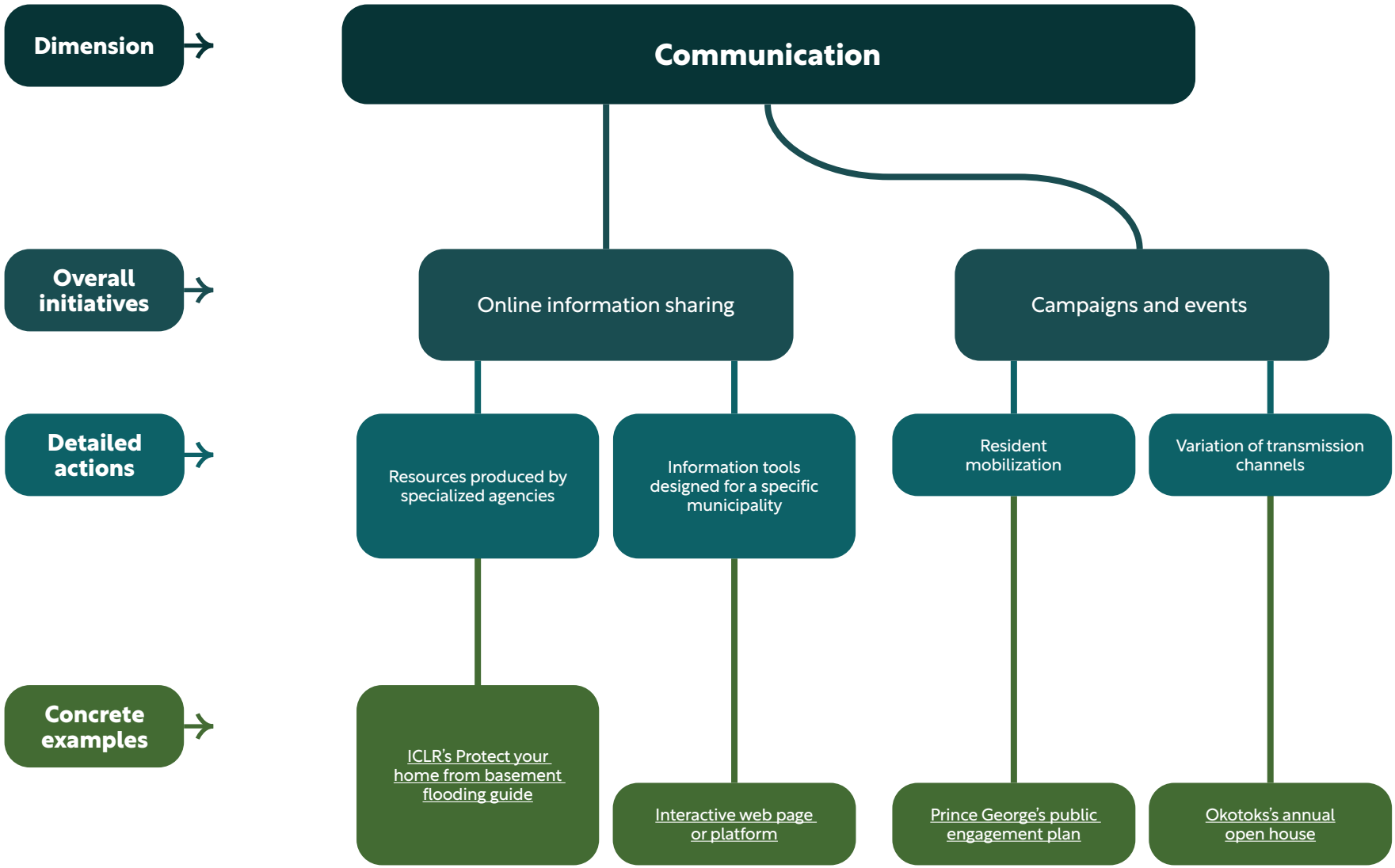
4.5 DECISION-SUPPORT PATHWAYS – TAKE ACTION

The diagrams in this section mainly reflect the steps taken by the municipalities surveyed to promote adaptation to flood risk, which can be found in Section 4.4 Take Action. Each example contains a clickable link that takes you to either the appropriate section of this document or the online resource.

Concrete measures implemented by Municipalities.


Dimension
Regulations, policies, and guidelines
Overall initiatives
Stormwater management
Acquisition and funding of infrastructure
Construction
Detailed actions
Controlling or prohibiting the connection of gutters to the storm sewer system
Measures supporting the permeability of properties
Purchase of land or properties in wetlands
Levying of taxes for climate adaptation
Development and retrofitting constraints in flood-prone areas
Concrete examples
Mandatory disconnection in certain areas of Windsor's territory
Minimum percentage of permeable landscaping required in Okotoks
Acquisition of waterfront land by the City of Fredericton
Halifax: Cole Harbour Commons
Permanent framework for water environments in Quebec (in French)


Dimension
Financial incentives
Overall initiatives
Development of funding programs for retrofitting and construction
Municipal utility bill rebates
Detailed actions
Plumbing devices
Stormwater management systems and other landscaping
Credit for managing rainwater on a property
Concrete examples
Ottawa Residential Protective Plumbing Program
Thunder Bay Rain Gardens Discount Program
Windsor Stormwater Fee Credit Program


Dimension
Communication
Overall initiatives
Online information sharing
Campaigns and events
Detailed actions
Resources produced by specialized agencies
Information tools designed for a specific municipality
Resident mobilization
Variation of transmission channels
Concrete examples
ICLR's Protect your home from basement flooding guide
Interactive web page or platform
Prince George's public engagement plan
Okotoks's annual open house

4.6 BEST PRACTICES IN CANADA – CASE STUDIES

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About ten years ago, the ICLR published the document Cities Adapt to Extreme Rainfall – Celebrating Local Leadership, which contains 20 case studies.

The inspiring case studies cover a wide range of technical, incentive or communication measures that have been implemented by Canadian municipalities at the municipal or residential infrastructure levels and can generally be applied to other municipalities.

It seemed appropriate to use a similar formula—with a smaller sample—by outlining some interesting initiatives that have taken place in Canada since then.

THERE ARE SEVERAL EXAMPLES OF GOOD PRACTICES IN CANADA.

4.6.1 St-André-d'Argenteuil: Laying the foundation for resilient land use

Background

After experiencing historic flooding in the spring of 2017 and 2019, the small municipality of Saint-André-d'Argenteuil (QC) took part in a research project (in French) from 2020 to 2022 with the aim of :

01 Rethinking the city's relationship to water;

02 Reducing the vulnerability of residents that live along the river bank;

03 Planning sustainable development while relocating part of the population located in flood-prone areas (Gauthier and al., 2020).

The Université de Montréal's ARIAction research group (in French) composed of professionals from various fields (i.e., urban planners, architects, landscape architects, engineers, etc.) piloted this action research project in line with its mission to strengthen the resilience of communities. The documentary De vulnérable à résilient (in French) produced by ARIAction presents the approach taken.

Relevance

This project to develop a multi-criteria approach for resilience assessment in flood-prone areas (AMERZI) (in French) aimed to identify resilient and equitable solutions for this municipality located at the confluence of two rivers to enable it to move away from the traditional strategy of "resisting" water.

Using building damage and three additional risk indicators—mental health costs, direct and indirect losses for the municipality, and environmental benefits—the research demonstrated that savings of $1,645,661 can be achieved over 50 years (Thomas & Varsi, 2022)

This project and the recommendations that emerged from it may prove enlightening for municipalities with similar characteristics and issues.

Characteristics	Issues
Small community	Bank erosion
Housing on the banks	Adaptability of the built environment
Cottages converted into residences	Wetland preservation
Aging population	Relocation of residents resulting in a decline in the territory's land value
Spring flooding	

Table 1 : Resilience project in St-André-d'Argenteuil – recommendations.

Planning and implementation

The Ministère de la Sécurité publique du Québec (MSP) allocated $351,000 in funding to the project through the Loss Prevention Framework (Gauthier et al., 2020). The resilient renewal objective was based on a co-construction approach that involved the municipality, the research team, regional organizations, external professionals, the provincial government, and a residents' committee. To ensure that the scenarios developed take into account the new framework for land-use planning in flood-prone areas, the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC) and the Ministère de l'Habitation et des Affaires municipales (MAMH) established a monitoring committee.

Key elements to be replicated

01 Involving residents and applying a co-construction approach that incorporates the municipality and other stakeholders;

02 Using a variety of tools that promote the "emergence of prevention strategies by sector", such as risk analyses and multi-criteria cost-benefit analyses (Thomas & Fakiroff, 2023).

Benefits

01 Increasing public awareness;

02 Highlighting the need for education about watercourse mobility;

03 Boosting the political and social acceptability of possible renewal scenarios;

04 Obtaining several recommendations to build resilience (Appendix 1).

Challenges and lessons learned

01 There is still a strong desire among citizens to divert water rather than learn to live with it. People who have been affected by flooding in the past never want to have problems of this kind again. Awareness campaigns were needed to explain to citizens, for example, that a solution that protects only their land by blocking water can be harmful to their neighbours.

02 A period of transition between the completion of the research project and the adoption of building retrofit measures by citizens is to be expected. It takes time for citizens and entrepreneurs to develop confidence in the measures proposed by research and experts. More well-known—but not necessarily appropriate—work, such as land grading, has been carried out on properties despite recommendations to take other measures instead.

03 There is not funding available for all the measures suggested by the project.

04 Even if people manage to protect their homes, they need psychological resources to avoid becoming isolated during long-term flooding.

05 Because the flood mapping of this region is not up to date, it is difficult to know which factors to rely on to determine which adaptation measures are appropriate for a specific building.

4.6.2 Halifax: Build Back Better (BBB) and the residential retrofit pilot project

Background

In 2020, the Halifax Regional Municipality adopted **HalifACT: Acting on Climate Together**, which is a climate action movement aimed at achieving carbon neutrality by 2050 and adapting to climate change. The implementation of HalifACT has created jobs in sectors such as energy efficiency and building energy retrofitting. A Climate Action Tax (CAT) was introduced to implement the strategic initiatives of HalifACT and leverage climate action funding from the private sector and the federal and provincial governments to ensure sufficient funds for HalifACT's success in the years to come.

The CAT funds projects and programs that support HalifACT outcomes, including climate change mitigation and adaptation efforts, with major projects ranging from acquiring electric buses to retrofitting existing municipal buildings. Some CAT funds support the **Small Projects Fund**, which subsidizes climate action initiatives such as distributing free trees. This measure has helped to integrate climate change in municipal operations and fostered a prototyping culture.

However, after Hurricane Fiona, devastating wildfires and extreme flooding, there was a need to fund major capital projects focused on increasing infrastructure resilience.

As assets reach the end of their life span, are damaged by extreme weather, or need to be repaired, it is possible to build back better to increase the resilience of infrastructure and communities.

The CAT therefore supports resilient critical infrastructure projects by funding improvements and new designs adapted to the impacts of future extreme weather events. The transparency exhibited and the explanations provided regarding the inclusion of the CAT in the tax bill are worth noting. This funding is reserved for work conducted by a municipal department on public infrastructure.

Examples of eligible work	Possible uses of funds
Increasing the size of culverts	Entire projects (in some cases)
Upgrading roads and bridges	Design work for more resilient options
Using heavier-duty materials	Difference in cost compared to identical reconstruction
Improving stormwater management capacity	
Building green infrastructure	

Table 2 : Work funded by the CAT.

How does it work?

A department that wants to obtain CAT funds for a project must complete the appropriate internal form and prepare a business case for the project in question.

The reasons for requiring additional funding and wanting to make the project more resilient must be detailed. The department in charge of the BBB program can also approach other municipal departments about projects that would meet the criteria and increase the sustainability of infrastructure.

Mapping tools for long-term planning

The Climate Layering Program combines data on climate risk, socio-economic characteristics, critical infrastructure, and the state of public assets by layering maps to make it easier to identify priority areas for climate adaptation efforts. This method also makes it possible to prioritize the most vulnerable areas when planning upcoming construction sites and the upgrading of infrastructure as it reaches the end of its useful life. BBB is one program that uses the Climate Layering Program to inform decision-making.

Example of Cole Harbour Commons

Halifax took inspiration from the transformation of Mississauga's Eastgate Park (Figure 15) into a stormwater management facility. Cole Harbour Commons is vulnerable to heavy rainfall and has experienced many episodes of flooding (Figure 14). At the moment, the park is nothing more than a soccer field, but work will take place next summer to add a multisolving functionality and carry out the necessary work on the field and also building flood-resistant infrastructure funded by BBB.

Figure 14: Cole Harbour Park, Halifax.

Figure 15: Eastgate Park, Mississauga

For residents

While the program is limited to municipal public infrastructure, Halifax promotes the concept of build back better with stakeholders across the province and the country. This approach could be extended to private buildings in partnership with insurance companies and provincial governments to be able to also build back better at the residential level after disasters. This has in fact been achieved in Halifax under the Financing Resilient Infrastructure Project (FRIP) carried out in partnership with ICLEI and Co-operators. The FRIP has funded work to make the roofs of homes destroyed by wildfires more resilient.

Residential assessment and retrofitting **pilot project** in partnership with Clean Foundation

Background

This program was led by the Nova Scotia non-profit Clean Foundation, which advocates for positive environmental change, and was completed in 2024. The City of Halifax, the Town of New Glasgow and the Province joined forces to create the Resilient Home Retrofit (RHR) Program.

Participants were recruited using a number of measures, including door-to-door canvassing, the distribution of leaflets, information sessions, and word of mouth. A total of 20 residences were selected in two neighbourhoods that were not only at risk of flooding but also vulnerable from a socio-economic point of view.

How it works

Two types of assessment professionals were sent to the homes: one for energy efficiency and the other for flood risk. They then had to submit reports. The flood risk report identified issues such as cracks in foundations, a lack of pumps, and clogged gutters. Ten of the 20 residences assessed benefited from the free installation of various solutions, including rain gardens, pumps, batteries or new gutters, depending on their needs.

Challenges and lessons learned

There were several reasons for the limited access to retrofitting that was observed: a tight budget allowance, renovations being deemed optional, or the risk of flooding being deemed lower than expected. The program nevertheless generated a lot of enthusiasm, even knowing that the retrofit portion was not guaranteed. The enthusiasm observed for this project also highlighted that similar future initiatives are relevant.

4.6.3 Victoria: Surcharges to make homeowners accountable for their water management

Relevance

The stormwater utility fee contributes to the City's financial health and promotes decreasing stormwater at the property level. By encouraging property owners to manage their own rainwater, the City eases the pressure on its infrastructure and improves stormwater quality.

CITIES CAN EASE THE PRESSURE ON INFRASTRUCTURES.

How it works The fee is based on the specific characteristics of a property. The following table shows the different factors that influence the amount of the fee:

Impervious area	Street frontage	Type of property	Compliance with stormwater regulations – Codes of practice
Impervious area refers to hard surfaces such as roofs, parking areas and driveways. Rainwater flows off these surfaces and is diverted into the stormwater management system.	Keeping our streets clean goes a long way to keeping our stormwater clean. This is determined by the length of the property's frontage and the street type.	The intensity code refers to the impact a property has on the stormwater system, based on the property type, as determined by B.C. Assessment:	The municipal stormwater bylaw requires that certain types of properties comply with prescriptive practices to clean stormwater before it leaves a property. The annual rate per registered property is $191.78.
Imperious surfaces have been measured by building plans, aerial photographs and GIS mapping technologies. The impervious area rate is $0.8391 per square metre.	The street cleaning rate is charged per metre of street frontage and varies according to the type of street[2] : Local : 2,00$ Collector : 4,23$ Arterial : 4,78$ Downtown : 47,69$	Low-density residential : 0$ Multi-family residential : 87,72$ Civique/ institutionnelle : 76,63$ Commercial/ industrial : 161,81$	10 or more parking spaces Automotive businesses, recreational facilities, recycling operations and storage yards On-site construction activities

Thus, for a single-family residence with 12 metres of street frontage, a 98 m^2 roof and two 10 m^2 parking spaces, the annual fee would be **$147.30.**

[2] Note: Low-density residential properties are charged the local streets rate regardless of the type of street.

Table 3 : Rainwater management fee – Adapted from the City of Victoria.

Key elements to be replicated

A communication and engagement plan was developed to shape the incentive program, share information, and gather feedback on the proposed public stormwater utility. The feedback informed the final Rainwater Rewards Program and helped to adjust the final utility fee model.

Communicating the impacts of the charges and the characteristics considered for each property prior to the first year of billing helped prepare property owners for the transition to the new utility.

A key element of the program was to improve transparency, as the charges are directly related to a property's impact on the stormwater system and the services the property receives.

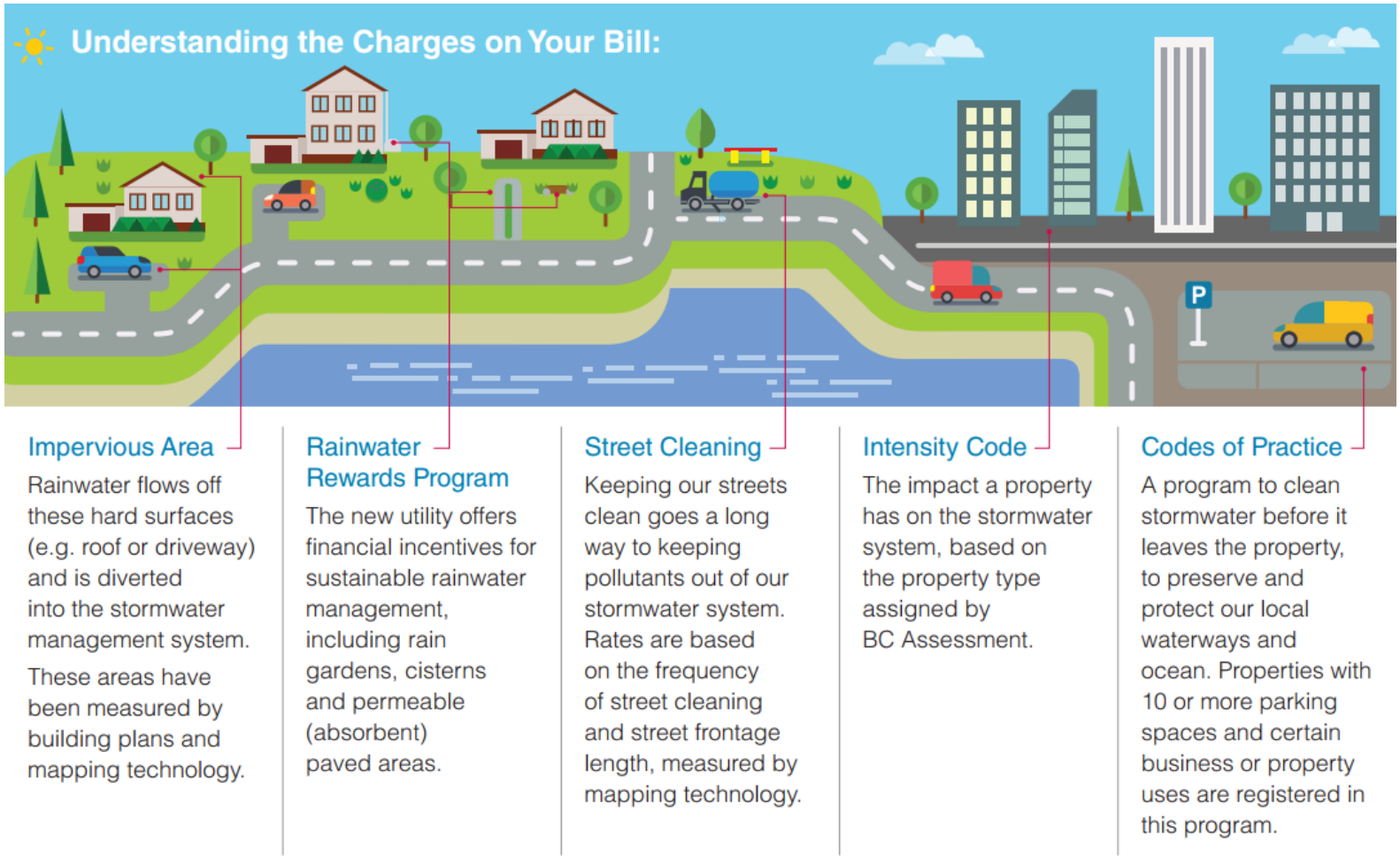


Figure 16: Infographic published by the City of Victoria when the fee was introduced. Source: Arnold, 2018.

The Rainwater Rewards Program the City introduced in collaboration with its stormwater utility offered owners of low-density residences (one to four units) both rebates of up to $1,500 for the installation of targeted rainwater management solutions and a credit of 10% on their annual stormwater utility bill. Owners of larger buildings and IBI could qualify for up to 50% off their annual bill.

The City also offered a water bill credit of up to 10% to organizations that help to educate their employees and the public by posting signage or holding information sessions to explain the stormwater management methods they use. Technical documents were produced to support the implementation of the program.

Challenges

The target audience for these incentives was new real estate projects that could incorporate the stormwater management approaches from the design phase. However, because housing costs have risen significantly in Victoria since the program was introduced, the voluntary nature of the program has often led to cutbacks, and its development has stagnated. Furthermore, minimal promotion of the program among low-density residential property occupants resulted in very few retrofit rebates being granted. Despite these challenges, the City has seen consistent participation in the program for new real estate projects, particularly those undergoing a rezoning process.

The complexity of stormwater management charges is due to the adoption of an approach that is as transparent and representative of impacts as possible. This led to a complex calculation methodology that required a new billing system. In addition, a large number of enquiries were received after the first two years of billing despite efforts to proactively communicate billing details. Staff have invested a great deal of time in responding to these enquiries.

Lessons learned, success factors and positive outcomes

01 Financial sustainability: The city has started to contribute to the stormwater utility's financial reserves.

02 Implementation of green infrastructure: Although it has been modest, implementation has been increasing steadily since the program was launched.

Finally, for a more detailed picture of the factors that contributed to the successful implementation of the fees, see the article "Stormy fees: Stormwater user fees can reduce flooding risk and improve municipal finances" on the website of Canada's Ecofiscal Commission, which sums up "Victoria's secrets" nicely.

Elsewhere in Canada

Other Canadian cities have also adopted fee-based systems for water use, including storm sewer services. To learn more about the different calculation methods used, click on the links below.

01 Windsor (ON) :

- Sewer Surcharge Calculation – Explains the different components of the fee (changes expected in 2025)
- Stormwater Fee Credit Program Manual – Explains how credits are determined for certain types of properties

02 Ottawa (ON) :

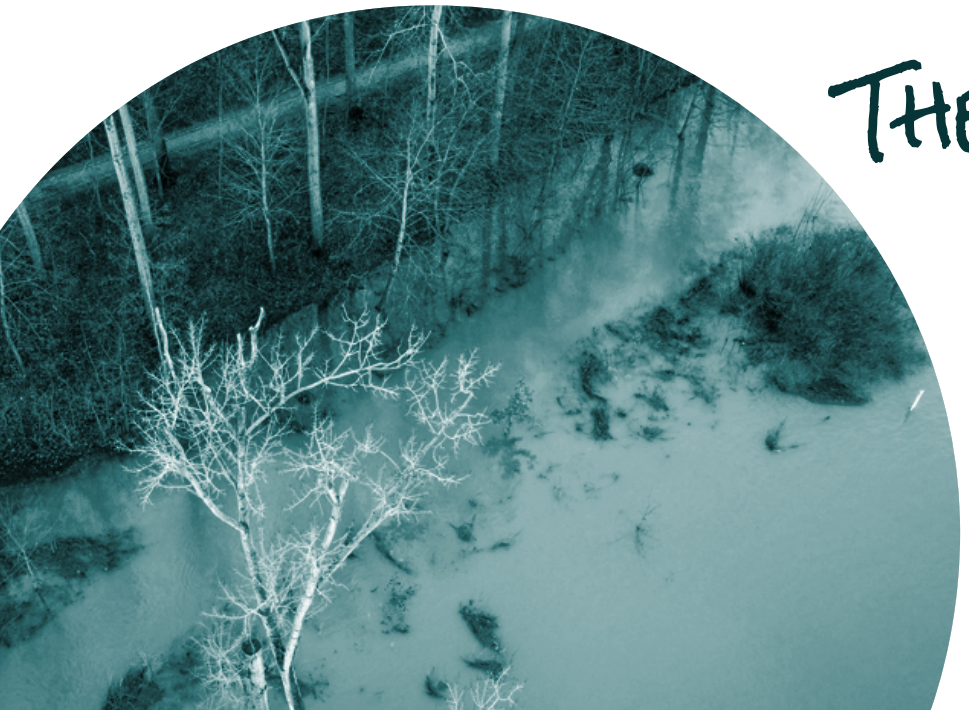
- Water rates and fees – Meter size, property type, connection and consumption
- Understand your water utility bill – Explanatory video in the first tab of the drop-down menu
- Water billing rates increasing April 1, 2024 – Informs citizens about how fees are used

4.6.4 Ottawa: a multitude of incentive programs for residential adaptation

The City of Ottawa has implemented several programs to support Ottawa residents who wish to make additions or modifications to their residence aimed at building resilience to rainfall events and preventing flooding.

Rain Ready Ottawa (RRO)

Under the Rain Ready Ottawa program, residents can get up to $5,000 in rebates for installing a series of onsite residential stormwater management practices. Incentives are targeted toward people living in priority stormwater retrofit areas.



THE CITY OF OTTAWA HAS LAUNCHED A NUMBER OF PROGRAMS TO SUPPORT ITS CITIZENS.

These priority areas were identified through the City's stormwater retrofit study process, which recommended the retrofitting of onsite stormwater management to private properties in urbanized watersheds in order to meet current and projected stormwater runoff volumes.

The five rebates offered are as follows:

Key elements to replicate

01 Downspout Redirection and Disconnection (up to $1,000);

02 Rain Garden Installation (up to $2,500);

03 Installation of a soakaway pit or infiltration trench (up to $2,500);

04 Permeable Hardscapes (up to $5,000);

05 Landscaping by fusion certified landscaper ($500).

To be eligible, residents need to either complete the online courses available through the program page or work with a fusion certified professional (FLP) landscaper to access the rebates.

The City also offers stormwater management home assessments to certain property types to help them identify the best solutions, these assessments can subsequently be used for rebate eligibility. The types of installations are also well explained on the program page.

Utilizing a multidisciplinary approach of community engagement, industry partnerships, and education, the program has received 169 rebate applications for 277 individual projects to date. Approximately $435,000 in rebates have been awarded, and this has been matched by a private investment of $2.5 million, for a combined investment of $2.9 million in onsite stormwater management through RRO. Figure 17 provides an overview of the outcomes of the program to date.

Figure 17 Ottawa's incentive program outcomes.

Residential Protective Plumbing Program (RPPP)

Through the Residential Protective Plumbing Program, residents can receive rebates to support the installation of protective plumbing devices such as backwater valves and sump pumps to prevent basement flooding resulting from surcharging in the City's system. The program is available City wide but is targeted toward homeowners who reside within older neighborhoods that have combined or partially separated sanitary and sewer systems.

Since 2016, approximately two-hundred and sixty (260) residents have applied to the program, with approximately $350,000 in funding being awarded.

Table 4 provides an overview of the rebate amounts available to residents :

Element	Maximum amount
Permit	80 $
Inspection of sanitary sewerby CCTV	100 $
Storm sewer inspection by CCTV	100 $
Check Valve (Sanitary Sewer Only – Interior)	700 $
Check Valve (Storm Sewer Only – Interior)	500 $
Check valve (sanitary and storm sewers – interior)	1000 $
Check Valve (Storm Sewer Only – Exterior)	1750 $
Sump pump with backup battery (steep flow slope or flat roof)	1250 $

Table 4 : Amounts awarded under the Plumbing Device Installation Incentive Program - City of Ottawa.

The program page includes a Q&A explaining different flood prevention backflow prevention devices, and links to IPSC documents and vignettes such as the popular Basement Flood Prevention Guide.

It also includes some diagrams such as Figure 19. The program is currently undergoing an update to streamline the application process, increase rebate amounts, and add new project types. It is anticipated that the changes will be implemented starting April 1, 2025.

Link to Council Report: Residential Protective Plumbing and Compassionate Grant Program – Review and Proposed By-law and Program Updates - Environment and Climate Change Committee - February 18, 2025

Residents who experience recurring basement flooding as a result of surcharging are also eligible for the City's Compassionate Grant Program. The program provides grants of up to $1,000 to assist with damage caused as a result of a basement flood.

Better Homes Ottawa Loan Program (BHLOP)

This pilot program provides homeowners with access to between $10,000 and $125,000 for additions or renovations to improve the energy efficiency and climate resiliency of their homes. Households with incomes below the program thresholds or who receive certain listed government assistance can still get a loan without interest and administrative fees, which are now 4.33% and 4% of the total loan value under the program, respectively. The zero-interest loan is also available to homeowners who rent homes below the average market price as established by CMHC criteria for specific areas of Ottawa. The loan and interest are repaid over a 20-year period, through an amount added to property taxes or in a single payment if prepayment is chosen.

Although the program is primarily aimed at energy retrofits, flood prevention and resiliency retrofits can be bundled in so the loan can cover them as well. Applicants can apply to Better Homes, RPPP, and the Rain Ready program to maximize their options for building flood and rainfall resilience. Eligible expenses from the two categories shown in Table 5 may be relevant to flood prevention :

Water efficiency	Climate adaptation
Low flow toilets	Backwater valves
Hot water pump and circulation system[3]	Sump pumps
Grey water treatment system	Waterproofing basements[5]
Closed circuit shower water recovery system	Permeable pavements
Rainwater harvesting system[4]	Tree planting

Table 5 : Example of measures eligible for the loan when combined with an energy measure – Sustainable Homes Ottawa.

[3] Aims to improve the efficiency of hot water flow so that water runs for less time
[4] Subject to eligibility criteria.
[5] Under appropriate conditions only: Although foundation waterproofing can prevent water infiltration into the basement, it may not be suitable in situations of high hydrostatic pressure.

To access the loan, applicants must complete a pre-retrofit an EnerGuide assessment. This will indicate which measures will allow for further energy savings and will offer recommendations to this effect. Other supporting resources are available as part of the program to help plan the modernization work.

This program has several advantages for Ottawa residents compared to similar federal programs, including the location and availability of the service, the duration of the loan, the fact that the loan is attached to the home on which the renovations are carried out and not to the person requesting it, and finally, the amount of the total loan that can be granted.

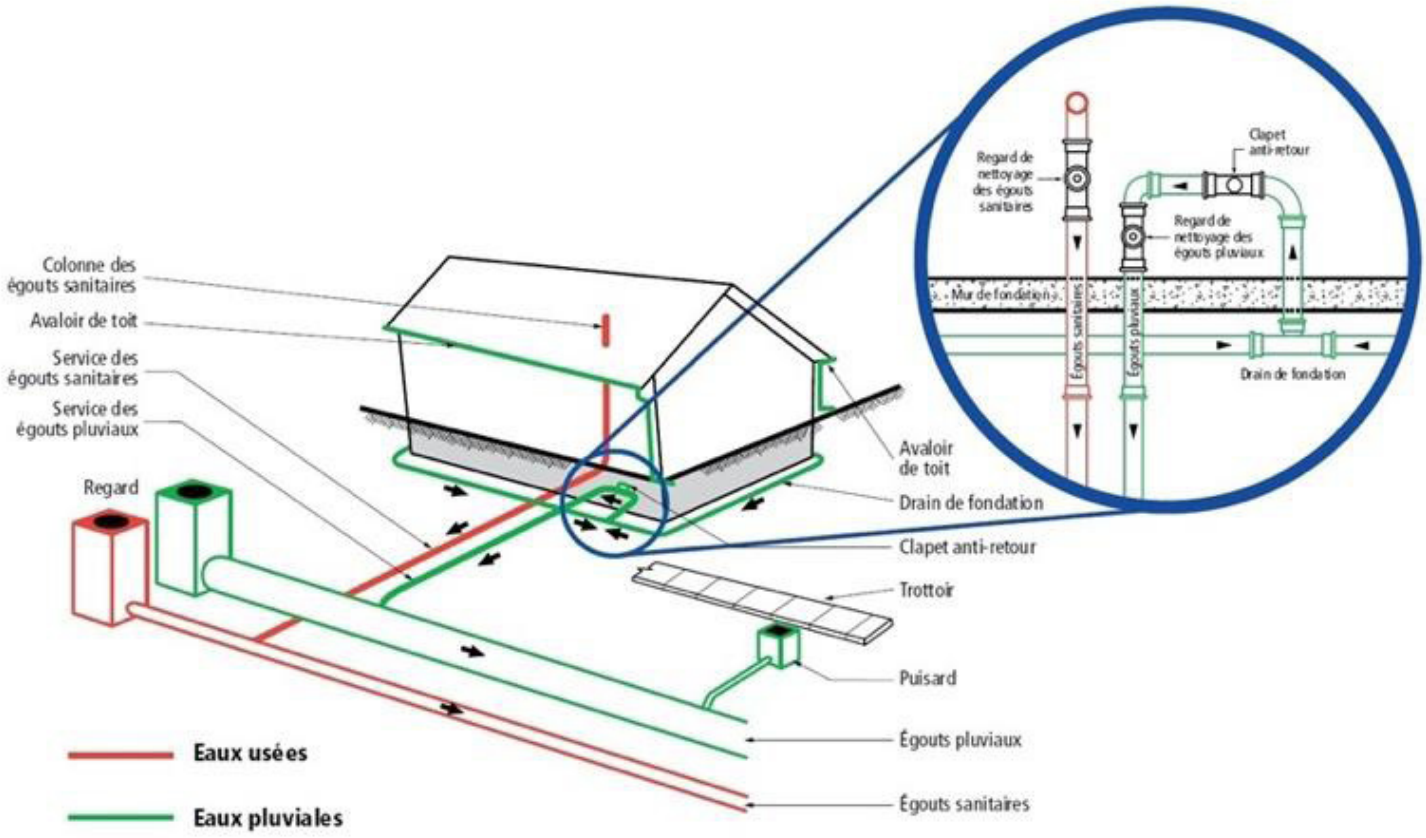


Figure 18 : Backflow prevention devices for sanitary and storm sewers, Source: City of Ottawa.

05

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CONCLUSION

5 CONCLUSION

This first guidance document covers the main concepts that municipalities must bear in mind in their iterative approach to flood adaptation. We hope to improve it over time.

Climate resilience is a long and complex journey that is full of successes and obstacles. Actions taken should not be limited to public spaces. All spaces must be reconsidered in order to incorporate climate resilience principles. Municipalities and their citizens must work together on flood management in both public and private spaces. Private spaces must also be invested in to reduce the impacts of flooding on homes.

Municipalities are making progress in this regard, one action at a time. They are implementing more and more adaptation measures to reduce the risk of residential flooding. Monitoring and evaluation of these actions will be essential to ensure that actions deliver desired results and reporting is transparent and thorough. For this to happen, rigorous data collection, regularly updated maps, and ongoing engagement with residents will be crucial. Insurers will also have a unique role to play in providing innovative financing options such as partnerships with the private sector, including SMEs and promoters.

Following multiple flood events in recent years, the time has come to take advantage of the increased efforts being made to implement resilience programs so that Canadian municipalities can make the necessary shifts to adapt to climate change.

CLIMATE RESILIENCE IS A LONG AND COMPLEX ROAD.

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7 APPENDIX

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7.1 Appendix 1: Definitions of water damage from the IBC

01 Sewer backup

A phenomenon that occurs when, for example, the water table rises or when urban sewer pipes become pressurized during a storm. The buildup of pressure causes water to reverse back up through the main outflow pipe in the house to emerge through drains in showers, sinks or toilets. This type of damage can be prevented through the installation of a backflow prevention valve on the main outflow drain in a house.

02 Overland flooding

Whatever the cause, a significant increase in the water level on surfaces not usually submerged can cause water to flow into homes through doors and basement windows.

Overland flooding events can last weeks, and the prolonged exposure to water can cause structural damage to buildings. Hydrostatic pressure exerted on the structure by the weight of stagnant water acting on the walls and doors of a building (lateral pressure) as well as on the foundation (uplifting) can lead to subsidence. Contaminants from local landfills, oil tanks and septic fields can penetrate the surfaces.

Fungi and mould can seed behind drywall during a flood event, flourish later and cause health issues if not removed. Reconstruction[6] and renovation can take over a year and often requires homeowners to find alternative living arrangements for a lengthy period of time.

03 Seepage

Water seeping through foundations or seams in the building intended to be watertight. Unlike other types of events, seepage is typically not a sudden event.

04 Water and sewer lines

Some insurers are providing protection for the water and sewer lines connected to homes in the event that they leak, break, tear, rupture or collapse.

[6] Note that in Quebec, for example, rebuilding in flood-prone areas following a flood is prohibited. Voluntary demolition followed by resilient rebuilding is also prohibited. Rebuilding is only authorized following a natural disaster such as a fire.

Sources : Adaptation of the IBC document A Primer on Severe Weather and Overland Flood Insurance in Canada, (2019, p. 8) with additional details taken from the AWBQ's Living With Water Project.

Appendix 2: Recommendations for flood resilience issues

Recommendations to strengthen flood resilience in Saint-André-d'Argenteuil – adapted from "Comment réaménager des collectivités résilientes" in Faire face aux risques (Thomas & Fakiroff, 2023; in French).

01 Knowledge of the risk

- Document the vulnerability of different areas
- Incorporate speed and duration in flood hazard mapping criteria

02 Sharing of skills and resources

- Share budgets and services to develop support networks
- Incorporate uncertainty and alternatives in emergency management
- Ensure the transfer of competencies and knowledge about local issues

03 Learning and innovation

- Develop experience feedback mechanisms within the institutions and agencies involved in emergency management, and share results and lessons learned
- Install forecasting tools, monitor water levels, and make them public
- Develop and share data on standards for the height of main floors

04 Improvement of communication, education, and perception

- Develop communication strategies that are tailored to local issues and specific audiences
- Create communication tools that are tailored to stakeholders' needs, concerns, priorities, and values
- Place flood level marks and explanatory signage about flooding in strategic locations
- Monitor citizens' Facebook and social media posts, and ensure accurate information is being shared

05 Strengthening of long-term post-disaster assistance

- Provide psychological support and address other health issues
- Accompany the victims in their claims for compensation
- **Support victims in the resilient transition of their building (adaptation or relocation)**
- Ensure regular monitoring of the condition of the buildings and the adaptation measures

06 Support and capacity building

- Regularly update land-use planning rules and programs
- Provide training on regulations and assistance programs, and ensure the retention of support staff

07 Regional adaptation to local issues

- Rethink land-use planning and adaptation by sector in accordance with strict regulations and innovative tools
- Consider adaptation and protection as complementary tools in a systemic perspective
- Integrate different spatial and temporal scales, and ensure upstream/downstream solidarity between municipalities
- Develop pre-emption (or other) programs for buildings in high-risk areas to facilitate the relocation and renaturalization of the most at-risk sectors
- Develop a funding program to facilitate the adaptation of buildings
- Develop a specific program for the protection of built and architectural heritage
- Fund and promote resilient projects
- Regulate the development of areas subject to urban scattering

08 Strengthening of collaboration

- Ensure stakeholders collaborate and information is shared
- Establish collaboration protocols between stakeholders and municipalities ahead of crises
- Train, manage, and share volunteers

7.3 Appendix 3: Additional resources –Canada-wide and by province

01 Canada-wide

- Data and information they need to build low carbon, climate-resilient housing and infrastructure | Climate Insight
- Flood resources for your province or territory | Government of Canada
- Flood maps listed by province and territory | FloodSmart Canada
- Funding opportunities for climate change adaptation | CLIMAtlantic
- ClimateData.ca
- Flood mapping in your province or territory
- Technical guidance document for the design of flood-resistant buildings and supplementary technical report for existing buildings | NRC
- Standards and guidance : Assets and hazards (filter using with the term "flood")

02 Quebec

- Stormwater management guide (in French)
- Flood-prone areas map | CMM (temporary; in French)
- Flood-prone areas map | MELCCFP (in French)
- What to do before, during and after a flood
- Financial support | Quebec government
- Prepare an Emergency Kit and [a] Household Evacuation Plan
- Best practice fact sheets on land-use planning in the context of climate change (in French)
- S'ADAPTER AU CLIMAT – Guide pour une réglementation municipale adaptée aux changements climatiques | Union des municipalités du Québec (in French)
- Climate change adaptation planning – A guide for municipal bodies | Ouranos Consortium
- Guide de bonnes pratiques sur la planification territoriale et le développement durable | MAMH (in French)
- Adaptation measures by Quebec municipalities: Progress and determinants according to deprivation level | Jacob, J. and Valois, P. (2024)
- Comment prévenir les inondations dans le sous-sol de ma résidence | Ville de Sherbrooke (in French)
- Steps to follow to protect homes and the health of occupants in case of flooding | SHQ (in French)
- Flood information with Web Vigilance | Ministère de la Sécurité publique (in French)
- Fiches de bonnes pratiques de gestion des eaux pluviales | Ville de Montréal (in French)

03 Ontario

- Education Curriculum for Youth (elementary and secondary)
- Rain Gardens Design and Installation
- The Municipal Collection System handbook (simplification of the ICLR document)
- Page listing various sources of conservation information for landowners

01 Saskatchewan

- Flood Damage Reduction Program

02 British Columbia

- City of Prince George Integrated Stormwater Management Plan Guiding Document
- Sunshine Coast Regional District Property viewer
- SCRD Homeowner Guide to Building Permits

03 Alberta

- Flood Awareness Map Application
- Guidelines for improving the climate resiliency of homes | Climate Resilient Home (CRH)

7.4 Appendix 4: List of municipalities surveyed in summer 2024

Municipalité	Province
Airdrie	**Alberta**
Calgary	**Alberta**
Charlottetown	**Prince Edward Island**
Fredericton	**New Brunswick**
Halifax	**Nova Scotia**
Muskoka	**Ontario**
Okotoks	**Alberta**
Ottawa	**Ontario**
Prince George	**British Columbia**
Rosemère	**Quebec**
Saint-Raymond	**Quebec**

Municipalité	Province
St-André-d'Argenteuil (STADA)	**Quebec**
Sudbury	**Ontario**
Sunshine Coast Regional District	**British Columbia**
Thunder Bay	**Ontario**
Victoria	**British Columbia**

8 GLOSSARY

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This glossary is based mainly on the glossary of the sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2023), the Guidance on Good Practices in Climate Change Risk Assessment report (CCME, 2021), and the Guide for Municipal Climate Adaptation (ICLEI Canada, 2010).

01 Adaptation

In human systems (including built systems), the process of adjustment to current or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.

02 Adaptive capacity:

The ability of built, natural and social systems to adjust to climate change (including climate variability and extremes), moderate potential damages, take advantage of opportunities or cope with the consequences.

03 Climate change

Changes in long-term weather patterns caused by natural phenomena and human activities that alter the chemical composition of the atmosphere through the buildup of GHG, which trap heat and reflect it back to the Earth's surface.

04 Climatic hazard

The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

05 Exposure

The presence of people; livelihoods; species or ecosystems; environmental functions, resources and services; infrastructure; or economic, social or cultural resources or property in a place or setting that may be affected by climate change.

06 Extreme weather event

A meteorological event that is rare at a specific place and time of the year (e.g., intense storm, tornado, hailstorm, flood or heat wave), and is beyond the normal range of activity. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability.

07 Flood-prone area

An area of land that becomes occupied by a watercourse when the watercourse overflows its banks.

08 Flood risk area

A sector that is likely to be flooded because it has been flooded in the past, is a flood-prone area, or is exposed to water accumulation (e.g., basin areas in urban environments).

8 GLOSSARY

09 Impacts

The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability.

10 Maladaptation (or maladaptive actions)

Actions that may lead to increased risk of adverse climate-related outcomes (including via increased GHG emissions), increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Maladaptation is rarely intentional.

11 Mitigation

The promotion of strategic, regulatory or project-based measures that help stabilize or reduce GHG concentrations in the atmosphere. Renewable energy and energy efficiency programs are examples of climate change mitigation measures.

12 Resilience

The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.

13 Risk

The potential for adverse consequences for human or ecological systems. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic changes and human decision-making.

14 System

Water and ecosystems, infrastructure and buildings, and socio-economic interactions.

15 Vulnerability

The predisposition of a system or an individual to be adversely affected. This factor combines sensitivity or fragility with the ability to cope with and adapt to a new situation.

9 LIST OF ACRONYMS

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AAL

Average annual loss

CCME

Canadian Council of Ministers of the Environment

CMHC

Canada Mortgage and Housing Corporation

CMM

Communauté métropolitaine de Montréal (Montreal Metropolitan Community)

EDI

Ministère des Affaires municipales et de l'Habitation

FCM

Federation of Canadian Municipalities

FPI

Flood protection infrastructure

GIS

Geographical Information System (SIG in French)

IBC

Insurance Bureau of Canada (BAC in French)

IBI

Industries, businesses and institutions

ICCA

Intact Centre on Climate Adaptation

ICLR

Institute for Catastrophic Loss Reduction (IPSC in French)

IDF

Intensity-duration-frequency

IPCC

Intergovernmental Panel on Climate Change (GIEC in French)

MAMH

Ministère des Affaires municipales et de l'Habitation

MELCCFP

Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs

NPO

Non-profit organization

NRC

National Research Council Canada

NRCan

Natural Resources Canada

OQACC

Observatoire québécois de l'adaptation aux changements climatiques

P.E.I.

Prince Edward Island

SHQ

Société d'habitation du Québec

UMQ

Union des municipalités du Québec

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