Climate change adaptation planning

A guide for municipal bodies

2024

Ouranos

Québec

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Executive summary

The climate change adaptation plan development guide is a tool designed specifically to facilitate adaptation action by Québec municipal bodies by means of the assessment and treatment of climate change related risks.

This guide of best practices reflects the Québec government's climate change policy orientations and complements support tools pertaining to the development of climate action plans endorsed by the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) and the Ministère des Affaires municipales et de l'Habitation (MAMH). It seeks to support municipal bodies and the Québec government in attaining their climate change action targets. It must be used in conjunction with the other tools available, particularly those designed to support municipal bodies in the development of greenhouse gas emission reduction plans. Indeed, most municipal bodies opt to undertake integrated planning to fight climate change that encompasses both adaptation to climate change and greenhouse gas reduction, thereby ensuring coherence and bolstering synergies in the context of climate change fighting.

This guide proposes a comprehensive methodology to allow for the assessment and treatment of climate risks in the context of the development of a climate change adaptation plan. It is based on numerous existing methodologies in this field and mainly follows the ISO 14090, 14091 and 31000 standards that present climate change adaptation and risk management guidelines. It also considers the MELCCFP's *Directive pour l'appréciation et le traitement des risques liés aux changements climatiques*. The risk assessment methodology that was selected for this guide is the risk matrix. Several bodies and organizations in the world have already tested the methodology and it has proven effective in the context of adaptation planning.

The first section of the guide outlines the conditions for success inherent in the adaptation process, which consider the principles of multidisciplinarity, equity, and social acceptability.

The second section proposes five key steps to successfully carry out an adaptation process:

- Step 1: Setting up the project team
- Step 2: Establishment of the objectives, scope, and framework of the process
- Step 3: Climate risk assessment
- Step 4: Climate risk treatment
- Step 5: Production, monitoring, and revision

While the guide is based on a structured process, it should be noted that the method presented is flexible, adjustable, and open-ended. A critical reading of the document is therefore recommended in light of the municipal body's specific context. Municipal bodies must align their adaptation needs, priorities, and resources with the good practices recommended in this guide to determine a formula suited to their situation, key concerns, and applicable government requirements.

Acronyms

AIAOD: *Act respecting industrial accidents and occupational diseases*

ALUPD: *Act respecting land use planning and development*

AOHS: *Act respecting occupational health and safety*

APSAM: Association paritaire pour la santé et la sécurité du travail

AZDP: Agricultural zone development plan

CBA: Cost-benefit analysis

CMIP: Coupled Model Intercomparison Project

CMM: Communauté métropolitaine de Montréal

CMQ: Communauté métropolitaine de Québec

CNG: Cree Nation Government

COGESAF: Conseil de gouvernance de l'eau des bassins versants de la rivière Saint-François

CRE: Conseil régional de l'environnement

DFO: Fisheries and Oceans Canada

DSP: Direction de santé publique

ECCC: Environment and Climate Change Canada

EIJBRG: Eeyou Istchee James Bay Regional Government

EQA: *Environment Quality Act*

FADOQ: Fédération de l'âge d'or du Québec

FCM : Federation of Canadian Municipalities

FQM: Fédération québécoise des municipalités

GDD: Growing degree-days

GHG: Greenhouse gases

GLPG: Government land-use planning guidelines

GPPH: Government Policy of Prevention in Health

HVAC: Heating, ventilation, and air conditioning

INFC: Infrastructure Canada

INSPQ: Institut national de santé publique du Québec

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organization for Standardization

ISQ: Institut de la statistique du Québec

JBNQA: *James Bay and Northern Quebec Agreement*

KRG: Kativik Regional Government

LUPDP: Land use planning and development plan

MAMH: Ministère des Affaires municipales et de l'Habitation

MCC: Ministère de la Culture et des Communications

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

MLUDP: Metropolitan land use and development plan

MP: Master Plan

MPA: *Municipal Powers Act*

MRNF: Ministère des Ressources naturelles et des Forêts

MSP: Ministère de la Sécurité publique

MSSS: Ministère de la Santé et des Services sociaux

MTMD: Ministère des Transports et de la Mobilité durable

MTRAV: Ministère du Travail

NGO: Non-governmental organization

NPO: Non-profit organization

NAV: Net Asset value

PNAAT: *Politique nationale de l'architecture et de l'aménagement du territoire*

PNSC: Plan national de sécurité civile

PNSP: Programme national de santé publique

PPTFI: Plan de protection du territoire face aux inondations

PRDIRT: Regional plan for integrated land and natural resource development

PRMHH: Regional wetlands and water bodies plans

RBQ: Régie du bâtiment du Québec

RCM: Regional county municipality

RCP: Representative Concentration Pathway

RLRUP: Regional Land and Resource Use Plan

ROBVQ: Regroupement des organismes de bassins versants du Québec

SIZ: Special intervention zone

SODEC: Société de développement des entreprises culturelles

SOPFEU: Société de protection des forêts contre le feu

SPAIP: Site planning and architectural integration program

SSP: Shared Socioeconomic Pathways

UMQ: Union des municipalités du Québec

UPA: Union des producteurs agricoles

UT: Unorganized territory

VRAC-PARC: Regional climate change vulnerability assessment and design of regional public health climate adaptation plans (VRAC-PARC)

WO: Watershed organization

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Introduction

Adaptation to climate change is a critical challenge facing municipal bodies. Climate change is already present in Québec and will intensify in the coming decades. The social, environmental and economic repercussions are already apparent across the region and will become more pronounced in the future. Indeed, even if the worldwide implementation of robust greenhouse gas (GHG) emission reduction measures eventually curtails global warming, their impact will nevertheless intensify because of past and present GHG emissions.

What constitutes a municipal body and for whom is this guide intended?

In Québec, municipal bodies encompass local municipalities, regional county municipalities, metropolitan communities, agglomerations, cities, boroughs, northern villages, the Kativik Regional Government, and the Eeyou Istchee James Bay Regional Government. This guide is intended for such bodies but can also be of use to groups of municipal bodies or Indigenous communities.

Québec in a changing climate

Since the industrial revolution, human activities have contributed to climate change worldwide through atmospheric GHG emissions. Underlying trends such as increasing temperatures, changing precipitation patterns, rising sea levels, and permafrost thaw reveal changes in Québec's climate. The proliferation of extreme meteorological phenomena such as the number and duration of heatwaves, droughts, and heavy rainfall is also noteworthy.

Changes observed to date in Québec:

- more significant warming in the winter than in the summer; [1 2 3]
- more rapid warming in northern Québec; [1 2 3]
- increased total annual precipitation. [2 3 4]

Other changes anticipated in Québec by the end of the century:

- a shorter cold season that begins later and ends earlier; [3 4]
- generally milder winters; [2 3]
- increased snow cover in the north and reduced snow cover in southern, eastern and central Québec; [4]
- longer hot seasons; [3 4]
- an increase in the number of very hot days and heatwaves;
- a reduction in the extent and duration of sea ice cover in the north;
- increased permafrost thaw;
- longer thunderstorm seasons; [2]
- an increase in the number of rain events; [2 4]
- an increase in the frequency and intensity of forest fires; [5]
- an increase in summer and fall flooding in northern Québec. [2 6]

Projected global warming varies substantially depending on the GHG emission scenario used, especially in the long term. Projected warming in Québec is systematically more significant than the global average and Northern Québec will be more substantially affected than southern Québec (Table 1).

Table 1: Estimated global warming and warming in Québec according to three GHG emissions scenarios (changes calculated in relation to the period 1850–1900)

	Medium term (2041-2070)				Long term (2071-2100)			
	Global		Québec		Global		Québec	
GHG scenario	Median (°C)	10-90e (°C)	Median (°C)	10-90e (°C)	Median (°C)	10-90e (°C)	Median (°C)	10-90e (°C)
SSP2-4.5	1.97	1.69-2.64	3.41	2.78-5.92	2.38	2.14-3.45	4.24	3.48-7.90
SSP3-7.0	2.22	1.91-2.69	4.08	3.04-5.72	3.33	2.89-4.13	5.89	4.93-8.06
SSP5-8.5	2.47	2.12-3.04	4.58	3.90-6.10	3.75	3.45-5.04	7.26	6.09-9.76

Note: These values are calculated using model outputs from Ouranos' ESPO-G6-R2 dataset. Please consult the "Data sources of climate profiles" page for additional information.

For more information:

See Appendix A, which presents climate fact sheets for Québec's administrative regions.

Climate change impacts

Climate change impacts affect both anthropic and natural systems. With regard to anthropic systems, climate change can affect the operations of municipal bodies, the built environment, the health and well-being of communities, and the economy. As for natural systems, climate change can affect several of their characteristics, including their biodiversity, quality, and the ecosystem services that they provide. The severity of climate change impacts on anthropic and natural systems depends on factors such as the frequency, duration, intensity, and extent of climate hazards, territorial and population vulnerabilities, and risk management capacity.

For more information:

See Appendix B, which presents certain climate hazards and possible related impacts in the municipal context. Climate change does not cause such climate hazards but exacerbates them.

The urgent need to implement measures to tackle climate change

The message in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[7] is unequivocal:

The urgency and complexity of the climate crisis demand adaptation measures of an unprecedented depth and scale. The complementarity and balance between mitigation and adaptation are the key to tackling the climate crisis.

Several recent studies suggest that adaptation to climate change represents a profitable investment for municipal bodies. Indeed, it has been shown that in several situations the cost of inaction exceeds adaptation costs. In other words, costs stemming from damage caused by climate change would be greater than the requisite investments to prevent such damage.[8] The Canadian Climate Institute has calculated that the proactive adoption of adaptation measures halves climate change-related costs, and when such adaptation is combined with a global reduction in emissions, they would be divided by four.[9]

The complementarity of mitigation and adaptation

Mitigation and adaptation are the two central concepts for addressing the climate crisis. Although they do not operate on the same scale, it is important to implement them in symbiosis to generate net benefits in the fight against climate change and minimize costs.[10 11] Adaptation alone thus has its limits when it is not accompanied by GHG mitigation measures. In this context, the climate action plan is a structuring process for municipal bodies since it enables them to produce a planning document that covers both adaptation and climate change mitigation issues.

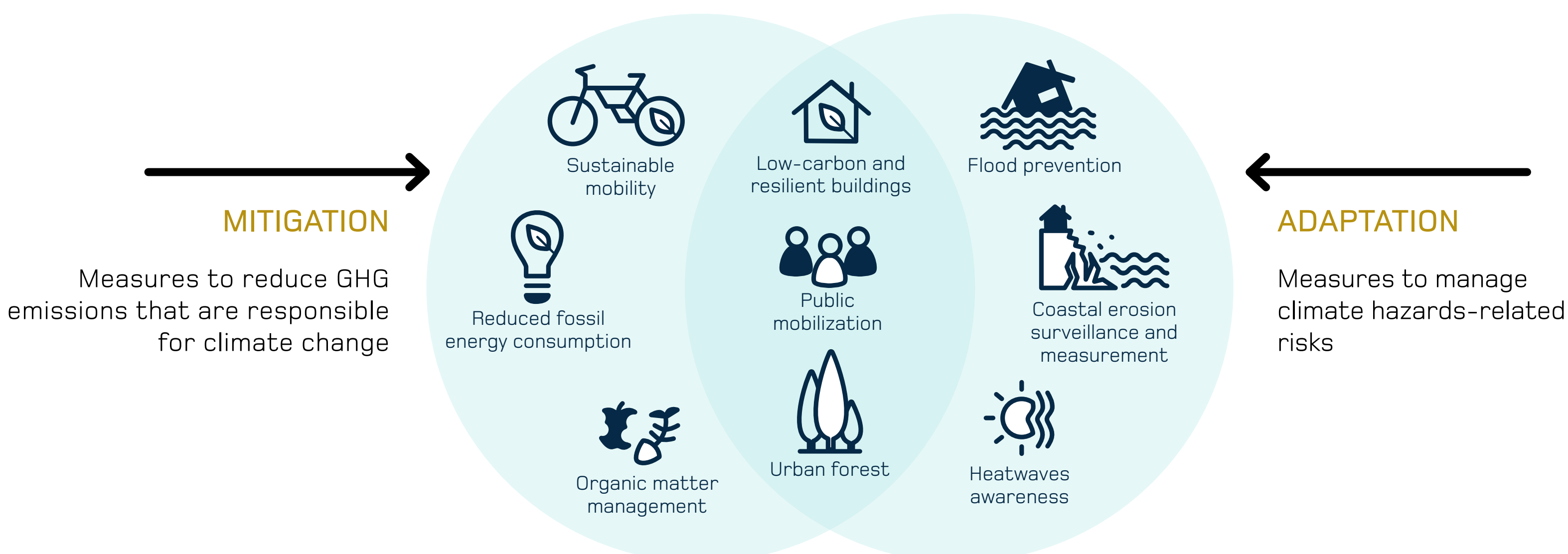


Figure 1 : Complementarity of mitigation and adaptation (inspired by [12])

Prompt implementation of structured, effective measures is essential to bolster the resilience of communities, individuals, and infrastructure in the face of the challenges linked to climate change. Adaptation, which includes the entire array of measures needed to achieve and maintain resilience, represents an opportunity to create living environments aligned with the new climate reality.

In general, planning adaptation to climate change offers municipal bodies and their partners the possibility of enhancing the well-being and quality of life of residents, the security and sustainability of infrastructure, the attractiveness of communities, and the quality of the services that they provide. Such planning also protects them against current and future climate change impacts and reduces its associated costs.

The climate change adaptation plan is a structuring tool for each municipal bodies

A climate change adaptation plan is a relevant, facilitation tool to properly structure the adaptation process. It identifies current and projected climate change risks, identifies and prioritizes adaptation measures and monitors them, while considering the requisite effort and resources. Such a plan also identifies existing facilitating factors such as human resources, expertise, regulation, and the actors mobilized, etc. It reduces the risk of maladaptation that could exacerbate the risks and consequences of climate change or create new ones. Lastly, the plan allows for the implementation of adaptation measures by making actors aware of their responsibilities with a view to maximizing efficiency and inclusiveness.

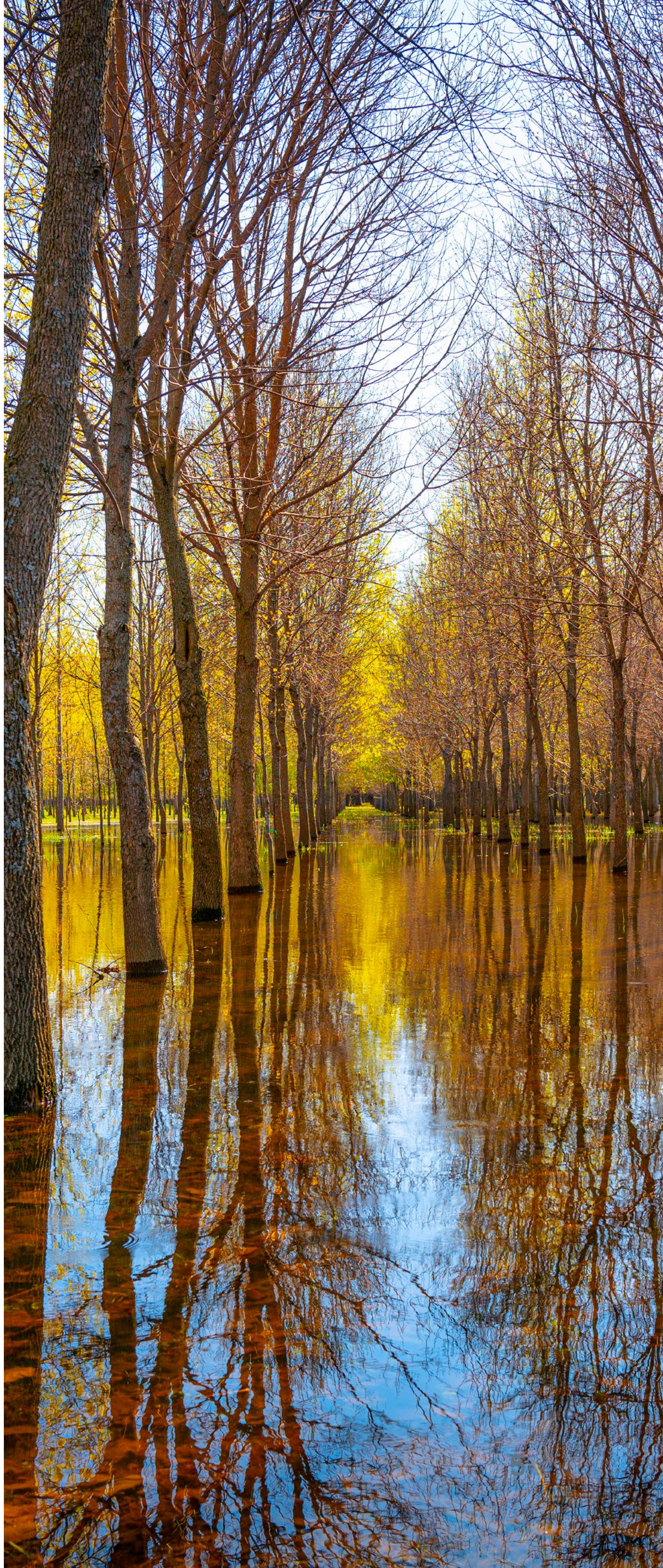
A plan for municipal decision-makers

An adaptation process and the development of an adaptation plan is intended to equip each municipal bodies such as an RCM or a local municipality with a description and prioritization of the risks specific to its territory and to identify the measures that it could singlehandedly or jointly implement to reduce such risks. The municipal bodies' legislative jurisdiction must, therefore, be considered when the plan is elaborated. At the conclusion of the process, the RCM and municipal councils should have the requisite tools to make investment decisions based on the municipal bodies' budget, and to solicit financial or technical support from governments and other contributors/partners.

The adaptation plan development process provides data and analyses that can be reused to support the consideration of climate change in the context of a municipal body's obligations, especially regarding its land-use planning and development plan (LUPDP), metropolitan land use and development plan (PMAD), and emergency management plan.

For more information:

See Appendix C concerning the advantages of planning adaptation.



Over the past 15 years, some municipal bodies have prepared and implemented climate change adaptation plans, especially in the wake of the publication in 2010 of *Élaborer un plan d'adaptation aux changements climatiques*, a guide intended for the Québec municipal sector[13] and the introduction of government financial assistance programs. The rapid development of knowledge in the realm of climate and adaptation science in the past decade and Québec's evolving objectives in this field have led to the updating of the 2010 guide. Against this backdrop and given that the adaptation is an iterative process, it may be relevant or even necessary for a number of municipal bodies to update their adaptation plan if only to update the adaptation measures to be implemented in light of those implemented previously.

The formula that this guide presents is not unique. It is advisable to use the guide as a flexible, adjustable, evolving support tool to take into account new knowledge and regulatory requirements.

The objectives of this guide are to:

- enable you to implement the conditions for success in the development of a climate change adaptation plan;
- provide you with the tools needed to carry out each of the stages in the development of a climate change adaptation plan.

The guide is divided into two main sections:

Section 1

Conditions for success

- The municipal body as the driving force of the process
- The alignment of its adaptation process with other relevant processes
- The integration of the equity principle
- The stakeholder engagement
- The availability of financial, human, and physical resources

Workbooks to guide the development of the adaptation plan

Several workbooks accompany the guide to provide support in the application of the adaptation process. The tools are a valuable resource to ensure that essential elements are not overlooked. They organize the information collected at each step in the process in a structured manner. They can be adapted according to the needs and specific objectives of each municipal body.

Workbook 1 – Climate risk assessment tool

Workbook 2 – Climate risk assessment tool (hypothetical example)

Workbook 3 – Planning the implementation of the measures

Workbook 4 – Planning monitoring of the measures

Section 2

The steps in the adaptation process

1 **Step 1 – Setting up the project team**

- Assemble the project team
- Choose support experts

2 **Step 2 – Establishment of the objectives, scope, and framework of the process**

- Establish the objectives of the process
- Establish the scope of the process
- Establish the framework of the process:
  - ◊ Produce a portrait of the organization and its territory
  - ◊ Define the key systems
  - ◊ Identify climate hazards
  - ◊ Collect climate data
- Define the scales of analysis

3 **Step 3 – Climate risk assessment**

- Identify the risks:
  - ◊ Define the components of the systems
  - ◊ Perform an exposure analysis
- Analyze the risks
- Evaluate the risks

4 **Step 4 – Climate risk treatment**

- Determine the specific adaptation objectives
- Identify and select the adaptation measures
- Develop monitoring and evaluation indicators
- Plan the implementation of the plan and adaptation measures

5 **Step 5 – Production, monitoring, and revision**

- Produce and disseminate the adaptation plan
- Monitor and evaluate the plan and adaptation measures
- Revise and update the adaptation plan

Section 1

Conditions for success

Conditions for success

Certain conditions are essential to ensure the success of the process. First, the strategic position of municipal bodies enables them to adapt proactively by assuming several roles with respect to adaptation to climate change. Second, the adaptation process must be conducted with consideration of other ongoing complementary initiatives to ensure coherence and consistency. Moreover, it is essential to consider the equity principle in the adaptation process and the municipal body must ensure its application throughout the process. Lastly, stakeholder engagement and monitoring of available resources prior to development of the adaptation plan are conditions conducive to its success.

The municipal body as the driving force of the process

A strategic position

Municipal bodies occupy a strategic position to accelerate adaptation to climate change in that they:

- are responsible for coordinating, planning, and implementing land-use planning for existing and future communities;
- own and manage key community infrastructure;
- deliver services to the community;
- are responsible for the regulatory, normative, planning, or policy frameworks;
- are front-line actors in the realm of civil protection.

Municipal bodies are encouraged to work reciprocally in some cases beyond their administrative boundaries to avoid duplicating certain steps in the adaptation process and jointly tackle the shared challenges.

Municipal bodies are local governments that are well positioned to be citizen-responsive and anticipate the necessary changes in the context of socioeconomic and urban development. First Nations and Inuit also play a leadership role in adaptation to climate change and dialogue is strongly encouraged.

Adaptation to climate change is a vast focal area that must rely on certain specialized expertise and municipal bodies can seek assistance to obtain support from organizations such as other municipalities, NPOs, municipal unions, and private firms, for example to draft certain sections of the plan.[13] [14] They must also consider existing provincial and federal legislation, policies, and key guidelines that structure, guide, and facilitate the work of municipal bodies in the fight against climate change.

For more information:

See Appendix D, which presents the roles and responsibilities of municipal bodies and examples of adaptation measures at each level (Table D1). This appendix also explains government support pertaining to climate change adaptation issues in the municipal sector (Table D2). Lastly, Appendix D presents the municipal system in the Nord-du-Québec administrative region, which has several particularities (Table D3).

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An organization invested in the process

The municipal bodies, including its components, must be involved and aware of the importance of its role to ensure the success of the adaptation process. It must act as a facilitator in the coordination and the efficient, effective realization of the adaptation process.[15] Here are key factors that facilitate the initiation and successful roll-out of the process:

- **inform elected municipal officials** to obtain their support to launch an adaptation process by means of a **resolution of the municipal or regional council;**
- **secure adequate financial and human resources** in terms of quantity and number of hours;
- **appoint a project manager** to assemble the team and choose the support experts. The manager must be able to coordinate and guide the adaptation process within the project team and during meetings with the experts, motivate the team members to maintain their commitment but also consult and inform the stakeholders, municipal employees, and the public outside the project team;
- **foster multidisciplinary collaboration** between the municipal body's services and the services of other municipal bodies and with external entities such as the regional offices of government departments, tourist associations, and businesses;
- **monitor funding programs** to consider them in the implementation of adaptation measures;
- **relay or offer training and support** to municipal employees.

An adaptation champion is a valuable asset

It is recommended to appoint an adaptation champion to communicate the progress of the adaptation process and plan to the general public, as well as to the municipal body's teams and staff. The champion is, in short, the team's spokesperson and must possess certain core skills, especially a solid general knowledge of issues related to climate change and adaptation, excellent communications skills, and a sound understanding of municipal operations and problems affecting residents.[16] The champion can be the same person as the process manager, an elected representative, or any other relevant person.

Credit: Vivre en ville

The alignment of the adaptation process with other relevant processes

The adaptation process of municipal bodies should be carried out in complementarity and in keeping with their existing or impending adaptation processes pertaining to a municipal bodies body or a given territory and with the other complementary approaches related to adaptation to climate change impacts. This approach is more effective, saves time, and avoids working in isolation, both between the municipal bodies and external stakeholders, as well as among the different departments within the municipal bodies. Furthermore, it also maximizes benefits related to the security, health, and well-being of individuals, the local economy and the environment, minimizes the costs and risks of maladaptation and fosters equity and social acceptability. It bears noting that certain measures in other municipal plans can be adaptation measures without being explicitly identified as such.

Other processes with which alignment is relevant include:

- the revision of land use planning and development plans (LUPDPs) under the governance of the MAMH, which must be in conformity with government land-use planning guidelines (GLPG). The latter contain requirements pertaining to adaptation to climate change, which imply the completion of work similar to that required to elaborate an adaptation plan. The work completed in the context of the adaptation plan will be useful for the revision of the LUPDPs and vice versa. It is, therefore, advantageous to align such processes when possible;
- the risk assessment processes that municipal bodies must conduct to fulfill their obligations in the realm of civil security or in the context of planning interventions to prevent the risks that the Ministère de la Sécurité publique (MSP) oversees. Civil security covers both natural and anthropic risks and must consider climate change. It is to municipal bodies' advantage to align their initiatives in the realm of emergency management and adaptation to bolster their efficacy and ensure their coherence;
- the adaptation processes of the Directions de santé publique (DSP) that have undertaken a climate change adaptation process in the health sector, e.g., regional climate change vulnerability assessment and design of regional public health climate adaptation plans (VRAC-PARC). When possible, linking with their climate or populational vulnerability analyses can reduce the time and cost of the municipal body's adaptation process;

- the municipal body's strategic and political plans (MP, SPP, SPZ, LUPDP, RWBWP, AZDP, MLUDP, drinking water source protection plans, and other specific policies such as those governing trees, snow-clearing, and housing);
- the other specific processes: certain risk assessments or other relevant initiatives may have been undertaken on a smaller scale on certain municipal systems such as the road network and housing infrastructure by government project management offices or various stakeholders. It is, therefore, necessary to ensure that these specific analyses are accessible
    - ◊ vulnerability analyses of municipal drinking water sources;
    - ◊ the processes pertaining to risk management and the adaptation of the territory in the face of flooding and coastal erosion and flooding, with MAMH project management offices;
    - ◊ the climate change adaptation processes carried out by Indigenous organizations and communities;
    - ◊ the complementary approaches of other organizations working in the same territory as the municipal body.

It should be emphasized that certain measures stemming from the adaptation process can be incorporated into any of the processes indicated above. Similarly, certain measures relating to the consideration of climate change and adaptation developed in the context of these processes can sometimes be part of the adaptation plan.

The integration of the equity principle

We are not all equal in the face of climate change. Certain communities or individuals are more likely than others to be at risk or affected by climate change impacts. Some are more exposed to climate hazards, including some that are more vulnerable because they are especially sensitive to a given hazard or because they do not have the same adaptive capacity.[17 18] Some examples are the elderly, young children, the homeless, low-income earners, or certain categories of workers.[19] Moreover, the intervention strategy and adaptation measures to be implemented will affect communities and populations differently both in the short and longer terms, which can engender equity-related challenges.

The process of elaborating, implementing, and evaluating a climate action plan provides an ideal opportunity to achieve a fair climate transition at the local level and support those who are experiencing or will experience climate change or climate transition impacts with greater intensity. Municipal bodies are encouraged to consider the integration of the equity principle into their adaptation plans attentively to make them a vector for a fair transition.

Equity is an extremely important success factor in the context of the adaptation process and in the subsequent implementation of the adaptation plan both to promote the community's adherence to the adaptation measures to be implemented and to consider the most-at-risk populations.

It is, therefore, important to integrate the question of equity from the outset of the adaptation process and during each of its steps. During the risk assessment step, the focus will be on identifying the systems and populations exposed to current and future climate hazards bearing in mind their vulnerability by identifying how climate change might more specifically affect certain groups in the population. Equity must also be considered in the selection and planning of adaptation measures and in their implementation. Indeed, the overly delayed implementation of certain adaptation measures such as the prohibition to build in a zone highly exposed to a climate hazard can culminate in significant human and financial costs for future generations, thereby creating an intergenerational equity challenge.

Similarly, if equity is not considered, the implementation of certain adaptation measures might have negative consequences and engender inequality for vulnerable groups or individuals. Certain inequalities can, indeed, be generated or exacerbated in the wake of inadequate adaptation measures or policies, such as the example of the gentrification linked to the greening of neighbourhoods that can lead to the displacement or social exclusion of low-income households.[19 20]

Converging on equity

Here are several concrete examples of tools that lead to an equitable and inclusive adaptation process:

- produce a socio-economic overview of the territory to identify vulnerabilities to climate hazards and assess the deprivation index in order to elaborate measures that satisfy the needs of the populations exposed in light of their vulnerability.[21] To avoid duplicating initiatives related to the inclusion of vulnerable populations, it is advisable to examine the available data and measures that have already been implemented, are in progress, or are planned. To do so, the Directions régionales de Santé publique can be involved in various ways;
- foster participation by, and support of, vulnerable individuals and groups to ensure that their needs are considered, or at least to understand their opinions and feelings, so that the adaptation measures are geared to their specific needs to achieve equity.[22 23] It could eventually be useful to collaborate with the community-based organizations in the territory that have the resources to communicate with certain marginalized populations, such as the homeless or the disabled, who are more rarely included in the usual consultation processes since they are harder to reach;
- initiate an effective communication and needs survey process aimed at the population and adapt it to the specific challenges facing vulnerable groups, bearing in mind that it is harder to communicate with these groups because of the day-to-day economic, social, and technological barriers that they face;
- conduct reviews of the consultation on the consensus activities to review the feedback of vulnerable individuals and groups. Understanding the reasons why their comments are or are not retained helps enhance transparency and build trust with participants.

Just transition, a principle at the heart of the fight against climate change

Québec has undertaken a sweeping, rapid transformation process to achieve carbon neutrality and become more resilient in the face of climate change. The transition that this implies must be fair, the benefits and social, economic, and environmental costs being equitably apportioned among the different stakeholders in society as well as current and future generations. The equity principle is central to a just climate transition.

The Québec government published a factsheet in 2023 to publicize the concept of a just transition and encourage its uniform interpretation.[24]

The stakeholder engagement

The climate change adaptation process addresses an array of cross-cutting, highly complex issues. This requires the intervention of stakeholders from different segments of society at all stages to ensure success.[25 26 27] Measures adopted by a single stakeholder limit an understanding of the issues, room to manoeuvre, and the relevance of the measures, whereas measures adopted by a group of stakeholders encompass a greater diversity of interests, positions, responsibilities, and vulnerabilities. The population is more inclined to adhere to the decisions taken if it participates in the entire process.[27] To ensure successful stakeholder engagement, three key actions are recommended: knowing the stakeholders, raising their awareness, and mobilizing them.

The distinctive characteristics of the Indigenous Nations

Eleven Indigenous nations live together with the Québec nation. It is important to consider their diverse realities and concerns when the municipal adaptation plan is elaborated. A flexible approach carried out in conjunction with Indigenous nations, communities, or organizations ensures the appropriate adaptation of intervention measures. It is important for municipal processes to align with Indigenous initiatives.

Know the stakeholder

Knowing the stakeholders in the territory of the municipal body facilitates the identification of those that it is relevant and essential to include in the process, on the project team, or as support experts, and those that must be informed or consulted. To include relevant stakeholders, it is important to consider inclusion and social justice. The stakeholders can belong to other municipal bodies, services that are part of the municipal body's network, Indigenous communities, non-profit organizations (NPOs), government departments and agencies, research sector, private-sector enterprises, industries, citizens' groups, or groups of vulnerable individuals.

Raise stakeholder awareness

Raising awareness among stakeholders is a decisive factor for a successful climate change adaptation process. If the stakeholders are aware of the importance of climate change and its impacts, the current and projected consequences of climate change can become a motivating factor in the development of an adaptation plan and the timely implementation of adaptation measures.[13 28] In the specific case of a climate change adaptation process that requires behavioural changes, dialogue with the stakeholders concerned is especially important.

Mobilize the stakeholders

Aside from obtaining stakeholder support by raising awareness, mobilizing them to gain their active, concrete participation in the adaptation process, is another essential factor to ensure the process' success. Indeed, mobilized stakeholders agree to make the necessary effort to develop and maintain sound collaboration and better communication between them to share their reflections, contribute to achieving the objectives of each step in the process, and elaborate solutions that satisfy the majority through consensus despite potential pre-existing tensions. This enhances the efficacy of the decision-making processes. [29]

The importance of stakeholder mobilization must not be taken lightly. On the contrary, it is necessary to allocate resources to ensure sound mobilization throughout the adaptation process [27 29 30 31] The establishment of collaborative governance is a valid means of maintaining the stakeholders' mobilization. [32 33]

For more information:

See Appendix E, which describes the steps that make it possible to know the stakeholders better and the means to raise awareness and mobilize them.

The availability of financial, human, and physical resources

The climate change adaptation process must from the outset be managed by means of available, sufficient financial, human, and physical resources, since they affect the power to act to achieve adaptation. [34] The absence of adequate resources can compromise a municipal body's ability to adapt. While such resources are important to successfully carry out the process, they are often not available from the outset and can be added gradually.

Inventory and reallocate resources internally

The municipal body can inventory its internal financial and physical resources to undertake a climate change adaptation process. Certain bodies have at their disposal teams and budgets that are dedicated or can be used to combat climate change. The municipal body can also contemplate reliance on ecofiscal mechanisms to enhance the financial means available to it. When possible, it can also reallocate its budgets or rely on ongoing measures to optimize the use of its resources and the conduct of the adaptation process.

Join forces with other bodies

Municipal bodies can group together around common issues to share the costs and human resources pertaining to their process. For example, the municipalities of Baie-des-Chaleurs – Carleton-sur-Mer, Maria, New Richmond and Bonaventure have joined forces under a participatory governance structure to find solutions in the face of coastal erosion. This initiative has contributed to the adoption of an adaptation strategy.[35] [36] Jointly conducting certain tasks can be especially advantageous for small municipal bodies with fewer resources.

Working together also generates considerable added value for RCMs and municipalities. Indeed, much of the risk-assessment work carried out in the territory covered by the RCM is necessary both for the RCMs and the municipalities that they encompass to successfully carry out their respective adaptation processes. Similarly, it can be advantageous and more effective for them to jointly elaborate certain adaptation measures, especially when the management of certain risks requires intervention of both municipal levels. Working together instead of singlehandedly optimizes the use of resources and accelerates the adaptation process.

Monitor financial resources

Municipal bodies are urged to carefully monitor climate change adaptation funding programs. Given that governments periodically launch financial support measures such as subsidies, tax credits, and low-interest targeted loans, it is relevant to frequently consult their websites or register for newsletters. It is also useful to consult municipal unions (FQM, UMQ and FCM), which offer funding programs in collaboration with governments. Philanthropic foundations, associations, and private enterprises involved in the community can also offer financial assistance to support an adaptation process.

It is also important to examine the conditions governing offered funding to ascertain to what extent a municipal body can combine different funding sources (obtained from the programs of one government or different levels of government) for a given project.

Provide staff training on the adaptation process

While implementing the adaptation process, municipal bodies gain by providing training to their staff to ensure the acquisition and consolidation of in-house skills in a context where the adaptation process must be perpetuated indefinitely in the face of an ongoing climate emergency. Such in-house training, which can be complementary to external expertise when the need arises, greatly facilitates staff development and the sustainability of the adaptation plan. It can also be less costly in a process that is cyclical.

Training and support are available for municipal employees, whether elected officials, directors general, managers, or professionals. These can be found by consulting municipal unions (FQM and UMQ) and Québec government departments, including the MELCCFP. While it may be difficult for small municipalities to earmark human and financial resources for training. In this instance, one solution is to hire a firm or NPO already trained in the adaptation process to work in close collaboration with municipal staff and knowledge transfer services.

VALIDATION OF SUCCESS FACTORS

Validation criteria		Validated	Comments
Act as a mainspring in the process	Define the roles and responsibilities of the municipal body throughout the process	☐	
	Consider the government's regulatory framework related to the process	☐	
	Inform elected municipal officials and obtain a resolution of the municipal or regional council	☐	
	Appoint a project manager	☐	
	Appoint an adaptation champion	☐	
Align the adaptation process with other relevant processes, e.g., MAMH, MSP, and DSP		☐	
Integrate the equity principle	Initiate a discussion on the integration of the equity principle	☐	
	Define tools and practical measures to achieve a fair, inclusive process	☐	
Stakeholder engagement	Identify and know the key stakeholders in the territory	☐	
	Raise stakeholder awareness	☐	
	Mobilize the key stakeholders with respect to the process	☐	
Make available the appropriate resources	Inventory and reallocate resources internally	☐	
	Join forces with other municipal bodies	☐	
	Monitor external funding sources	☐	
	Provide staff training on the adaptation process	☐	

Section 2

The steps in the adaptation process

The steps in the adaptation process

The development of a climate change adaptation plan is a key component of a more general adaptation process within a municipal body. It is divided into five main steps.

It is an ongoing, iterative, open-ended process divided into five steps (Figure 2), which facilitates the adjustment of the climate change adaptation plan according to changing knowledge, risks, and group learning. The steps are based on several international frameworks, notably the ISO 14090 - Adaptation to climate change standard[37 38] and the ISO 31000 - Risk management standard,[26] as well as the Québec government's "Directive pour l'appréciation et le traitement des risques liés aux changements climatiques." They are also based on the climate change adaptation concepts adopted by the IPCC. While there is no single adaptation process, the frameworks of the existing standards and tools share similarities. Figure 3 presents the steps in sequence based on the inputs and outputs for each step.

The importance of workshops

The organization of workshops provides valuable support to facilitate the process and the development of an action plan. Workshops can initially offer training to ensure that the project team and the support experts possess sufficient basic knowledge of climate change, its impacts, and the process to be carried out. They also create opportunities to brainstorm and discuss the impacts of climate change in the region and any concerns related to future impacts. For example, climate science experts can present climate change concepts and vocabulary as well as anticipated climate hazards for the municipal body according to different time horizons. When needed, municipal employees can also provide insights into how the municipal body is managing climate change impacts through informal adaptation measures or existing policies that may include such measures. Such brainstorming can establish a common vision of the municipal body's future in the face of climate change issues, which will help to guide decision-making and mobilize stakeholders with respect to the adaptation plan.[14 39] The organization of workshops that rely on support experts throughout the steps in the process will ensure smooth dialogue and facilitate the attainment of the common goals.

Figure 2: The steps in the adaptation process

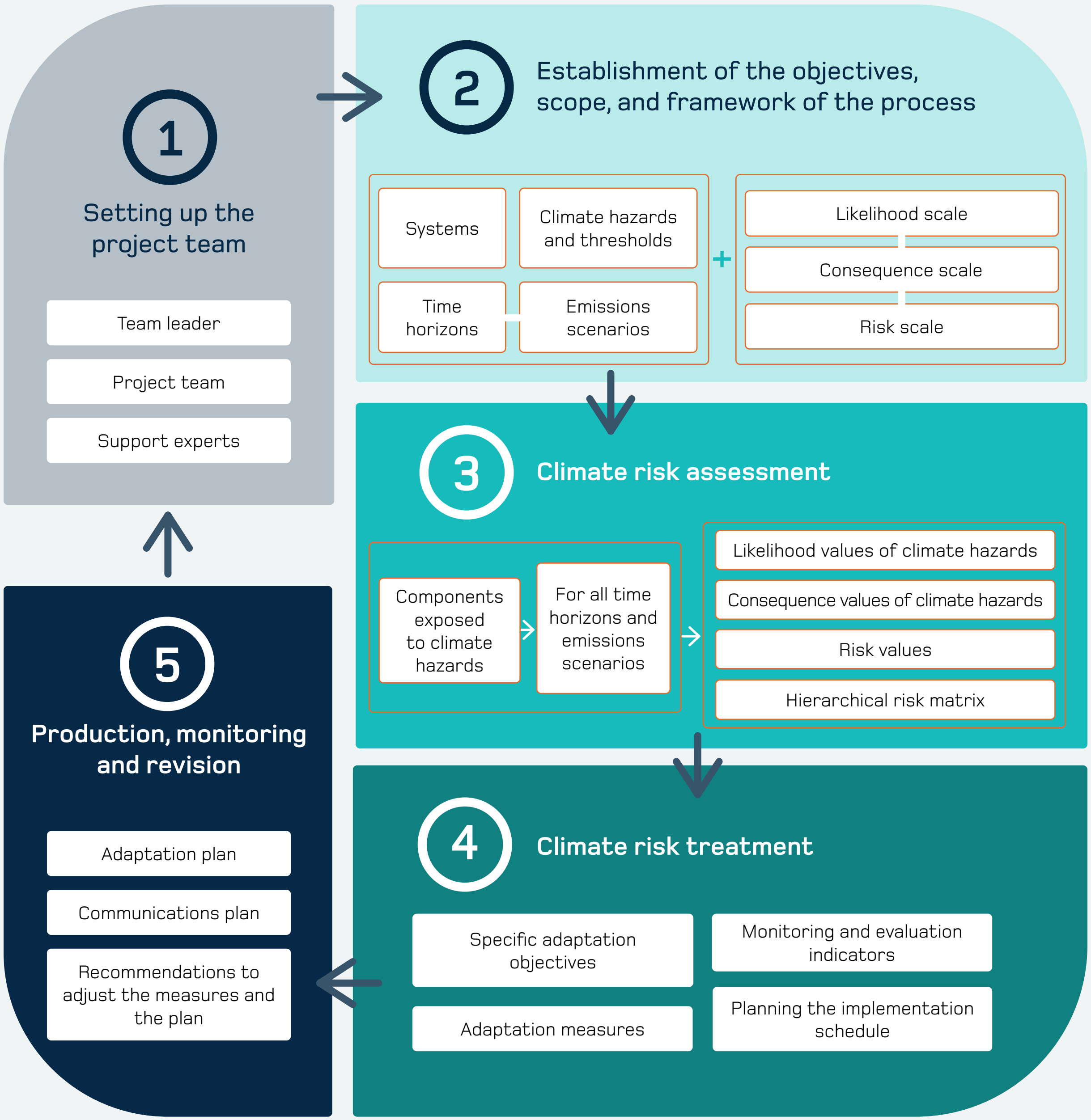
Step 1, "Setting up the project team" seeks to determine which actors will be responsible for managing the adaptation process that will lead to the development of the adaptation plan. During this phase, the support experts who will intervene throughout the process will be identified along with their roles and responsibilities. They will then train the project team members with respect to climate change adaptation processes to ensure that they effectively commit themselves to a rigorous adaptation process.

Step 2, "Establishment of the objectives, scope, and framework of the process" is essential to define the objectives of the development of the plan, the process' scope (geographic and temporal limits), its framework (a profile of the territory and the body, the identification of the systems and hazards that will be considered in various analyses, the collection of climate data), and risk analysis scales (likelihood, consequence, risk) that will be used to elaborate the matrices in the subsequent risk assessment step.

Step 3, "Climate risk assessment" reveals current and future climate risks and organizes them along hierarchical lines to prioritize those that will require the implementation of adaptation measures. The development of knowledge of such risks depends on the data collected during step 2 and the likelihood, consequence, and risk scales established at this stage.

Step 4, "Climate risk treatment" seeks to identify the adaptation measures that will facilitate risk management. It is necessary at this stage to establish a timetable for the implementation of the measures that also indicates the requisite resources and monitoring and evaluation indicators.

Step 5, "Production, monitoring, and revision" focuses on the production and dissemination of the adaptation plan, and monitoring and evaluating the measures to ascertain their effectiveness. At this stage, the measures will be adjusted if need be and the plan will be revised if necessary.



*The elements framed in orange are essential for risk assessment

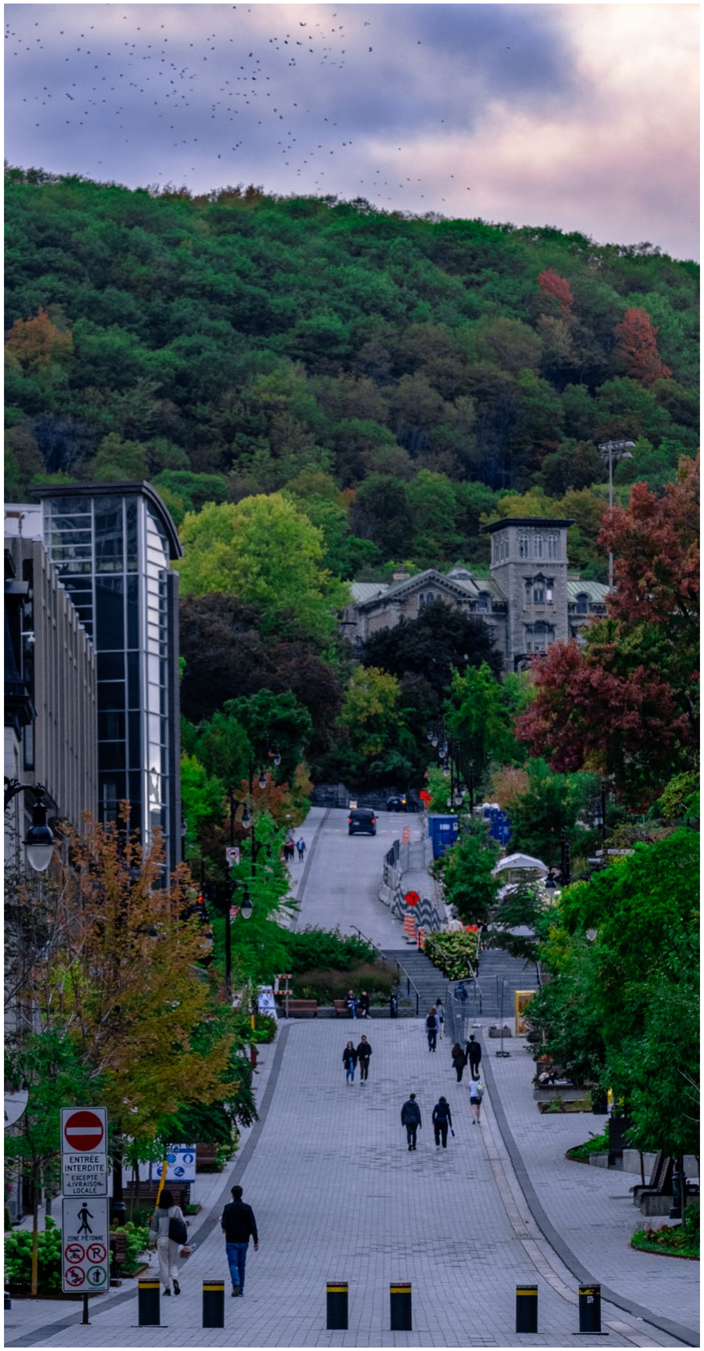
Figure 3: Inputs and outputs of each step in the adaptation process

STEP 1 SETTING UP THE PROJECT TEAM

Preferred experts to successfully carry out this step:

- Risk assessment experts
- Climate science experts
- Territorial planning experts
- Environmental experts
- Communications experts
- Project management experts

At this stage, the team leader must establish a project team comprising an array of stakeholders who will be responsible for overseeing and structuring the process. Support experts, who will intervene at the appropriate time and as needed at each step in the process, will also join the team. Once the project team has been established, it can organize the first work sessions to initiate reflection on climate risks and impacts.



Assemble the project team

Role of the team leader

The team leader must recruit the stakeholders who will directly contribute to the development of the plan or participate in the discussions throughout the adaptation process. The leader is part of the project team and attends all meetings since he coordinates and oversees the process, makes decisions at meetings, and ensures that the project team's commitment is maintained. As subsection 1.4 explains, the commitment of the stakeholders is essential to establish a dynamic, effective project team to successfully carry out the adaptation process.

Roles and responsibilities of the project team

The role of the project team is to bring to fruition the development and implementation of the plan while making decisions at each step in the process and ensuring compliance with set objectives, according to the schedule and available resources.

A multidisciplinary team

A versatile team allows for the examination of various challenges from different perspectives stemming from varied expertise, which will contribute to the quality and the relevance of the adaptation plan.[13 34] While the project team must assemble a sufficient number of individuals to cover the needs of the adaptation plan, it is important that it be of a manageable size to avoid making the process cumbersome and complex, thereby delaying progress.

It is important to include an array of civil servants, managers, and elected officials from different municipal services such as:

- Land-use planning, urban planning, and mobility: involved in the integration of the adaptation measures into the municipal body's territorial planning documents and into the adaptation of public infrastructure, architecture, and the territory;
- Transportation: involved in the design, management, and adaptation of transportation infrastructure and services;
- Infrastructure and public works: involved in the integration of the adaptation measures into the asset management plans and the adaptation of infrastructure such as buildings or road infrastructure;
- Housing and living environment: involved in the adaptation of housing and living environments;
- Emergency services: involved in the integration of the adaptation measures into civil protection documents and the management of disaster-related emergencies;
- Sustainable development, environment, and parks: involved in biodiversity conservation, ecosystems, and ecosystem services;
- Leisure activities, culture, and sports: involved in the adaptation of tourism and cultural offerings and recreational and sports activities;
- Financial operations: involved in the management of the cost of implementing the measures and compensation for damages;
- Communications and local media: involved in awareness-raising and the transmission of key messages and the transparency of the process.

The services to be included depend on the municipal body's administrative structure and the scope and framework of the process. The project team can also include partners from the municipal body's network.

1

Choose support experts

The team leader must also recruit the stakeholders who will participate in discussions in their capacity as support experts and involve them in a timely manner according to their knowledge, skills, and centres of interest. Support experts can be drawn from the municipal body's in-house human resources or externally.

Roles and responsibilities of support experts

The role of support experts is to act as advisors and offer one-off assistance, but they do not intervene in the project management process and the planning of the adaptation plan.

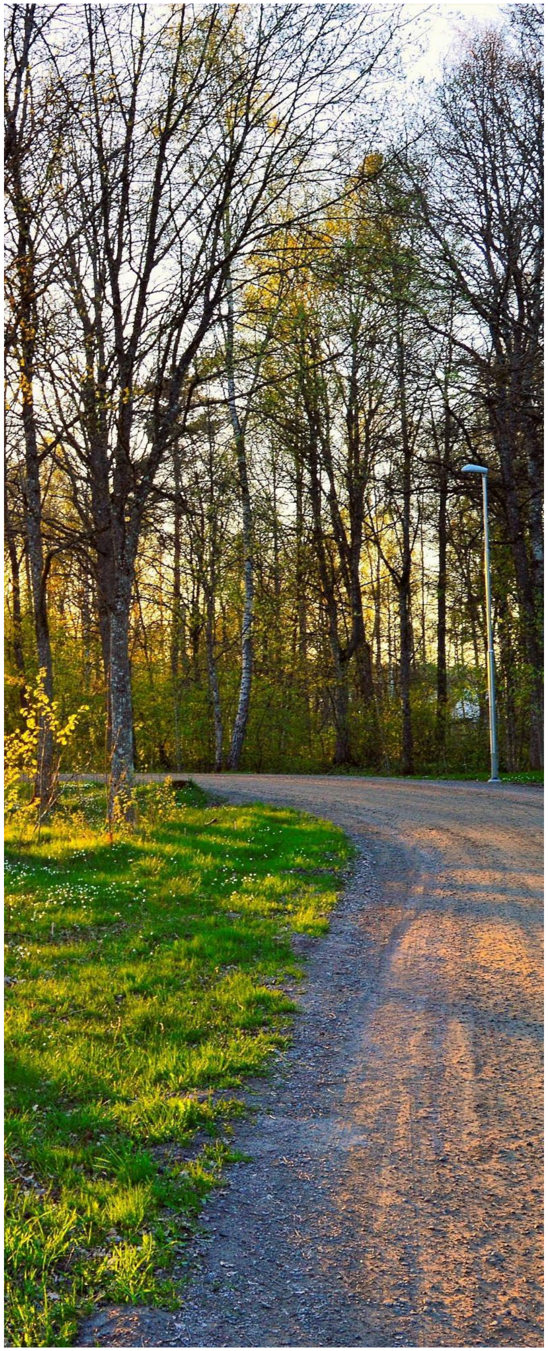
Varied support experts

The support experts' expertise and skills must complement those of the project team, which can call upon them throughout the process. For example, it may be useful to obtain the advice of climate change experts when the context is established, of impact experts during the risk assessment stage, or adaptation experts during the risk treatment stage.[14][15]

Support experts

Several types of external stakeholders can be involved as experts:

- governments and non-governmental organizations (NGOs) such as drainage basin organizations (DBOs), regional environmental councils (RECs), regional civil protection, the Association paritaire pour la santé et la sécurité du travail (APSAM), and public health branches (PHBs);
- development corporations such as the Société de développement des entreprises culturelles (SODEC), chambers of commerce, and commercial development corporations;
- vulnerable communities, e.g., the Fédération de l'âge d'or du Québec (FADOQ);
- professional associations in sectors such as engineering, insurance, health, social services, the collegiate and university sector, and heritage and culture;
- academia;
- individuals and workers, e.g., citizen advisory committees;
- Indigenous communities and organizations;
- tourist associations and organizations.



1

VALIDATION OF THE STEPS IN SETTING UP THE PROJECT TEAM

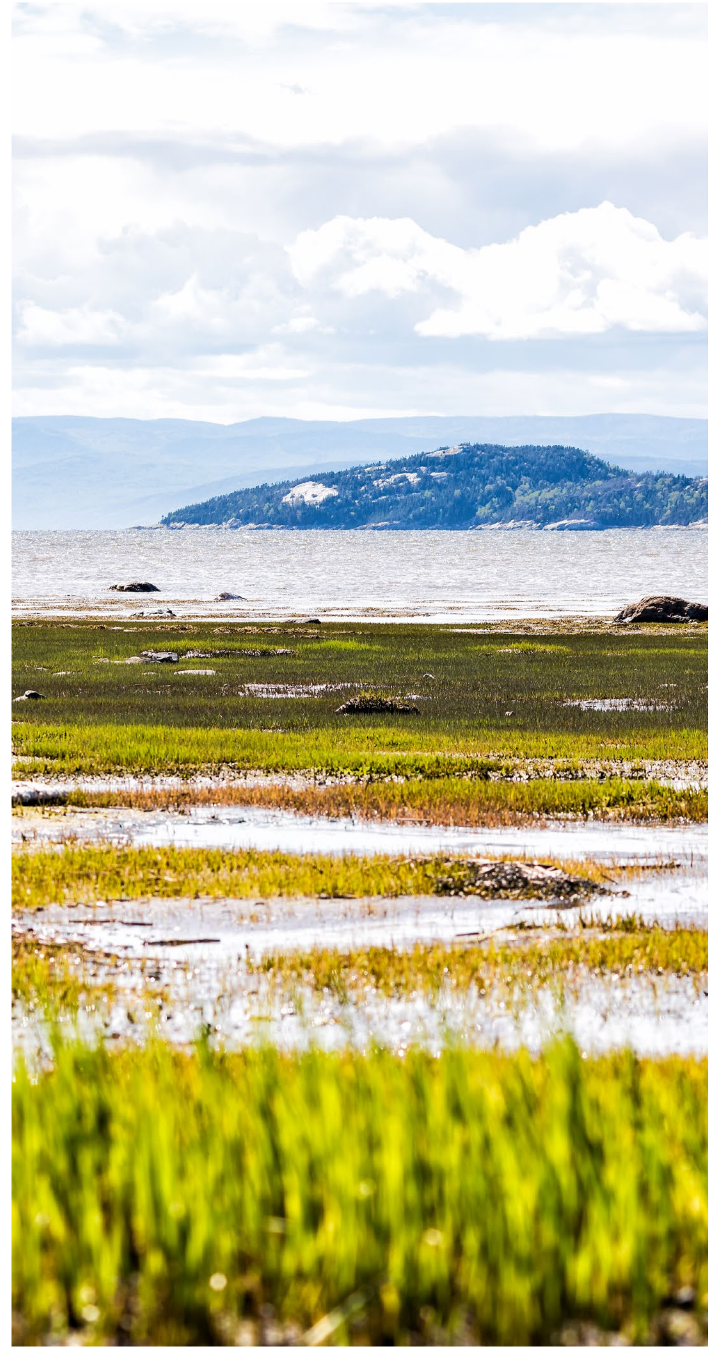
Validation criteria		Validated	Comments
Assemble the project team	Define the team leader's roles and responsibilities	☐	
	Define the project team's roles and responsibilities	☐	
	Establish a team comprising an array of stakeholders and train them	☐	
Choose support experts	Define the support experts' roles	☐	
	Choose varied expertise	☐	

STEP 2
ESTABLISHMENT OF THE OBJECTIVES, SCOPE, AND FRAMEWORK OF THE PROCESS

Preferred experts to successfully carry out this step:

- Risk assessment experts
- Project management experts
- Climate change experts
- Elected officials
- Climate science experts
- Experts in the realm of the socio-economic evaluation of vulnerabilities
- Territorial planning experts
- Environmental experts
- Representatives of the First Nations and Inuit
- Representatives of vulnerable populations
- NPOs

This step consists in establishing the objectives of the adaptation process, its spatial and temporal scope, and characterizing the key factors of the framework that will be necessary during the risk assessment stage, such as a portrait of the municipal body and its territory, hazards, systems, current and past climate, projected climate change, and the likelihood, consequence, and risk scales of analysis.



2

Establish the objectives of the process

Based on the collective vision of the municipal body's future and its needs, it is important to explicitly identify the desired objectives, as they will define the scope and framework of the adaptation process. It will also be easier to explain to the stakeholders the nature of the process to which the municipal body is committing itself if the objectives are clearly established.

Certain fundamental objectives are, from the outset, common to all comprehensive adaptation processes:

- elaborate a climate change adaptation plan;
- assess the vulnerabilities and climate risks in the territory both from the standpoint of the current and future climate according to different time horizons;
- define climate change adaptation needs;
- identify adaptation measures.

More specific objectives that reflect local concerns could also be identified and receive special attention during the process, for example:

- treat a risk such as coastal erosion and flooding or an issue (i.e. a flooded road) more thoroughly, given its scale within the territory of the municipal body or because it is a source of concern for residents;
- examine climate change risks on a prospective basis over the very long term to better consider the social and economic implications of decisions made now for future generations;
- optimize the synergy between adaptation measures and those aimed at mitigating climate change.

It is usually easier to establish more precise objectives if the municipal body has already engaged in an adaptation process and already knows the areas in which it must act.

Establish the scope of the process

The scope of the process concerns its spatial and temporal scales. The initial risk assessments that organizations produce are often general as regards geographical coverage in order to provide a comprehensive overview of climate risks. Subsequent analyses, focusing more specifically on a problem or territory, can then round out the initial overview.

The geographic limit

For the purposes of elaborating a municipal adaptation plan, the adaptation process must focus on the entire territory over which the municipal body has jurisdiction.

It may be relevant to consider certain risks and adaptation measures on a broader scale when their assessment and management can be optimized by acting in a coordinated manner with neighbouring RCMs or municipalities or in tandem with processes carried out on another territorial scale. One example is flood risk management in a drainage basin.

2

Risk assessment and treatment are a question of scale

The objective of an adaptation process and the development of an adaptation plan is to equip each municipal body such as an RCM or a local municipality with a description and prioritization of the risks specific to its territory and to pinpoint the measures that it could singlehandedly or jointly implement to reduce such risks.

Organizing risks along hierarchical lines implies putting them into perspective and comparing them by means of the same territorial and temporal scale for each one. In other words, two different spatial or temporal scales cannot be used to organize the risk along hierarchical lines. Indeed, the overview of risks and their assessments differ greatly in the territory of an RCM and in each of its municipalities. For example, flood-related risks can be weak overall in the territory of the RCM but very high in two of its municipalities. Conversely, a risk can be high at the level of the RCM given its consequences or likelihood over a substantial portion of the territory, but null or negligible in certain municipalities. Furthermore, risks can develop differently over time in the RCM and its municipalities.

When the RCMs and municipalities work hand in hand to elaborate adaptation plans, much of the risk assessment work can be carried out collaboratively at the RCM level. However, each RCM and municipality must carry out the risk assessment stage, especially the prioritization of risk, if it wishes to obtain an overview adapted to its territory and focusing on the objectives that fall under its jurisdiction. Indeed, in addition to the question of the territorial scale, certain risks concern only one level of governance. For example, drinking water or wastewater infrastructure is only of concern to the municipalities.

The temporal limit

Given the scope of projected climate change impacts and the social, economic, and budgetary implications of the implementation of adaptation measures, it is important to carry out risk assessments projected as far as possible over time, taking into account the limits of scientific knowledge and available data. Indeed, emerging climate risks are not temporary phenomena but will persist and intensify, becoming the “new normal”.

Producing long-term projections will facilitate an intervention strategy that avoids maladaptation and an adaptive lock-in, and will consider intergenerational equity and the precautionary principle. It is also necessary to do so to obtain the requisite data to plan certain adaptation needs, whose long-term importance is especially critical, such as those concerning urbanized areas and long-lived infrastructure.

This long-term perspective will also make it easier to better explain and justify the need to immediately implement certain measures, the benefits of which will only be felt in the longer term, or which will enable anticipated risks to be avoided.

Risk assessment must also reveal changing risks over time to guide reflection on the best time to implement the adaptation measures and optimize their implementation in the short, medium, and long terms, bearing in mind available capacity and resources. To this end, the implementation of a progressive, scalable risk management process geared to changing risks can be advantageous when it is possible and safe to do so.

It is important to bear in mind that the level of uncertainty is usually greater for projected data, especially in the long term. Consequently, risk assessment can be more qualitative for more distant temporal limits.

2

Establish the framework of the process

It is also important to determine the framework within which the process will take place. In particular, this entails establishing a portrait of the body and its territory, defining the main systems, identifying the hazards to be prioritized, and obtaining the requisite climate data to characterize their evolution.

Produce a portrait of the body and its territory

The overview of the municipal body and its territory seeks to delineate the municipal body's responsibilities and powers of intervention, inventory current or relevant processes related to adaptation to climate change, and emphasize the social, economic, and environmental facets to be considered in the process.

To characterize the overview of the municipal body and its territory, it may be important to reflect on the spheres in which it operates and that can affect the framing of the process, including:

- the administrative sphere: the structure of the municipal and supralocal administration such as the RCM and the metropolitan communities, the responsibilities of different units, and the relevance of such responsibilities in relation to climate change;
- the physical sphere: elements of the landscape, urban fabric, architecture, constraint zones, geography, geology, climate, and natural resources;
- the socioeconomic sphere: economic and commercial activities, tourist activities, and demographic characteristics;
- the legislative sphere: administrative boundaries, the skills and responsibilities of municipal administrations pertaining to climate change, summaries of legislation related to the management of the environment, and other relevant institutional considerations;
- the normative and regulatory sphere: zoning, standards, regulations, plans, policies, strategies, or municipal key directions that might affect the process.

Build on what already exists

Various existing plans and documents in municipal bodies help to establish the local context, such as previously elaborated risk assessments and adaptation plans, land-use planning and development plans, urban planning master plans, emergency measures or civil protection plans, triennial capital expenditure plans, and other similar documents. All these documents contain part of the requisite information to describe the municipal body and its territory. For example, they contain sociodemographic and economic characteristics, certain regulatory constraint zones where risks may be present, infrastructure, and major facilities.

Consulting such documents ensures coherence with existing initiatives pertaining to planned or existing municipal measures. It is especially important for RCMs to be well informed of the processes under way in the municipalities that they encompass and the specific adaptation challenges facing each one of them. The municipalities must also possess a solid overview of the processes and challenges in their RCM to foster alignment with respect to adaptation as well as the efficacy and coherence of the initiatives.

For more information:

See Table D1 and Table D2 in Appendix D, which indicate the roles and responsibilities of municipal bodies and adaptation-related local and supralocal policies and regulations.

2

Define the key systems

It is important to identify and characterize the main systems in the municipal body's territory that are likely to be affected by climate change. In particular, this should include systems under the municipal body's purview or on which it can impose regulations or exercise direct influence pursuant to its powers and jurisdiction. The main systems that the municipal body can consider are indicated below. The systems identified with an asterisk are deemed essential to a municipal body:

- Infrastructure:
  - ◊ road network*;
  - ◊ energy and telecommunications;
  - ◊ disaster-resilient infrastructure*;
  - ◊ drinking water system;
  - ◊ wastewater and rainwater collection and treatment network;
  - ◊ municipal buildings*;
  - ◊ residential buildings*;
  - ◊ recreation and tourism infrastructure.
- Population and local economy:
  - ◊ population*;
  - ◊ businesses and socioeconomic activities.
- Natural environment:
  - ◊ biodiversity;
  - ◊ parks, green spaces; and protected areas;
  - ◊ aquatic environments and groundwater;
  - ◊ soils.
- Municipal services:
  - ◊ public works*;
  - ◊ public safety*;
  - ◊ finance;
  - ◊ recreation.

Certain systems can extend beyond the municipal body's administrative and territorial boundaries. Hence, it is worthwhile to collaborate with neighbouring municipal bodies to coordinate risk management initiatives, for example from the standpoint of flood risks and with respect to ecosystems.

It should be noted that a municipal body that elaborates an adaptation plan could be obliged at the time of development or subsequently to conduct more detailed analyses of certain systems deemed to be at greater risk.

For more information:

See Appendix F, which presents a municipal body's main systems and components.

2

Identify climate hazards

Once the municipal and territorial context has been established and the main systems identified, the climate hazards that can affect these systems must be defined.

In the context of this guide, the term "climate hazard" is used comprehensively to also include natural hazards affected by climate such as the presence of allergenic pollen or disease vectors.

Identify the observed and projected climate hazards in the territory

An initial list of hazards to be considered for the adaptation process can be established by inventorying events and impacts that have already affected the territory.

To establish such a list of climate hazards and begin to grasp their relative importance, it is necessary to ask whether they are all relevant to the territory and the municipal body and to ask the following questions:

- Are there climate hazards that have not occurred in the past that might do so in the future (identify new climate hazards to be added to the initial list)?
- Will current climate hazards intensify in the future?
- Will current climate hazards occur more frequently in the future?
- Will current climate hazards affect more sectors in the future than in the past?
- What is the current and projected geographical extent of each climatic hazard in the territory? How can certain affected zones be mapped, e.g., flooding, coastal erosion and flooding, heat islands, and landslides?

To facilitate this process, the following climate hazards are likely to significantly affect Québec. If they affect the territory of the municipal body, it is necessary to assess their importance to determine if they must be selected for the process. Certain climate hazards identified by an asterisk are essential within the scope of an adaptation process if they are likely to affect the territory:

- Heatwaves*;
- Cold episodes;
- Heavy or frequent precipitation (liquid*, solid, and mixed);
- Coastal erosion and flooding;
- Fluvial floods (open water*, ice jams);
- Pluvial floods*;
- Forest fires*;
- Landslides*;
- Permafrost thaw*;
- Drought;
- Low river flows
- Winter thaws:
  - ◊ freeze-thaw events;
  - ◊ rain on snow events;
  - ◊ reduced ice and snow cover;
  - ◊ shortened freeze period.
- Extreme weather events
  - ◊ ice storms*;
  - ◊ tornados;
  - ◊ storms;
  - ◊ violent winds;
  - ◊ snowstorms;
  - ◊ post-tropical storms;
- The presence of allergenic pollen
- The presence of disease vectors:
  - ◊ Ticks carrying Lyme disease;
  - ◊ Mosquitoes carrying West Nile virus.

2

For more information:

See Appendix B for examples of the direct and indirect impacts of these climate hazards.

Issues related to climate hazards

Conducting a cross-sectional analysis of climate hazards and systems identifies the risks for municipal bodies. Below are some of the main issues that are likely to affect numerous municipal bodies in Québec.

- Impacts on infrastructure and buildings:
  - damage to roads and other road structures;
  - loss of essential priority infrastructure in the wake of extreme weather events;
  - damage to public and private buildings;
  - saturation of water management infrastructure, e.g., sewer backups and overflow;
  - damage to underground systems such as water and wastewater infrastructure.
- Impacts on the population and the local economy:
  - heatstroke and dehydration;
  - pollen-related allergies;
  - greater risk of contracting Lyme disease;
  - health issues related to exposure to forest fire smoke;
  - injury to the lives, health, and security of individuals when extreme weather events occur;
  - power outages.
- Impacts on the natural environment:
  - adequate supplies of quality water.
- Impacts on municipal services:
  - increased demand for emergency services;
  - more extensive resources and higher costs related to municipal services, e.g., public works, building management, snow removal, and the management of parks and green spaces;
  - dams and retention structures management.

Credit: Jonathan Bélisle for the project: 'Sous les pavés' from the Centre d'écologie urbaine

2

The data and map layers available to municipal bodies

Several databases and geospatial information layers pertaining to climate hazards and their projected future evolution are available online. Such tools are useful to various actors, especially the municipal bodies, which must elaborate adaptation plans. They can serve as inputs to determine the existing or projected climate hazards in their territory. The geospatial information layers, or mapping, are also the preferred tools to ascertain the challenges, communicate information to the public, support the organization of consultations, and mobilize the stakeholders with respect to the planning of initiatives.

Here are some examples of sources of map layers:

- the MELCCFP (e.g., river flow data);
- the MSP (e.g., civil security events);
- the INSPQ (e.g., urban heat and freshness islands);
- the MRNF (e.g., eco-forestry data);
- the MSSS (e.g., the location of health facilities);
- Ouranos (e.g., climate data);
- Université Laval (e.g., indices of vulnerability to heat);
- the SOPFEU (e.g., forest fire inventories);
- ECCC (e.g., climate data).

When access to a geographic information system is possible, a sound practice is to indicate on maps certain key factors that affect the territory, such as:

- the socioeconomic characteristics;
- the physical and territorial characteristics;
- the climate hazards that affect the territory and their evolution over time under climate change;
- the risk-prone zones or systems and priority response zones.

The map layers elaborated should ideally be made available in an open format such as shapefile to facilitate sharing among the stakeholders in the adaptation process.

Define climate thresholds

Climate hazards are characterized by their duration, intensity, frequency, and scope. It may be necessary to define the threshold beyond which damage is sustained. For example, an X-metre flood may not have an impact whereas a higher Y-metre flood can be very detrimental. The thresholds vary according to the systems under review and, consequently, several thresholds may have to be considered for a given climate hazard. It is not always easy to establish climate thresholds, and it is important to consult experts, especially municipal employees, who possess empirical knowledge.

Climate impact chains

It may be worthwhile for a municipal body to consider climate impact chains, which reveal how given hazards engender direct or indirect impacts that spread in a risk-prone system. Visualising this cascading chain of the impacts enables the stakeholders to better grasp how climate change is affecting their systems.

For more information:

See Appendix G for a simplified example of a climate impact chain.

2

Collect climate data

Gathering climate information plays a central role in the risk assessment step since it facilitates an assessment of how changing climate hazards affect risks over time. To assess such changes, it is important to obtain an overview of the past and future climate.

Characterize current and past climates

To measure and assess the scope of impending changes, it is important to understand the climate in which we live today or have lived in the past. Current and past climates give municipal bodies a reference point in relation to the future climate. The current climate captures the already measurable impact of climate change. To establish a climate average for the current climate, it is strongly recommended to rely on the period from 1991 to 2020 when data are available. Past climate data, on the other hand, are especially useful in attempting to ascertain the frequency and intensity of one-off or extreme climate events such as flooding and high tides.

Several databases can be used to identify and characterize the climate hazards and climate indices that are relevant to the municipal body, such as:

- *Ouranos Climate Portraits*;
- *Climatedata from the Canadian Centre for Climate Services*;
- Environment and Climate Change Canada website;
- *Hydroclimatic Atlas of Southern Québec*;
- civil defence databases;
- municipal and government archives;
- experts' reports;
- territorial planning documents and emergency measures plans;
- infrastructure master plans;
- sectoral reports and natural hazards maps;
- consultations with municipal employees;
- newspaper articles.

It is preferable to use quantitative data to characterize climate hazards when such data are available. Otherwise, qualitative information or the opinion of a climate science expert must be sought. Table 2 gives a hypothetical example of the characterization of the "heatwave" climate hazard.

Table 2: Hypothetical example of a climate hazard, climate threshold, and annual number of past climate events that quantitatively characterize heatwaves in a municipality

Climate hazard	Definition*	Threshold	Annual number of past climate events
Heatwave	Annual number of events where the temperature exceeds 30°C for three consecutive days	5 annual events	6

*The definition of a heatwave varies from one region to the next.

2

Characterize the future climate

To characterize the future climate, it is necessary to rely on climate projections, i.e., climate models that incorporate different greenhouse gas emission scenarios such as the Shared Socio-economic Pathways (SSPs).

Preferred tools and data to characterize the past and future climate – a question of consistency

For the sake of comparing province-wide adaptation plans and the quality of the information used, the ***Ouranos Climate Portraits*** platform is the preferred tool to analyze the past and future climate. Indeed, the climatic scenarios that the platform presents have been adapted in light of the most recent knowledge available for Québec. The standardization of data produced on the ***Ouranos Climate Portraits*** platform will ensure coherence between the plans from the standpoint of the data used.

Climate projections are available on both provincial and federal Web platforms. They provide quantitative data related to several climate indices, based on various climate thresholds. For example, the *Ouranos Climate Portraits* website and the ClimateData.ca website of the Canadian Centre for Climate Services provide projected climate indices data. Projected hydrological data such as water flows and levels can be obtained from the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP)'s Hydroclimatic Atlas of Southern Québec.

Aim for carbon neutrality while adopting a preventive adaptation approach

International greenhouse gas emission reduction efforts under the Paris Agreement, to which Québec adheres, seek carbon neutrality to stabilize global warming below 2°C and, preferably, 1.5°C, in relation to the pre-industrial era. However, in light of the scope of the human and economic consequences that would stem from a higher level of warming, and recent and projected changes in global GHG emissions based on current government commitments, the precautionary principle requires a preventive approach geared to preparation for a higher level of warming than what governments are collectively attempting to attain. For this reason, the scenario associated with the Paris Agreement is not one of the scenarios recommended for the adaptation process.

As a precaution, it is desirable to strive overall to adapt at the very least to a moderate emissions scenario, while avoiding compromising the capacity to adapt to a high or very high emissions scenario. However, certain significant risks require the immediate adoption of the necessary measures to become resilient in the face of high or very high warming scenarios.

Time horizons

To assess long-term risks and their evolution over time and to consider uncertainty related to climate projections, it is necessary to use at least two future time horizons.

To ensure some degree of coherence and comparability of risk assessments in Québec, the following time horizons should be used in the adaptation process, the 2050 horizon for the medium term (2041-2070) and the 2080 horizon for the long term (2071-2100). The long-term horizon is especially important from the standpoint of land-use and major infrastructure planning, which will be in place for several decades or hundreds of years. Moreover, it may prove relevant to conduct a longer-term analysis to avoid adaptive lock-in, for example, as regards the management of land-use planning in the face of coastal erosion and flooding. Conversely, a short-term analysis, e.g., 2011-2040, can be useful for certain hazards, when climate change is likely to affect them and such variations, which are usually minor, are of interest to the municipal body. To better understand the use of climate projections, please refer to the guide to scientific recommendations on the Ouranos website.[40]

Emissions scenarios

The use of moderate (SSP2-4.5) and high (SSP3-7.0) emissions scenarios is recommended to assess risks in order to consider a large portion of the possible range of climate projections.

The very high emissions scenario (SSP5-8.5) is more relevant when focus centres on highly unlikely hazards with catastrophic consequences or as a post-2100 climate analogue. When the use of this scenario is deemed necessary, it is important to include it in the risk assessment to integrate it into the risk treatment step and identify the adaptation measures. In this instance, the very high scenario (SSP5-8.5) can be substituted for the high scenario (SSP3-7.0) or complement the latter.

It should be noted that, in the transition interval between the Shared Socio-economic Pathways (SSPs) and the Representative Concentration Pathways (RCPs) (see box), it will be necessary to resort to outcomes based on RCPs for certain hazards. In such a case, the medium and high RCP (RCP 4.5 and 8.5) should be used. In practical terms, it will be necessary to use certain information available with SSPs and other information with RCPs to elaborate the adaptation plan. Furthermore, no modelled data exist to date for certain climate hazards, which means that qualitative data, based on the judgment of experts, can also become essential to round out the risk assessment. Table 3 presents the hypothetical example of the characterization of the "heatwave" climate hazard, including future climate values.

2

Climate scenarios based on SSPs and RCPs

The most recent group of climate simulations stemming from the sixth phase of the CMIP (CMIP6) is based on four key scenarios pertaining to concentrations of GHG, aerosols, and land use, i.e., SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. These different emission scenarios are used by the IPCC to produce its assessment reports. The SSPs now replaces the RCPs, which were used in the fifth phase of the CMIP (CMIP5). As they are more recent, they should be used when data are available. This is currently the case for several hazards based on temperatures and precipitation, but not yet for others, which must be calculated by means of specialized models (e.g., coastal erosion and flooding).

Table 3: Hypothetical example of a climate index: heatwaves are characterized using a past climate value to project the future climate values

Climate hazard	Definition	Threshold	Annual number of past climate events	Annual number of events			
				SSP2-4.5		SSP3-7.0	
				2041-2070	2071-2100	2041-2070	2071-2100
Heatwave	Annual number of events where the temperature exceeds 30°C for three consecutive days	5 annual events	6	7	12	7	20

Define the scales of analysis

The objective of this sub-step is to define the scales of analysis that will be used at the risk assessment stage (likelihood scale, consequence scale, and risk scale) based on information collected during the preceding stages.

The climate risk is calculated using the following equation: [26]

$$R = L \times C$$

where R = Risk, L = Likelihood, and C = Consequence on the systems.

Risks must be assessed for all of the emissions scenarios and time horizons selected.

Three scales must be defined to assess risks:

- likelihood, which estimates the occurrence of a climate hazard;
- consequence, which estimates the scope or the severity of damage stemming from an event;
- risk, which allows for the classification of the risks during the assessment.

The first two scales are used to construct a risk assessment matrix, to which will be linked the risk scale (Table 4). The scales will be used during the assessment step by the project team members or the support experts, who possess climate expertise or knowledge of the systems under consideration, to establish the likelihood, consequence, or risk values.

This guide recommends five-level scales since this allows for fairly fine distinctions between the different levels of likelihood and consequence, and ensures greater coherence with established practices, especially in the realm of civil security (Table 4). However, different scales can be relevant for certain targeted needs.

Table 4: Example of a risk matrix

		Likelihood				
		1	2	3	4	5
Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

It is essential to define scales that are well understood by all stakeholders to ensure a shared understanding of what the values 1 to 5 represent. If the stakeholders do not have the same understanding of the scales, their analyses will not be comparable, which will compromise the risk analysis.

The scales are used throughout the risk assessment stage. This work must, therefore, be carried out upstream from this step. It is strongly recommended to define the scales by resorting to a consultative, collaborative process. The consultation of experts, especially in the realm of climate science, adaptation to climate change, land-use planning, and civil security, and the organization of a brainstorming workshop, are strongly recommended.

The team leader is the guardian of the definitions chosen at this stage. He must ensure a shared understanding and the mastery of the scales by all the project's internal and external stakeholders, who will intervene at different steps in the risk assessment.

The municipal body can start to fill out workbook 1. Sheet 1 explains the likelihood and consequence scales.

Likelihood versus probability

In this guide, the term "likelihood" has been preferred to "probability" because it is more comprehensive and reflects current good practices in the field. Probability is a quantitative value while likelihood can be both quantitative and qualitative. Likelihood is better adapted to broach certain hazards whose past or present likelihood of occurrence is harder to pin down or which manifest themselves more gradually.

Define the likelihood scale

The likelihood scale provides a quantitative or qualitative estimate of the occurrence of a climate hazard, depending on the data available and/or the type of hazard (Table 5). The description given for each level must reflect a shared understanding of the scale to ensure that evaluators assign likelihood scores in a similar manner. It is advisable to prioritize quantitative scales when possible since they can be interpreted more uniformly from one individual to the next and thus reflect more representative results.

The choice of the scale used mainly depends on two factors, namely the type of data available (quantitative or qualitative) and the type of hazard (punctual or progressive).

If quantitative data (e.g., on return periods) are available, it is possible to resort to quantitative descriptions, such as scales B and D in Table 5. On the other hand, qualitative scales such as scales A and C can be used for qualitative climate data.

Moreover, there will probably be differences on the likelihood scale between a punctual hazard such as forest fires, floods, and heatwaves, and a slowly developing or ongoing hazard such as coastal erosion, average precipitation, and average temperature. In the first instance, the quantitative scales B and D can be used while it is preferable to use a more qualitative scale such as scales A or C in the second instance.

Table 5: Examples of likelihood scales

Likelihood scales	Levels of likelihood				
	Very unlikely	Unlikely	Probable	Very probable	Almost certain
	1	2	3	4	5
Qualitative scale A	Could occur under exceptional circumstances	Could occur occasionally	Will occur occasionally	Will probably occur in most cases	Is expected often or in most cases
Likelihood scale B	Likelihood below 5%	Likelihood between 5% and 29%	Likelihood between 30% and 69%	Likelihood between 70% and 94%	Likelihood of 95%
Criticality scale C	Will not likely become critical during the period	Will likely become critical in 30 to 50 years	Will likely become critical in 10 to 30 years	Will likely become critical in a decade	Will likely become critical in several years
Recurrence scale D	< 1 in 1 000 years	1 in 100 years	1 in 20 years	1 in 10 years	1 in 5 years

Drawn from [41 42 43].

To be adapted according to the municipal body's context.

Lastly, it is often necessary to use several descriptions to ensure that the definitions adequately represent all the hazards to be considered in the municipal body's adaptation process.

2

Define the consequence scale

The consequence scale is used to evaluate the scope or severity of the consequences of a climate hazard. Accordingly, the scale can measure physical damage, the loss of human life, economic or social costs, and environmental damage. It could also combine different economic, environmental, or social costs depending on what the project team deems to be important. Table 6 presents examples of the scale according to the consequences assessed. The different scales can be used in combination or separately depending on the context. The use of a combined scale simultaneously assesses different types of consequences and thus provides a more comprehensive picture of the potential social, economic, and environmental impacts and the entities affected, e.g., individuals, the municipal body, or the government. It is, however, harder to use since it implies weighting the consequences assessed. Following the example of likelihood, the description of each level must reflect a shared understanding of the levels of the scale and the levels presented here can be modified to reflect the municipal body's context.

In cases where only one type of consequence is anticipated, the line in Table 6 that best corresponds to the system studied should be used. For example, if the system under consideration is the biodiversity of urban parks, consequence scale D would be used for the analysis.

In cases where several types of consequences are anticipated and an overall consequence value is sought, the value must be defined bearing in mind several lines in Table 6. For example, for the road network system, flooding could affect the system's functionality, security, the local economy, and the municipal body overall. This approach will imply obtaining a consensus among several experts to determine an overall consequence value.

These discussions can be recorded in column F1 in workbook 1.

Table 6: Examples of consequence scales

Consequence scales	Levels of consequences				
	Negligible	Minor	Moderate	Major	Very high
	1	2	3	4	5
Scale A **Consequences for service functionality**	Negligible impact on service functionality	Low impact on service functionality	Moderate impact on service functionality	High impact on service functionality	Severe impact on service functionality
Scale B **Consequences on the economy**	Negligible additional costs for -the municipal body -individuals -businesses -the government	Low additional costs for -the municipal body -individuals -businesses -the government	Moderate increase in costs for -the municipal body -individuals -businesses -the government	Substantial increase in costs for -the municipal body -individuals -businesses -the government	Severe increase in costs for -the municipal body -individuals -businesses -the government
Scale C **Consequences on health and security**	No significant health consequences No potential for deaths or other consequences that irreversibly reduce the quality of life	Engenders quickly reversible health consequences No potential for deaths or other consequences that irreversibly reduce the quality of life	Low potential for deaths Significant potential for other consequences that irreversibly reduce the quality of life	Significant potential for deaths and other consequences that irreversibly reduce the quality of life	Deaths anticipated and consequences that are hard to avoid that irreversibly reduce the quality of life
Scale D **Consequences on the environment**	No or very limited environmental impacts	Few environmental impacts	Moderate environmental impacts	High environmental impacts	Severe environmental impacts
Scale E **Overall consequences for the municipal body and citizens**	Insignificant overall impacts for the municipal body and citizens	Minor overall impacts for the municipal body and citizens	Moderate overall impacts for the municipal body and citizens	Major overall impacts for the municipal body and citizens	Catastrophic overall impacts for the municipal body and citizens

Drawn from [41 42].

To be adapted according to the municipal body's context.

Define the risk scale

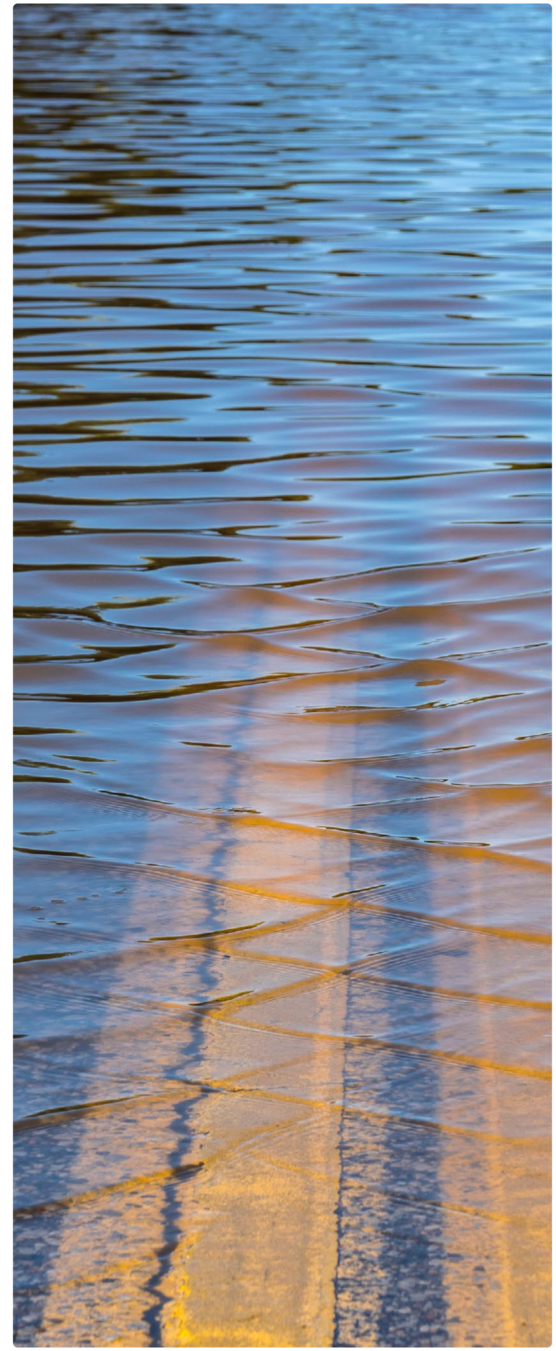
The last sub-step in the definition of the scales consists in defining the levels of risk that will subsequently facilitate their ordering. The description given for each value of the matrix must reflect a shared understanding of the risk and the project team's concerns.

It has been established that the higher the likelihood and consequence values are, the higher the risk, but we must be clear about the values that represent a low or less critical risk. Table 7 presents an example of the definition of risk values according to five levels: negligible, minor, moderate, major, and extreme.

Table 7: Example of a five-level risk matrix combining consequence and likelihood

		Likelihood				
		1 - Extremely unlikely	2 – Unlikely	3 – Probable	4 – Very probable	5 – Almost certain
Consequence	5 - Very high	5	10	15	20	25
	4 - Major	4	8	12	16	20
	3 - Moderate	3	6	9	12	15
	2 - Minor	2	4	6	8	10
	1 - Negligible	1	2	3	4	5

Five-level risk matrix	Negligible	Minor	Moderate	Major	Extreme
	1-2	3-4	5-9	10-16	20-25



2

VALIDATION OF THE ESTABLISHMENT OF THE OBJECTIVES, SCOPE AND FRAMEWORK OF THE PROCESS

Validation criteria		Validated	Comments
Establish the objectives of the process	Establish general objectives	☐	
	Establish specific objectives	☐	
Establish the scope of the process	Define the geographic boundary	☐	
	Define the temporal limit	☐	
Establish the framework of the process	Produce a portrait of the municipal body and its territory	☐	
	Define the key systems	☐	
	Identify climate hazards	☐	
	Collect climate data	☐	
Define the scales of analysis	Define the likelihood scale	☐	
	Define the consequence scale	☐	
	Define the risk scale	☐	

STEP 3 CLIMATE RISK ASSESSMENT

Reliance on the following experts is recommended to successfully carry out this step:

- Risk assessment experts
- Climate science experts
- Experts in the realm of adaptation to climate change
- Experts in the realm of the socio-economic evaluation of vulnerabilities
- Territorial planning experts
- Relevant engineers and technicians
- Environmental experts
- Operations and maintenance experts
- Financial and management experts
- Legal and insurance experts
- Representatives of the First Nations and Inuit
- Representatives of vulnerable populations
- Occupational health and safety experts
- Public health experts

This step consists in identifying, analyzing, and assessing the risks for each of the systems or their components through the examination of climate information, vulnerabilities, and the potential consequences of current and future climates.

The identification of risks consists in determining which risks might arise and should thus be selected in the subsequent risk analysis and assessment. A risk is present when a system or its components are simultaneously exposed and vulnerable to a climate hazard.

Risk analysis relies on the likelihood and consequence scales established at the outset of the process. It consists in establishing risk values and levels for each system component according to different time horizons, based on the likelihood of the occurrence of the event or hazard and the seriousness of the consequences that could ensue.

Risk assessment involves comparing the levels of risk obtained for each component and conducting an initial analysis of the requisite level of intervention.

Identify the risks

This step seeks to identify the risks by cross-referencing the list of system components with the list of climate hazards, which facilitates reflection on the risks that can affect vulnerable systems by considering the analysis of the current and future climate (step 2). It consists in:

- defining the components associated with the systems identified in the preceding step during the framework of the process;
- conducting an exposure analysis to determine if the components are exposed to climate hazards.

To carry out this step, workbook 1, which provides instructions to apply the risk assessment, must be used. Next, workbook 2 proposes a hypothetical example of a risk assessment.

Define the components of the systems

The objective of this sub-step is to specify the components of the systems likely to be impacted by climate change (see Table 8). Depending on the framework and the scope of the process, an initial risk assessment could focus on systems (see the "Define the key systems" sub-step). However, it could be necessary to determine the components to plan adaptation measures on the appropriate spatial and temporal scale. It then becomes important to rely on experts for each of the systems concerned and establish the relevant components. During this sub-step, it is also possible to modify the list of systems established previously.

To avoid overlooking significant components, the following elements should be considered:

- What can happen? Which circumstances or tangible or intangible problems are likely to have an impact in the future and why?
- Which characteristics of the component are more or less susceptible to being affected by a climate hazard?
- At what point is security no longer assured?
- At what point must the sub-system and its components be updated or replaced?
- What would happen if the supply chain were interrupted?

Table 8: Essential systems and components to be studied

System	Component
Infrastructure	
Road network	• Travel lanes; • Bridges, culverts, and tunnel.
Disaster-resilient infrastructure	• Flood defences such as embankment levees, protective walls, concrete blocks, sheet piling, masonry, or riprap; • Coastal erosion and flooding protective structures such as beach nourishment, green infrastructure, and riprap.
Municipal buildings	• Foundations; • Building envelopes; • Roofs; • Plumbing; • Heating, ventilation, and air conditioning (HVAC); • Equipment.
Residential buildings	• Principal residences.
Population and local economy	
Population	• Residents; • Municipal workers such as police officers and firefighters; • Non-residents such as tourists.
Municipal services	
Public works **Public safety**	• Snow removal and disposal; • Residual materials collection and management; • Maintenance of green spaces; • Fire and disaster management.

For more information:

See Appendix F, which presents a fuller list of systems and components.

Conduct an exposure analysis (yes/no analysis)

The components (or systems depending on the scope and framework) are then subject to an exposure analysis, commonly known as a yes/no analysis, to determine which ones should be retained for the rest of the process. This sub-step allows for an initial sorting of the system components identified previously.

The exposure analysis evaluates the interaction between the components of a system and a climate hazard regardless of occurrence and intensity. In other words, it is necessary to ask the following question: Were this climate hazard to occur now or in the future, would the components be affected? If the answer is "yes," a value of 1 is assigned to the analysis and if it is "no," a value of 0 is assigned. In case of doubt, if it is not possible to decide between "yes" and "no," the component is deemed to be exposed. Table 9 gives an example for certain components of a wastewater collection system.

Table 9: Example of an exposure scale for a wastewater collection system

Component	Climate hazard		
	Heatwave	Heavy rains	Freeze-thaw cycles
Culverts	0	1	1
Retention ponds	0	1	1
Operating staff working outdoors	1	1	0

In workbook 1, sheet 2 can be completed with the relevant climate hazards and components. An exposure scale is presented in workbook 1.

The exposure analysis can require the professional judgment of several experts. It is recommended that it be conducted in a workshop to foster discussion and understand the participants' viewpoints. During the discussion, the exposure analysis could be more thorough to ascertain whether a climate hazard's impact on the system might have a cascading impact on other systems. The objective is to understand the potential impact chains that a single climate hazard could trigger.

The vulnerability analysis

Before analyzing the risk itself, an optional vulnerability analysis can be conducted, which seeks to determine a system's propensity or predisposition to sustain damage from a climate hazard. It may be worthwhile to conduct a formal analysis since the vulnerability of a given environment determines in many ways the consequences of climate hazards. In other words, a vulnerability analysis collects information in a more structured, detailed manner. Such information will be used to determine the consequences during the risk analysis step. Should it be decided not to conduct a formal vulnerability analysis at this stage, it will still be important to consider it more qualitatively and intuitively when consequence values are ascribed during the risk analysis.

Vulnerability is assessed in light of the sensitivity and adaptive capacity of the exposed elements (Figure 4).

Figure 4: The components of vulnerability

To conduct a vulnerability analysis, see Appendix H and sheet 3 in workbook 1.

3

Analyze the risks

Risk analysis consists in examining each interaction between the climate hazard and the component to establish a risk level for all the time horizons selected. This step thus implies establishing a likelihood value for each climate hazard and a consequence value for each exposed and vulnerable component that reflects the potential damage and its extent. Such likelihood and consequence values are established by means of the scales defined previously.

The importance of the support of experts must not be underestimated at this stage, especially when the quantitative likelihood and consequence values are not available. The risk analysis may indeed have to hinge on the opinion of experts, and it must, therefore, be acknowledged that this type of analysis involves some degree of subjectivity. However, the analysis should not hinge on the opinion of a single expert. The efforts of the team leader are essential to lead discussions and ensure the soundness of the process and obtain a consensus among the experts. It is also important to keep a record of such discussions and record the sources of the data used and the attendant uncertainty in order to be able to substantiate the findings of the analysis and plan the attendant measures.

Keep a record of data sources and uncertainty

It is important when the likelihood and consequence values are established to consider the uncertainty associated with climate projections and the data sources used to establish the values. Indeed, uncertainty can affect the prioritization and treatment of risks. For example, the likelihood of a hazard may be based on numerous climate projections, while the likelihood of another hazard is based on the judgment of several experts who attribute a low confidence level to this value. Column FI is provided for this purpose in workbook 1.

Sheets 4 and 5 in workbook 1 must be used for this sub-step.

Determine the likelihood values of climate hazards

This sub-step seeks to attribute a likelihood value to each climate hazard according to the scale defined in the "Define the likelihood scale" sub-step. The likelihood values vary according to the time horizon and should be provided for the reference climate and the future time horizons, and the emissions scenarios selected in step 2.

Hence, returning to the example of heatwaves in Table 2 (see the "Characterize current and past climates" sub-step) for the 2050 time horizon, the climate projections indicate that four heatwave events could occur, which corresponds to the description "will probably occur in most cases," i.e., level 4, "Very probable" in likelihood scale A (Table 10, column framed in red).

Table 10: Example of the choice of a likelihood value

Likelihood scales	Level of likelihood				
	Very unlikely	Unlikely	Probable	Very probable	Almost certain
	1	2	3	4	5
Scale A	Could occur under exceptional circumstances	Could occur occasionally	Will occur occasionally	Will probably occur in most cases	Is expected in most cases

Determine the consequence values of climate hazards

This sub-step seeks to attribute a consequence value for each climate hazard and each system or component selected for the analysis.

The consequence value is determined in response to the following question: What damage would be sustained if the climate hazard occurred?

Different factors affect a hazard's impact on a component. The vulnerability of a component, i.e., its sensitivity and adaptive capacity, directly affects the severity of the damage that a climate hazard inflicts. For example, a building that is more dilapidated than another one and thus more vulnerable will sustain more significant consequences than a less dilapidated building. Conducting a vulnerability analysis beforehand can thus facilitate the determination of the consequence values.

Table 11 presents a hypothetical example of consequence values on the health of employees working outdoors and facing heatwaves that can be assessed as "moderate" according to scale C (see Table 6 in the "Define the consequence scale" sub-step). This value reflects reduced activity and health impacts and employee comfort (Table 11, column framed in red).

Table 11: Example of the choice of a consequence value

Conse-quence scales	Levels of consequences				
	Negligible	Minor	Moderate	Major	Very high
	1	2	3	4	5
Scale C: health conse-quences	Negligible mortality or hospitalization rate in the population affected	Low mortality or hospitalization rate in the population affected	Moderate mortality or hospitalization rate in the population affected	High mortality or hospitalization rate in the population affected	Severe mortality or hospitalization rate in the population affected

Determine the risk values

This sub-step seeks to establish a correspondence between the likelihood of a climate hazard and its consequence for all the systems or components analyzed based on the risk scale defined in the "Define the risk scale" sub-step.

For example, a likelihood value of 4 (Table 10) and a consequence value of 3 (Table 11) result in a risk value of 12 (Table 12) (4 x 3 = 12).

Table 12: Example of a risk value

		Likelihood				
		1	2	3	4	5
Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Evaluate the risks

The objective of the assessment is to organize along hierarchical lines the entire array of risks identified in the risk assessment stage by grouping them by levels according to the previously established risk values. Once the hierarchy has been established, the risk levels can be put into perspective by climate hazard and by issue on a time scale, by comparing them and beginning to estimate the type and level of intervention required.

Sheet 5 in workbook 1 must be used for this sub-step.

Establish the risk levels

The risk scale established in Table 7 of the "Define the scales of analysis" sub-step is used here to categorize the risks according to their gravity (or risk level). This scale is used here to attribute a risk level to the values obtained in the preceding step. Once completed, the process will provide the risk matrices in several colours, each of which represents a separate risk level.

Reminder of Table 7: Example of risk level scale

Negligible	Minor	Moderate	Major	Extreme

Lower priority → Higher priority

Generally, major and extreme risks should have priority over negligible or minor risks in the climate risk treatment stage. However, it should be noted that the risk matrices do not always clearly reveal the scope of certain risks at their extremities, i.e., the risks that can engender very severe consequences but that are very unlikely, and those with limited consequences but whose likelihood is almost certain. These specific cases warrant special attention.

It should be noted that, although major and extreme risks and the specific cases identified in the risk assessment stage should usually be treated as a priority, other factors must also be considered to determine how and when it will be advisable to manage different risks. For example, the availability of a window of opportunity to act might encourage the priority treatment of a moderate risk while the need to carry out preparatory work to plan an intervention could mean that a major risk is treated later than a moderate risk. They will be presented in step 4 (Climate risk treatment).

Identify special cases

Aside from paying special attention to the major and extreme risk values stemming from the work carried out, it is prudent to closely examine two specific cases that appear in the matrix. Indeed, they can represent situations that demand more significant prioritization than their risk value suggests and require special treatment.

Reminder of Table 7: Example of risk level scale

		Likelihood				
		1	2	3	4	5
Consequences	5	① 5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	② 5

3

- First specific case: the likelihood of occurrence is highly improbable, but the consequences are severe.

For example, the “tornado” climate hazard is a very rare event in Québec (likelihood value = 1). However, it usually has catastrophic consequences (consequence value = 5). In such a case, it may be judicious to consider this risk, even if it is low, but to do so by adapting the type of intervention such that its low likelihood is considered.

- Second specific case: the likelihood of occurrence is almost certain, but the consequences are negligible.

For example, freeze-thaw cycles on roads usually have only limited impacts (consequence value = 1). However, this is a frequent event (likelihood value = 5) that can have significant cumulative impacts on the cost of maintaining and rebuilding certain roads. In this type of situation, the following question must be raised: could the greater frequency of freeze-thaw cycles on roads due to climate change engender significant cost overruns that affect a municipality’s budget balance?

Communicate the risk levels

The risk matrices obtained in the risk analysis stage provide information on the risk level for each system or component in the face of various climate hazards for different time horizons (current, 2050, and 2080) and for moderate and high GHG emissions scenarios. To facilitate the communication of these findings to the project team, elected officials, the public, and the stakeholders, and to facilitate their use when the measures are identified, it is necessary to present them in a format adapted to decision-making.

First, to present a broad portrait of the impact of climate on the territory over time, it is suggested to present the most significant hazards, i.e., those associated with the greatest number of risks and for the different time horizons selected.

Second, more specifically, to visualize and understand the evolution of risk over time for each system and component and in relation to each hazard, it is suggested to present the risks and hazards one by one, starting with those at the highest level (see the example in Table 13).

Table 13: Evolution of risks in the territory under consideration

Risk	Current horizon	2041–2070 horizon		2071–2100 horizon	
		SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Flood-related damage to infrastructure	Moderate	Moderate	Major	Moderate	Major
Heat-related mortality and morbidity	Negligible	Minor	Moderate	Moderate	Moderate
Forest-fire-related damage to infrastructure	Negligible	Minor	Moderate	Moderate	Extreme

3

VALIDATION OF THE CLIMATE RISK ASSESSMENT

Validation criteria		Validated	Comments
Identify the risks	Define the components of the systems	☐	
	Conduct an exposure analysis	☐	
	List the components exposed to the hazards revealed by the analysis	☐	
Analyze the risks	Determine the likelihood values of climate hazards	☐	
	Determine the consequence values of climate hazards	☐	
	Determine climate risk values	☐	
Evaluate the risks	Establish the risk levels	☐	
	Identify the special cases	☐	
	Communicate the risks	☐	

STEP 4 CLIMATE RISK TREATMENT

Preferred experts to successfully carry out this step

- Experts in the realm of adaptation to climate change
- Risk management experts
- Territorial planning experts
- The relevant engineers and technicians
- Environmental experts
- Operations and maintenance experts
- Financial and management experts
- Representatives of the First Nations and Inuit
- Representatives of vulnerable populations
- Occupational health and safety experts
- Public health experts

This step consists in planning the implementation of the adaptation measures. To do so, it is advisable to determine the adaptation objectives based on the risk assessment carried out previously, identify and select the adaptation measures to be implemented and their monitoring and evaluation indicators, and plan the implementation, monitoring, and evaluation of the adaptation measures selected using adequate resources. Throughout this step, it is important to maintain coherence with the perspective and general objectives established at the outset of the process.

Credit: Conseil régional de l'environnement de la Capitale-Nationale

4

Determine the specific adaptation objectives

Specific adaptation objectives: reference points for adaptation planning

Having identified the main risks and their evolution over time according to at least two GHG emissions scenarios during the risk assessment stage, the municipal body is now able to determine the specific objectives, which, if they are attained, will reduce such risks. For example, in cases where the flood-related risk for municipal buildings is likely to intensify and become severe in the future, the municipal body could set as its specific objective to relocate or adapt the buildings in anticipation of this possibility, bearing in mind the applicable regulations.

Setting specific objectives helps to adopt a concrete perspective of what needs to be done to adapt and to guide the identification and selection of the adaptation measures. Specific objectives are also useful to mobilize the stakeholders and demonstrate that the municipal body is committed to a structured approach that will ultimately enable it to significantly reduce risks. The adaptation measures identified must be coherent with, and contribute to, the specific objectives selected.

It is desirable to set both short-term objectives (5 to 10 years) and medium- and long-term objectives. The short-term objectives will guide the choice of the measures to be implemented in the first years while the medium- and long-term objectives are useful to map what then needs to be done and to guide the identification of further measures to be considered, thus enabling the municipal body to establish an adaptation trajectory. Indeed, the management of a climate change risk is rarely confined to the implementation of a single, one-off, short-term intervention. It is often necessary to implement an intervention strategy that involves the introduction of a series of adaptation measures over time. For example, faced with the imminent loss of essential infrastructure due to coastal erosion and flooding, a municipal body could adopt a temporary, short-term protection objective by undertaking beach nourishment, and a permanent, medium- and long-term protection objective by resorting to relocation. Similarly, to reduce health hazards during heatwaves, a series of progressive greening objectives and a planning horizon or several years to decades- could be necessary to transform a highly mineralized city centre.

Specific adaptation objectives can take different forms. The more precise an objective is, the more it facilitates planning and the implementation of effective adaptation solutions.[14 15]

Credit: Jacques-Cartier Centre

Credit: Jacques-Cartier Centre

Specific adaptation objectives: aiming for resilience in the face of global warming scenarios

To identify objectives and adaptation measures aligned with possible global warming trajectories and the level of risk tolerance of the municipal body, individuals, and the government, it is necessary to rely on a prospective vision, bearing in mind their inherent uncertainty. In this instance, at least two GHG emissions scenarios corresponding to the possible global warming trajectories were examined during the risk assessment stage, i.e., a moderate emissions scenario and a high emissions scenario. A very high emissions scenario was also examined for certain needs. Under the circumstances, there is good reason to ask how to use the information drawn from the risk assessment to identify such objectives. In other words, which scenario(s) should be used for risk treatment?

In the presence of high risks for security and human life or whose social and economic consequences are significant, especially when the window of opportunity to adapt is limited and there is a risk of adaptive lock-in, it is usually desirable or indeed, necessary, to consider high and very high emissions scenarios (SSP3-7.0, SSP5-8.5, RCP8.5) when the objectives and adaptation measures are defined and to project as far into the future as possible. For example, it is advisable to design long-lived infrastructure that is resilient to the climate conditions to which it will be exposed throughout its useful life. Similarly, from the standpoint of land-use planning, the establishment of new infrastructure and neighbourhoods in zones that are or that could become at high risk of disasters in the long term (e.g. coastal flooding and submersion) is to be avoided to protect individual health and safety and avoid significant economic impacts.

When risks are moderate or, for higher risks that will only occur in the longer term, and it is possible to adapt gradually to them, it may be desirable to consider objectives and adaptation measures based on the results of the risk assessment with a moderate emissions scenario (SSP2-4.5 or RCP4.5) and adjust them along the way if need be. This approach facilitates the implementation of robust objectives and adaptation measures in anticipation of a plausible moderate emissions scenario while maintaining the necessary flexibility to enhance the level of adaptation as needed in the future, should the level of future global warming approach that associated with a high emissions scenario. In such a case, it is nevertheless important to ensure that the adaptation strategy adopted does not risk engendering an adaptive lock-in. The adaptation approach based on a moderate emissions scenario can thus facilitate achieving a satisfactory and sufficient level of adaptation that can be adjusted as needed while avoiding overadaptation, which could limit the resources available to respond to the municipal bodies and the population’s other priority needs.

Identify and select the adaptation measures

Several approaches can be adopted to identify and select the measures in the municipal body's adaptation plan (see box). It is incumbent upon the project team to choose the approach best adapted to its context. The participants' level of expertise or the number of people consulted are factors that can affect the choice of the approach. The approach presented in this guide consists in listing the potential measures, then selecting the most propitious ones in light of the different criteria.

The backcasting approach

The backcasting approach is widely used to elaborate GHG emission reduction plans. In some instances, when it is possible to set sufficiently precise adaptation objectives and enough is known about the anticipated benefits from contemplated measures, this approach can also be used to develop an adaptation trajectory that includes the most promising measures to be implemented. Backcasting uses as a starting point the objectives established (e.g., GHG emission reduction target or a precise adaptation objective) to identify the measures that will facilitate their optimal attainment. In other words, this approach hinges on the desired outcome and the establishment of an optimized trajectory that facilitates its attainment by emphasizing from the outset the search for, ideation, and selection of the best possible measures to be implemented over time.

Identify potential measures

First, it may be useful to draw up the most comprehensive inventory possible of potential measures without considering the attendant constraints, such as social acceptability, high costs, and technical complexity, starting with an inventory of the adaptation measures that would respond as effectively as possible to the highest risks identified in the risk assessment stage. Avoiding the initial consideration of the constraints avoids restricting the ideation process. The adaptation measures identified must, however, be applicable in Québec.

This exercise lends itself to the consideration of equity and the just transition. For example, in the case of risks related to a vulnerable population, the project team should identify the preferred potential measures from the standpoint of a such a transition.[19 24 44]

To identify the measures, a literature review is highly useful. Here are some examples of resources to consult:

- websites;
- the literature;
- municipal or RCM adaptation plans;
- experts' reports.

It should be noted that, given the higher level of certainty surrounding short-term climate change-related risks and the greater ease of precisely planning short-term projects, the adaptation measures identified for implementation will usually be more detailed for the first years of the adaptation plan than in the medium and long terms.

For more information:

Appendix I presents several structural and non-structural risk adaptation measures. To obtain optimal results, a combination of both types of measures is preferable.

4

Select the measures

Once the potential measures have been established, several factors must be considered to determine which ones will be selected and to plan their implementation sequence. Basically, all the measures adopted should be in line with the values, vision, and specific objectives that the municipal body has established to satisfy its needs and priorities. They should also be realistic and feasible.

Certain selection criteria are related to the risk and its treatment while others are of a more operational nature. All these criteria can not only influence the choice of measures but also when they are implemented. Below are some examples.

Examples of criteria related to the risk and its treatment:

- the attainable level of risk reduction;
- the potential of a measure to simultaneously treat several risks;
- the duration of the need to protect infrastructure, a built environment, or a system;
- the lifespan of a system or one of its components;
- whether it is possible to adjust the adaptation measures over time, including the risk of adaptive lock-in;
- the risk tolerance of the municipal body, the population, and the government;
- the social acceptability and equity of the measures;
- the socioeconomic and environmental consequences of implementing the measures.

Examples of operational, financial, or related criteria:

- the municipal body's ability to implement the measures;
- the availability of external support such as professional or technical services;
- the ability to obtain the approval of all the stakeholders concerned to fund, plan, implement, and engage in monitoring and evaluation;
- the time required to obtain the requisite municipal and government authorizations;
- the presence of a window of opportunity such as taking advantage of the rebuilding of a street already planned in order to implement greening measures, an offer of one-off funding, or a regional dynamic to act in a certain field;
- the availability of funding;
- design, implementation, and maintenance costs are lower than the cost of inaction;
- the economic, social, or environmental co-benefits stemming from the implementation of the measures.

The precautionary principle, intergenerational equity, the cost of renunciation, and the risk of adaptive lock-in should be fully considered when the measures are selected. While these principles are applicable independently of the considered time horizon, it is especially important to examine them in the context of the adaptation measures intended to contend with the highest risks on the 2071-2100 horizon and beyond in a context of a just transition.

Tools to select the measures

A more structured assessment of the measures to be implemented can be conducted by means of different so-called "prioritization" analytical methods. They compare the measures with each other according to the municipal body's adaptation objectives and various criteria such as those mentioned earlier. Appendix J presents three examples of prioritization methods, i.e., the multi-criteria analysis, the scenario analysis, and the cost-benefit analysis. The methods display different objectives, contexts for application, advantages, and drawbacks. Moreover, they can complement each other and be used jointly if financial and human resources allow. The multi-criteria analysis can also be appropriate to select the measures on a qualitative basis, while the cost-benefit analysis can be preferable to select measures by comparing them to the cost of not choosing any of them (inaction). The scenario analysis is better suited to identify the appropriate adaptation measure according to the evolving climate. The participation of experts is recommended for each of the analyses.

For more information:

See Appendix J for additional information on the prioritization methods and tools.

Develop monitoring and evaluation indicators

The development of adaptation indicators poses a challenge since there is no single or universal indicator to measure adaptation, a field in which the design of quantitative indicators has proven particularly difficult. However, it is possible to develop robust indicators that facilitate the assessment of several key factors in an adaptation process, including the inputs. The existing government or municipal adaptation plans can be a source of inspiration in this respect. Special attention must focus on the choice of indicators since certain government funding programs can demand the use of precise indicators and it is advisable to bear this in mind during their development.

Once the municipal body has adopted the indicators related to the objectives determined beforehand in the process and/or the measures, the quantitative or qualitative targets must be linked to them. It is not necessary to set a target for all the indicators given that some of them can be used to measure or, indeed, simply indicate, trends instead of achieving objectives.

There are several types of monitoring and evaluation indicators in the realm of adaptation. Monitoring and evaluation indicators can measure different factors, including:

- changes in the municipal body's organizational strategies;
- the attainment of the objectives set in the context of the process (step 2), or specific adaptation objectives established upstream from the identification and selection of the measures;
- the progress of the implementation of the adaptation measures or groups of measures or their efficiency;
- benefits from or the impact of the measures.

It should be noted that, given the cumulative or cross effects of certain measures and depending on how they are structured, it is often appropriate to consider them in combination rather than individually.

Among the good practices relating to indicators and data collection to measure them, we can cite the following:

- the focus of each indicator must be clear and the municipal employees and officials who deploy it must be able to easily interpret it;
- the indicators are accompanied by measurable targets and a deployment schedule;[45 46 47 48]
- the data compiled by the indicators must be available and up to date throughout the territory covered, be credible and sufficiently precise, be freely accessible or accessible through a use and publication agreement;
- monitoring data should be collected in a format that facilitates the sharing of the findings, such as software in which changes are shared in real time;
- the use of the same monitoring and evaluation indicators from one adaptation plan to the next is the preferred practice when possible since it facilitates monitoring in the longer term. However, this must not impede the enhancement of the monitoring and evaluation indicators.

Credit: Conseil régional de l'environnement de la Capitale-Nationale

4

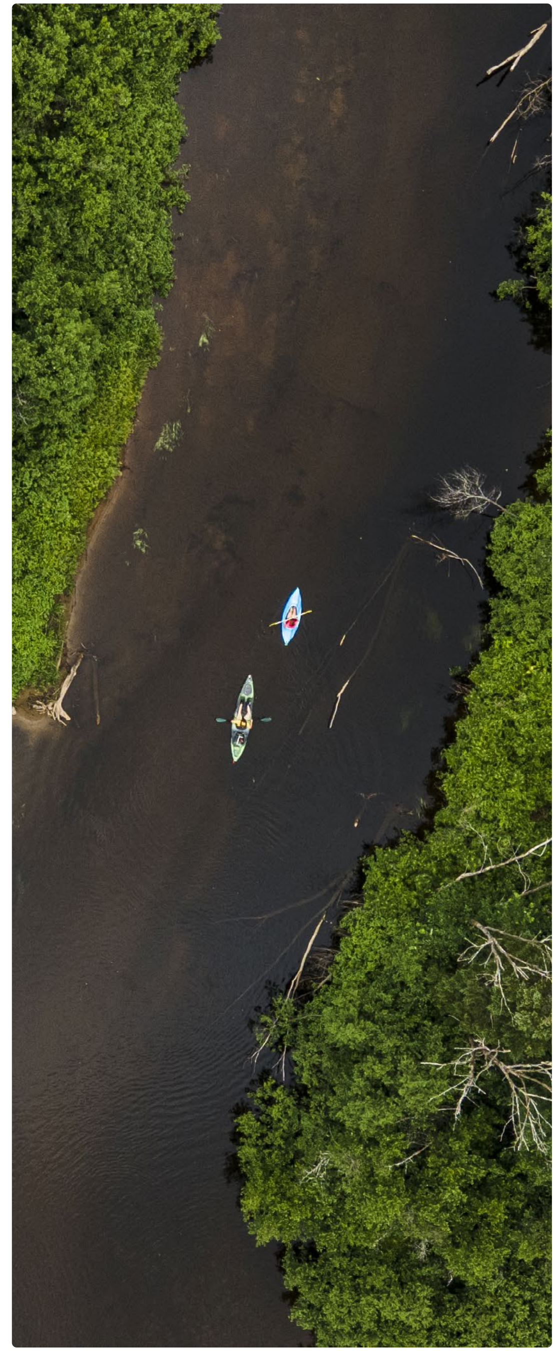
Indicators to monitor and assess the municipal body's organizational strategies

These indicators are used to ascertain whether the municipal body possesses the necessary tools to make headway in the adaptation process.

To help municipal bodies choose or develop this type of indicators, Table 14 provides certain examples and the questions that the indicators must answer.

Table 14: Examples of indicators to monitor and assess the organizational strategies of the municipal body and related questions to be raised

Examples of indicators	Related questions
The number of relevant climate hazards assessed in the future climate The number of relevant systems assessed in the future climate	Has the municipal body assessed the entire array of climate hazards that could affect its territory bearing in mind projected climate change impacts? Has the municipal body assessed its most risk-prone systems?
The number of relevant policies elaborated or adjusted to support adaptation to climate change	Has the municipal body adopted a climate action plan and has it adjusted its key policies, strategies, action plans, and tools to consider the risks identified in its territory and adapt to climate change, e.g., land-use planning plans, civil defence plan, and water environment and wetland protection plans?
The percentage of municipal employees who have attended an awareness-raising or training session devoted to adaptation to climate change	Has the municipal body trained its employees to enable them to consider climate change in the context of their duties or support the implementation of the adaptation plan?
The percentage of municipal employees who are aware of and support the municipal body's adaptation process	Are municipal employees informed and do they support the implementation of the adaptation plan?
The degree of commitment of the stakeholders asked to implement the measures	Do the partners feel responsible for the measures implemented?
The percentage of the population that is aware of and supports the municipal body's adaptation process	Has the municipal body succeeded in heightening public awareness of the process that it has undertaken?



Credit: Nature Québec - Mélanie Jean

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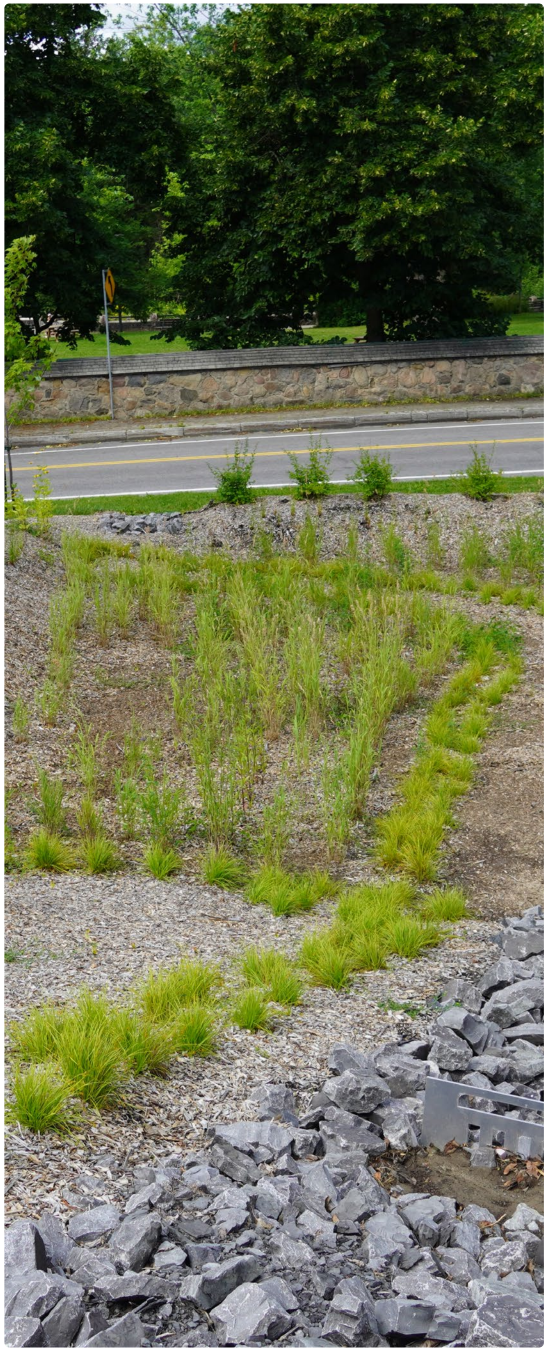


Credit: Conseil régional de l'environnement de la Capitale-Nationale

Monitoring and evaluation indicators for the implementation of measures or groups of measures

These indicators assess the implementation completion status of the measures and also reflect the success or difficulties encountered during the process.

To help municipal bodies choose or elaborate this type of indicators, Table 15 provides certain examples and the questions that the indicators must answer.

Table 15: Examples of indicators to monitor the introduction of the measures and related questions to be raised

Examples of indicators	Related questions
The percentage of the adaptation measures implemented	What remains to be done to fully introduce the measures? Has the implementation timescale concerning the measures been met?
The number of retention ponds established The area of impermeable surfaces withdrawn and replaced by permeable surfaces	Have the measures reduced the impacts of heavy rainfall?
Changes in the canopy index The number of trees planted The number of urban revegetation projects established The number of white or green roofs installed Changes in the area of the green infrastructure established	Have vegetated surfaces and wooded areas been established to reduce heat islands?
The number or percentage of households protected from coastal erosion and flooding	Have the measures enhanced public safety?
The number of buildings characterized in the face of flood risk	Have the risk-prone buildings been identified?
The number of calls received per hotline The number of information documents shared or downloaded online	Have residents used the tools made available to them?

4

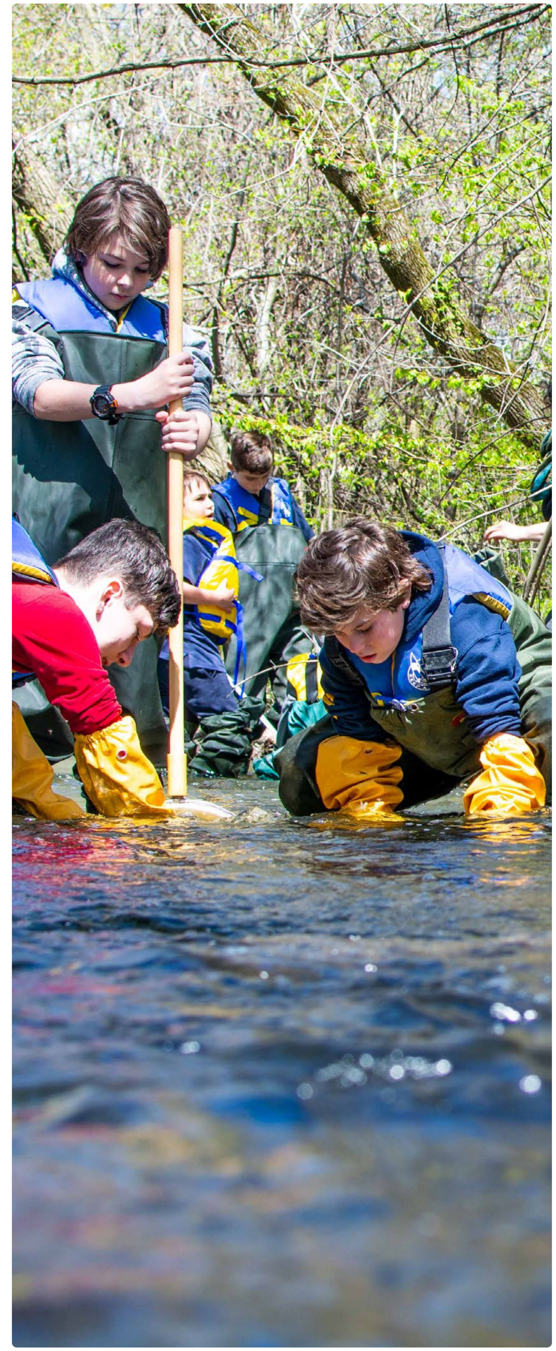
Monitoring and evaluation indicators for benefits from measures or groups of measures

These indicators assess the performance of the measure implemented and put to the test by the occurrence of a climate hazard.

To help municipal body choose or elaborate this type of indicators, Table 16 provides certain examples and the questions that the indicators must answer.

Table 16: Examples of monitoring and evaluation indicators respecting benefits (outputs or impacts) from the measures and related questions to be raised

Examples of indicators	Related questions
The percentage of buildings still exposed to flooding in 2100 The percentage of the road network exposed to flooding The number of flood-prone residences The number of people who have visited the cooling centre since it opened	Has the adaptation measure had the anticipated outcomes (reduction of vulnerabilities and risks)? Has the measure avoided damage when climate thresholds are exceeded? Does the measure enhance the ability to face climate hazards?
The number of times that operations have been suspended in the wake of the measure's implementation	Does the measure optimize the municipal body's activities? Has the investment in resources (individuals and cost) been profitable in relation to benefits from the measure?
The surface area of heat islands The number and duration of overflow episodes	Have the measures implemented reduced climate hazard-related risks?
The number of additional deaths caused by extreme heat episodes The percentage and number of inhabitants who have used the measure since its implementation	What changes have occurred in the population since the implementation of the measures, e.g., quality of life, the satisfaction of the beneficiaries, and impacts on the most vulnerable? Have the measures been well-received by the public?



Credit: Groupe d'éducation et d'écosurveillance de l'eau

4

Plan the implementation of the plan and its measures

The planning of the implementation, monitoring, and evaluation of the plan and the adaptation measures consists in organizing their rollout over time.

Planning the deployment schedule

The order of implementation of the measures should be guided, in particular, by the risk assessment (the importance and imminence of the risks) as well as by other considerations. Accordingly, an adaptation measure that responds to a major risk could be implemented before a measure that responds to a less urgent risk. However, other considerations can alter the implementation sequence, such as windows of opportunity, the availability of funding, the desire to act of the stakeholders concerned, and adaptive lock-in challenges related to inaction. The planning calendar is a key component of the adaptation plan that gives it greater credibility and helps to sustain the mobilization of the stakeholders who have participated in the process. [37]

Furthermore, the order of implementation of the measures also depends on the objectives that the municipal body has set. Certain temporary measures can be introduced before a permanent measure. For example, in the case of a neighbourhood prone to risks related to coastal erosion and flooding, beach nourishment can be planned to ensure protection on the 2041-2070 horizon. At the same time, the neighbourhood could be subject to a prohibition on new home construction since, over the 2071-2100 horizon, the adaptation measure deemed the most appropriate will be the relocation of the neighbourhood to ensure its permanent protection.

Rollout of the measures

There are numerous ways to implement the adaptation measures such as policies, standards, and design specifications selected. The choice will depend on the measure and the specific context of the municipality. In most instances, this will entail not just one but rather a series of measures. For example, to improve stormwater management, it is possible to resort to control measures at the source such as promoting the use of rainwater barrels and reducing impermeable surfaces to reduce pressure on the network, but it may also be necessary to plan work such as modifying the dimension of pipes and adding retention ponds on existing infrastructure.

The resilience of adaptation measures

The considerations that follow are to be considered when the adaptation measures are designed and the drawings and specifications are produced, and during the implementation of the adaptation plans.

The adaptation measures selected must be designed to be resilient to the future climate such that, depending on the circumstances, the systems are sustainable and functional for their desired lifespan or can fulfill their protective role. For example, if the adaptation measure adopted to contend with a high or very high flood risk calls for a long-lived levee to be built, the latter must be able to resist the most severe future climate conditions (RCP8.5 or SSP3-7.0, or even SSP5-8.5) to fully satisfy its protective role and avert the catastrophic consequences that would stem from its rupture or submersion. The lifespan of the adaptation measure and the duration of the need for protection are important criteria that will affect the design of the adaptation measures.

It is necessary to compile several informational items in order to plan the implementation of the measures and their indicators. These items are used to obtain an overall view of planning but also to explain in detail the roles and responsibilities of the different stakeholders.

Examples of items to be identified to plan the implementation of measures:

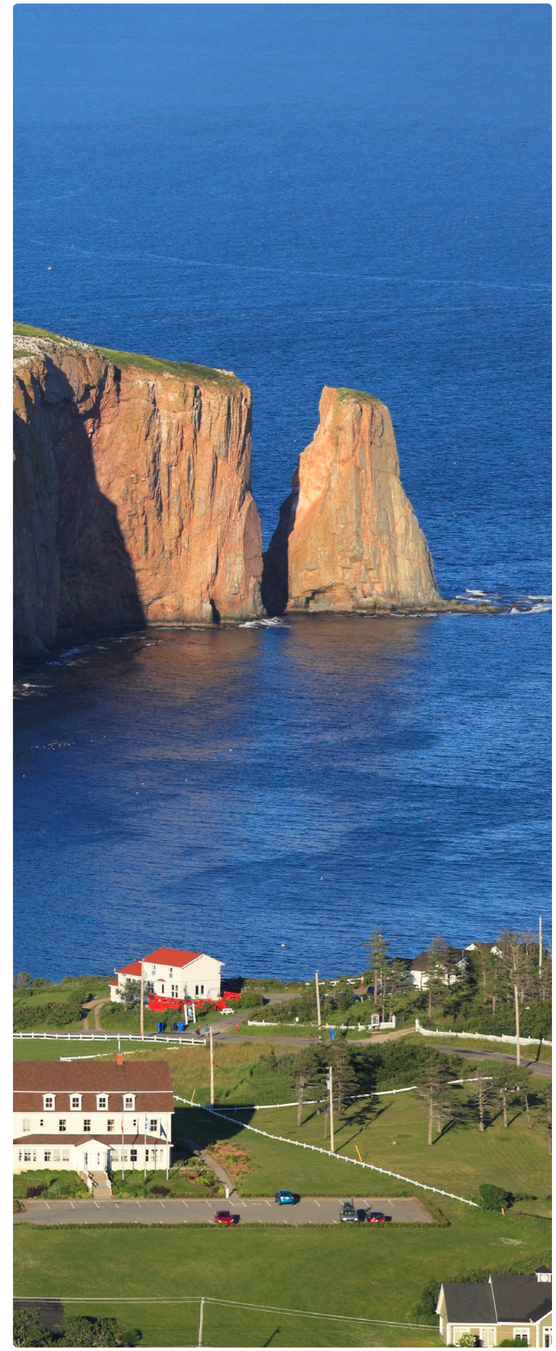
- the municipal division or stakeholder responsible for implementing the measure, and its collaborators;
- the funding method;
- the timetable for implementing the measure;
- the estimated cost of implementing the measure;
- a description of the steps related to the measure (a measure can be complete when several steps have been implemented).

See workbook 3 concerning the collection of information used to plan the implementation of the measures.

Examples of items to be identified to plan monitoring of the measures by means of indicators:

- the individual(s) in charge of introducing the indicator (name and title of the person in charge and municipal division or stakeholder);
- a schedule for implementing the indicator;
- the targets to be measured according to the timetable for implementing the measure;
- the cost of implementing the indicator (estimate, reasons for modifying the costs).

See workbook 4 concerning the collection of information used to plan the monitoring of the measures by indicators.



4

VALIDATION OF THE CLIMATE RISK TREATMENT

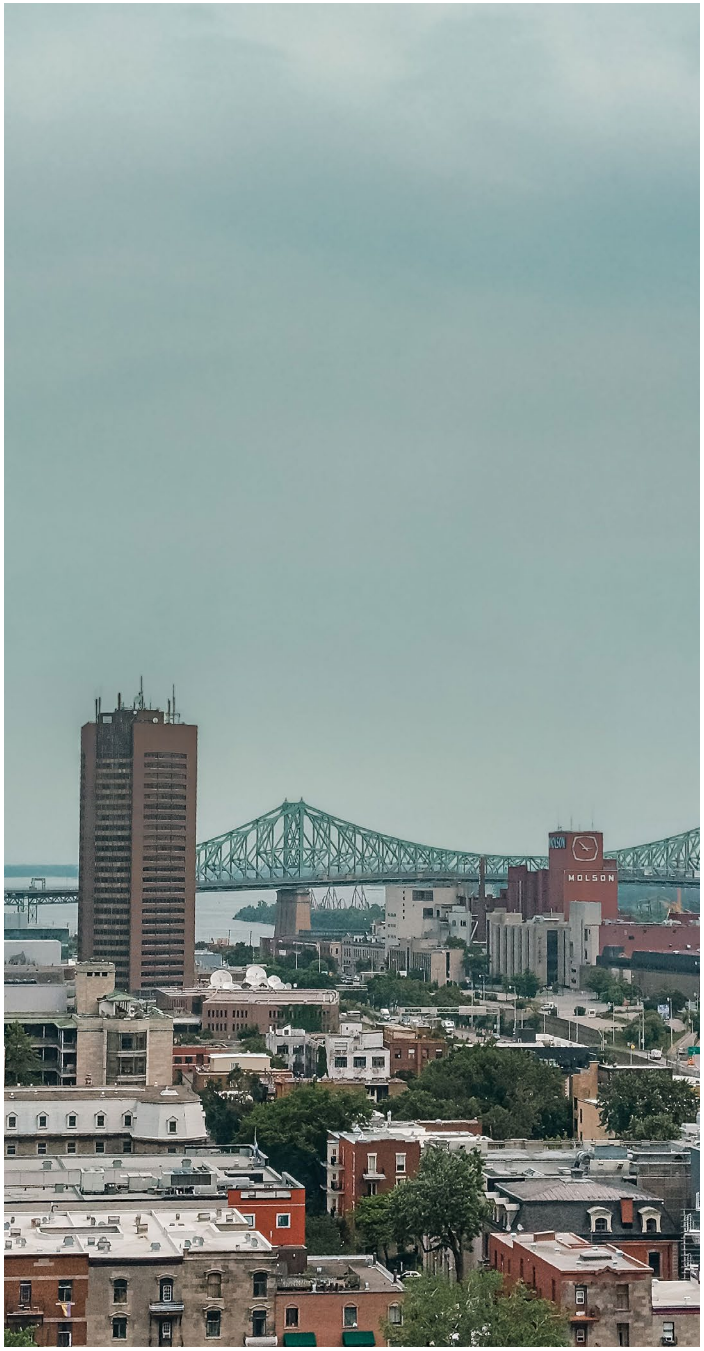
Validation criteria		Validated	Comments
Determine the specific adaptation objectives		☐	
Identify and select the adaptation measures	Identify potential measures	☐	
	Select the measures to be included in the adaptation plan	☐	
	Conduct a prioritization analysis	☐	
Develop monitoring and evaluation indicators	Develop the indicators of changes in the municipal body's adaptive capacity	☐	
	Develop monitoring indicators respecting the implementation of the measures or groups of measures	☐	
	Develop monitoring indicators respecting benefits from the measures or groups of measures	☐	
Plan the implementation of the plan and adaptation measures	Plan the implementation of the measures	☐	
	Plan monitoring of the measures by means of indicators	☐	

STEP 5 PRODUCTION, MONITORING, AND REVISION

Preferred experts to successfully carry out this step:

- Risk management experts
- Communications experts
- Project management experts

This step consists in producing, disseminating, and implementing the adaptation plan, engaging in monitoring by means of indicators, and making recommendations to update the adaptation plan. The adaptation plan must compile in a single document all the information produced during the adaptation process to provide the public and the stakeholders concerned with a transparent explanation of the choice of the measures to be implemented.



5

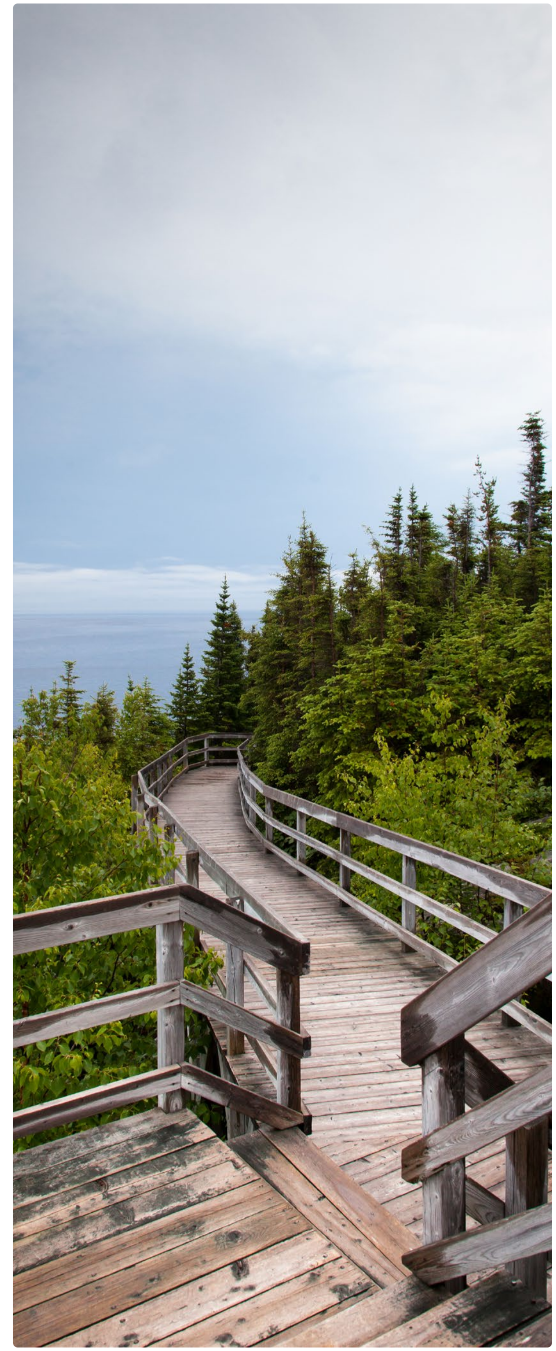
Produce and disseminate the adaptation plan

Produce the adaptation plan

The adaptation plan to be produced should follow the steps in the adaptation process. It may be useful to produce two versions of plans, i.e., a more detailed plan encompassing the process overall, and a simplified plan intended for the public. The representative table of contents of the simplified or detailed plan could include:

- An introduction;
- The objectives, scope, and framework of the process:
  - a portrait of the territory;
  - the climate hazards;
  - the systems under review;
- A climate risk assessment:
  - risk identification
  - risk analysis
  - risk evaluation
- The choice of adaptation measures and monitoring and evaluation indicators
- Planning the implementation, monitoring, and assessment of the measures
- The recommendations and conclusion
- The references

The adaptation plan seeks to provide the tools that the municipal body and its officers need to communicate to the public and to their partners the key risks affecting the territory and the systems under their responsibility and projected changes in such risks and the measures adopted to manage them. Against this backdrop, when several RCMs, several municipalities, or one RCM and its municipalities collaborate to conduct the risk assessment and identify the measures, it is important that they pay close attention to the structure and the presentation of the adaptation plan to ensure that each one possesses the necessary tools in anticipation of communications activities and the search for funding, and the implementation, monitoring, and updating of the plan.



Disseminate the adaptation plan

Once the adaptation plan has been produced, it is important to share it with the public, businesses, and the stakeholders concerned by the risks and the measures adopted. The dissemination by the municipal body of its adaptation plan affords individuals and all the stakeholders concerned the means to become aware of the risks that can affect them and assume their share of responsibility in the management of such risks. In some instances, they could rely on the municipal body's risk assessment to elaborate adaptation measures or produce their own plan.

Additionally, the municipal body's transparency fosters the social acceptability of the adaptation measures to be implemented and shows the partners, especially the financial partners, that it is fully committed to a robust, concerted adaptation process. It is recommended that a communications plan be elaborated to structure the dissemination of the adaptation plan.[13 14 15]

The adaptation plan can be publicized through communications channels such as the social media, press releases, brochures, and events. The municipal body and its partners could publish the plan on their websites and organize a public meeting to inform the public.

Mapping is useful to illustrate the development of certain climate hazards in the territory and certain risk-prone and high-priority intervention zones to facilitate an understanding of the issues and the measures proposed by the stakeholders.

The dissemination of a popularized version is strongly recommended since certain technical and methodological details can be complex or less relevant for the public and the partners. This version should include certain key components for the sake of information, accountability, linkage with the partners, and social acceptance:

- the objectives;
- the spatial and temporal scale;
- a summary of the portrait of the body and territory;
- the identification of the main systems and climate hazards analyzed;
- the current climate risks identified including, when relevant, the hazard-prone areas in the territory and projected changes in them over time, according to the emissions scenarios and time horizons used;

Credit: Écobâtiment

- the key adaptation measures that will be implemented, including, when relevant, the priority response zones in the territory and their relationship to the hazards identified, the relevant selection criteria, the associated monitoring indicators, the implementation timetable, and the municipal body responsible;
- the anticipated implementation budget, when possible;
- the impending stages (assessment and revision of the plan);
- a report on the key consultations conducted and the stakeholders involved in the process.

Appendix K provides a checklist of the contents that it is important to include in the adaptation plan made public. Furthermore, the municipal body should provide other more precise elements of its process and analysis in its detailed plan for internal or more specialized use, and to facilitate future updating of the plan.

5

Monitor and evaluate the adaptation plan and measures

Carry out monitoring and assess the outcomes

Monitoring and analyzing the indicators assesses the overall adaptation process but also, more concretely, evaluates the benefits from the adaptation measures implemented and the progress achieved.

This analysis is important, since the results obtained will significantly underpin updates to the adaptation plan. It is important to collect data at regular intervals over a sufficiently long period to obtain enough quality data to determine whether the measures implemented have achieved the adaptation objectives and if the risks have diminished. Monitoring also identifies problems encountered during the process and adjusts the interventions in order to attain the desired outcomes.[14]

Make adjustment recommendations

In the wake of the preceding analysis, recommendations are made to enhance the process overall and adjust the plan and the adaptation measures to better achieve the adaptation objectives. The recommendations will be considered when the adaptation plan is updated.[14 15 49]

Enhance the process:

- make to process more coherent and rigorous;
- integrate the necessary learning into the process according to the principle of continuous improvement through enlightened decision-making;
- adjust and improve the methodologies and work and collaboration methods to carry out the process;
- adjust training and awareness campaigns;
- adjust the communications methods in the adaptation plan to the general public;
- adjust the municipal body's strategies, e.g., standards, codes, legislation, regulations, and scientific or local knowledge.

Adjust the measures:

- review the measures if the climate projections have changed;
- add new measures;
- improve the measures, which, because of climate change or socioeconomic reasons, have become less effective over time to the extent that they may become inadequate in the face of the desired outcomes;
- modify and withdraw the measures whose outcomes are not sufficiently significant or that have not produced any positive outcome.

Be agile

Developments in climate change and the windows of opportunity to act can mean that new measures that are not integrated into the adaptation plan or adjustments to existing measures become desirable or necessary. Similarly, certain measures stipulated in the plan can become outmoded before the plan ends. To ensure optimal adaptation, it is desirable to be agile and flexible and adjust the implementation plan along the way.

5

Revise and update the adaptation plan

It is a sound practice to update the perspective, the municipal body's adaptation objectives, and the adaptation plan after roughly five years or if new knowledge that directly affects the adaptation objectives is available. The update should ideally not exceed 10 years.

It is advisable to review all the steps in the adaptation process when it is updated, in order to consider new knowledge at each decision point. Such knowledge can, for example, focus on climate change issues or vulnerabilities such as demography, policy, social change, the economy, and new climate knowledge. The recommendations formulated when benefits are analyzed are also an important facet of the update.

Considering that, against a backdrop of climate change, the regular updating of the adaptation plan is a practice that must from now on be integrated into ongoing municipal processes, it is useful to possess well-organized databases and mapping information layers that will facilitate the updates. Geographic information systems are an especially effective tool in this context.

5

VALIDATION OF THE PRODUCTION, MONITORING, AND REVISION

Validation criteria		Validated	Comments
Produce and disseminate the adaptation plan	Produce the adaptation plan	☐	
	Disseminate the adaptation plan	☐	
Monitor and evaluate the adaptation plan and measures	Carry out monitoring and assess the outcomes	☐	
	Make adjustment recommendations	☐	
Revise and update the adaptation plan		☐	

Conclusion

Québec municipal bodies must contend with inevitable climate change that will require considerable adaptation efforts in addition to greenhouse gas emission reduction efforts. The impacts will vary from one municipal body to another but all of them must face changes that will affect populations, infrastructure, the natural environment, and the socioeconomic activities that sustain these communities.

This guide describes a comprehensive adaptation process and provides practical tools to guide the municipal bodies in the development of a climate change adaptation plan.

The development of an adaptation plan falls within the scope of an iterative, participative, multidisciplinary process that reflects the concerns, challenges, ambitions, and perspective of a community to bolster resilience to climate change. It is a complex undertaking but essential to meet the major challenges that climate change poses.

Proper planning mitigates climate change-related impacts and projected risks and, consequently, the attendant costs of such risks. By investing in the adaptation process, the municipal bodies can better anticipate the climate change impacts and implement measures to minimize potential damage.

Glossary

Adaptation to climate change

In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects. [50]

Adaptive capacity

The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences. [50]

Adaptive lock-in

A situation in which it is no longer possible to attain an acceptable or desired level of adaptation or whose attainment implies excessive human, economic, or environmental costs.

Climate change

A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Adapted from [52].

Climate change mitigation

The entire array of initiatives aimed at limiting climate change that consist mainly in reducing greenhouse gas emissions at the source and increasing their absorption by carbon sinks.
Adapted from [24].

Climate hazard

A climate-related event likely to cause the loss of human life or to impact health or security, damage infrastructure and property, engender social and economic disruptions, or degrade the environment. Climate hazards can occur gradually or suddenly.
Adapted from [51].

Climate projection

Simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases (GHGs) and aerosols and changes in land use, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/ radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized.[50]

Climate threshold

The point beyond which a system is deemed less economically, socially, technologically, or environmentally effective.
Adapted from [37].

Climate transition

The transformation of a society and its economy such that it ceases to contribute to climate change and achieves resilience to such change.

Climate variable

Refers to a variable that can be measured directly in the field, e.g., by meteorological stations, or simulated by a climate model and on which climate statistics such as temperature or precipitation have been calculated.[58]

Consequence or impact

Effect, damage, or benefit for natural and human systems affected by the occurrence of a climate hazard.
Adapted from [51].

Emissions scenarios

A plausible representation of future greenhouse gas and aerosol emissions trends that engender rising global temperatures until the end of the century. They are based on assumptions concerning the underlying forces such as socioeconomic and demographic development or technological change. There are several generations of emissions scenarios. The most recent ones are the Shared Socioeconomic Pathways (SSP), which replace the Representative Concentration Pathway (RCP).
Adapted from [3].

Equity

Equity is reflected in a situation where each party initially has the same chances and opportunities, until the attainment of the desired aim.
Adapted from [19 53].

Exposure

The presence of people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure or system components or economic, social, or cultural assets on a site or in an environment likely to suffer consequences.
Adapted from [50].

Just transition

The transition that this implies must be fair, i.e., the benefits and social, economic, and environmental costs must be equitably apportioned between the different stakeholders in society and between current and future generations.

Likelihood

The possibility associated with the occurrence of a climate hazard that can be expressed qualitatively or quantitatively.
Adapted from [51].

Maladaptation

Measures likely to exacerbate the risk of adverse consequences, including increased greenhouse gas emissions, associated with climate change, intensify vulnerability to climate change, be ineffective, or degrade current or future living conditions. This outcome is rarely intentional.
Adapted from [2 54].

Non-structural measure

Any measure that does not include a construction that uses knowledge and practices aimed at reducing risks and impacts, especially through policies and legislation, heightened public awareness, training, and education.[55]

Opportunity cost

The value of what is relinquished when a choice is made.

Percentile

Any of the 99 numbered points that divide an ordered set of scores into 100 parts each of which contains one-hundredth of the total. Percentiles are often used to ascertain the mid-point or median or the extreme values of a data set, e.g., the 10th or 90th percentiles.
Adapted from [3].

Reference period

The time period in the past that serves as a basis for comparison to assess future climate change.
Adapted from [3].

Representative Concentration Pathway (RCPs)

Future scenarios that indicate the increase in radiative forcing in 2100 in relation to the period 1850-1900 resulting, by way of an example, in greenhouse gas and aerosol emissions in the atmosphere according to different combinations of assumptions that underpin the scenarios. The names assigned to the RCP scenarios correspond to their total radiative forcing by 2100 (or later), i.e., RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5. They stem from the fifth phase of the CMIP (CMIP5).
Adapted from [57].

Resilience

The capacity of interconnected social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure.
Adapted from [50].

Risk

The potential for a consequence stemming from the exposure of a vulnerable human or natural system to a climate hazard. Risk combines the likelihood of a climate hazard and its consequences.
Adapted from [50 51].

Risk analysis

A systematic process that seeks to determine the risk level by means of the likelihood analysis of climate hazards on different time horizons and the potential consequences that can stem from their occurrence, which is the second step in risk assessment.
Adapted from [51].

Risk assessment

The overall process of identifying, analyzing, and assessing risks. [26]

Risk evaluation

Process that seeks to organize risks along hierarchical lines, identify those that require the implementation of measures to reduce their significance, and assign them a treatment priority, which is the third step in risk assessment.
Adapted from [51].

Risk identification

The process that consists in systematically collecting information on climate hazards, the exposure to and vulnerability of systems or components in order to determine the risks that can affect them, which is the first step in risk assessment.
Adapted from [51].

Risk matrix

An analytical tool that links the likelihood of a climate hazard and its consequences to determine the risk level (Risk = Likelihood x Consequence).

Sensitivity

The extent to which a system or a species is positively or negatively affected by climate variability or climate change. The impacts can be direct, e.g., changes in agricultural yields due to a change in the average value, range, or variability of the temperature, or indirect, e.g., damage caused by more frequent coastal flooding because of rising sea level.[56]

Shared Socioeconomic Pathways (SSPs)

Future scenarios that combine the assumptions pertaining to socioeconomic conditions and other anthropic climate factors that affect GHG emissions and, therefore, radiative forcing. The entire array of socioeconomic factors and the levels of ambition are transposed to the GHG emissions scenarios, which comprise five families, i.e., SSP1, SSP2, SSP3, SSP4, and SSP5. They stem from the sixth phase of the CMIP (CMIP5).
Adapted from [57].

Structural measure

Any physical construction aimed at reducing or avoiding possible climate hazard impacts or the application of engineering measures to ensure structures or systems that are resistant and resilient to climate hazards.[55]

Time horizon

A future short-, medium-, or long-term time period used to assess and treat risks.

Vulnerability

The propensity or predisposition of individuals and natural and human systems to suffer damage due to a climate hazard resulting from physical, social, economic, or environmental factors. The notion of vulnerability encompasses sensitivity and adaptive capacity.
Adapted from [50].

Vulnerable population

A population likely to suffer the physical, mental, social, or economic consequences associated with a climate hazard. Adapted from the INSPQ (unpublished).

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Climate fact sheets

Abitibi-Témiscamingue

	Climate variables and indicators	Regional trends	Climate normals and anticipated change: 1991–2020	2041–2070 projections: SSP2-4.5	2041–2070 projections: SSP3-7.0	2071–2100 projections: SSP2-4.5	2071–2100 projections: SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	2.6	4.6 (4,1 – 5.8)	5.2 (4.4 – 5.9)	5.6 (5.1 – 7.3)	6.9 (6.4 – 8.1)
	Mean winter temperature	↑	-11.8	-9.2 (-10.0 – -7.2)	-8.2 (-9.7 – -7.4)	-7.8 (-8.6 – - 5.7)	-6.1 (-7.3 – -4.7)
	Mean spring temperature	↑	0.2	2.2 (1.5 – 2.9)	2.4 (1.6 – 3.3)	2.8 (2.0 – 4.3)	4.6 (3.5 – 5.0)
	Mean summer temperature	↑	16.5	18.5 (17.8 – 19.5)	18.7 (18.2 – 19.9)	19.3 (18.5 – 21.0)	20.7 (19.5 – 21.9)
	Mean autumn temperature	↑	5	6.8 (6.3 – 8.0)	7.2 (6.8 – 8.3)	7.7 (7.0 – 9.1)	9.0 (8.2 – 10.1)
	Annual number of heatwaves	↑	0	0.2 (0.1 – 0.5)	0.2 (0.0 – 0.7)	0.3 (0.1 – 1.1)	0.9 (0.3 – 1.8)
	Annual number of days >30°C (days)	↑	2	7 (5 – 12)	8 (5 – 14)	11 (7 – 21)	20 (11 – 35)
	Total annual growing degree days (GDD)	↑	1637	1995 (1885 – 2155)	2038 (1964 – 2222)	2135 (2020 – 2440)	2410 (2240 – 2642)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	91.5	90.5 (82.5 – 95.5)	89.8 (83.3 – 95.9)	90.2 (80.9 – 94.8)	86.8 (78.6 – 91.4)
	Number of winter freeze-thaw events	↑	13.2	18.3 (14.1 – 21.9)	18.9 (16.9 – 21.8)	21.8 (16.2 – 24.5)	23.9 (20.6 – 28.1)
	Number of spring freeze-thaw events	↓	47.8	44.6 (41.1 – 48.4)	42.9 (41.3 – 49.6)	42.6 (38.9 – 47.7)	40.0 (36.5 – 45.6)
	Number of autumn freeze-thaw events	↓	30.2	26.9 (22.5 – 29.3)	25.8 (22.6 – 26.9)	25.0 (20.4 – 27.2)	21.6 (18.3 – 24.5)
	Winter frost index (°C • days)	↓	1460	1121 (885 – 1188)	997 (887 – 1180)	963 (699 – 1028)	730 (603 – 879)
Precipitation (mm)	Total winter solid precipitation	↑?	165.1	172.4 (149.5 – 181.6)	176.2 (163.0 – 188.3)	176.6 (138.1 – 187.5)	169.1 (147.2 – 188.0)
	Total spring solid precipitation	↓	59.4	54.6 (37.1 – 62.5)	53.5 (38.7 – 60.8)	47.1 (38.3 – 62.6)	45.7 (31.0 – 51.3)
	Total autumn solid precipitation	↓	49.5	34.8 (24.8 – 45.7)	34.3 (26.7 – 43.6)	30.2 (23.0 – 40.2)	25.5 (16.7 – 31.6)
	Total winter liquid precipitation	↑	27.5	44.6 (28.3 – 69.4)	47.8 (35.4 – 64.6)	54.7 (41.3 – 86.1)	71.2 (51.6 – 101.1)
	Total spring liquid precipitation	↑	147.2	177.8 (160.6 – 193.9)	175.9 (165.6 – 190.0)	192.0 (161.6 – 216.3)	207.9 (193.0 – 227.0)
	Total summer liquid precipitation	↑?	300.0	307.1 (287.8 – 329.1)	310.3 (279.6 – 334.0)	308.0 (285.6 – 335.8)	297.6 (272.7 – 321.9)
	Total autumn liquid precipitation	↑	258.3	295.5 (265.0 – 303.0)	285.5 (276.4 – 302.2)	297.3 (284.9 – 306.4)	314.4 (297.5 – 334.5)
	Annual maximum five-day accumulated precipitation	↑	70.4	77.8 (71.5 – 85.7)	78.7 (73.6 – 85.9)	79.1 (73.3 – 87.5)	83.3 (74.6 – 97.2)
	Maximum five-day accumulated precipitation from April to September	↑	66.6	73.2 (66.5 – 82.6)	72.9 (66.8 – 78.8)	73.6 (67.5 – 81.8)	76.1 (67.2 – 85.8)

Bas-Saint-Laurent

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	2.6	4.6 (3.9 – 5.9)	5.0 (4.3 – 6.0)	5.5 (5.0 – 7.3)	6.9 (6.2 – 8.2)
	Mean winter temperature	↑	-11.2	-8.4 (-9.2 --6.3)	-7.7 (-8.8 --6.4)	-6.9 (-7.7 – -5.2)	-5.8 (-6.5 – -3.6)
	Mean spring temperature	↑	0.1	2.1 (1.1 – 3.0)	2.2 (1.5 – 3.1)	2.8 (1.8 – 4.1)	4.3 (3.2 – 4.8)
	Mean summer temperature	↑	16.1	18.0 (17.2 – 19.2)	18.3 (17.7 – 19.3)	18.7 (17.9 – 20.6)	19.9 (19.0 – 21.6)
	Mean autumn temperature	↑	4.9	6.6 (6.0 – 7.7)	7.0 (6.5 – 8.0)	7.5 (6.9 – 9.0)	8.6 (7.9 – 9.8)
	Annual number of heatwaves	↑	0.0	0.1 (0.0 – 0.4)	0.2 (0.1 – 0.5)	0.2 (0.1 – 0.8)	0.8 (0.3 – 1.5)
	Annual number of days >30°C (days)	↑	1	5 (3 – 10)	6 (3 – 11)	7 (4 – 16)	15 (7 – 31)
	Total annual growing degree days (GDD)	↑	1546	1889 (1762 – 2087)	1926 (1821 – 2107)	2021 (1917 – 2348)	2266 (2130 – 2544)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	94.6	93.4 (86.7 – 98.5)	92.0 (86.2 – 97.9)	92.5 (82.9 – 98.0)	89.8 (80.8 – 97.5)
	Number of winter freeze-thaw events	↑	13.2	18.4 (14.6 – 23.5)	19.9 (15.1 – 23.0)	20.5 (16.0 – 25.7)	24.7 (19.1 – 32.2)
	Number of spring freeze-thaw events	↓	47.5	44.2 (40.7 – 47.5)	42.7 (40.4 – 47.8)	42.0 (38.1 – 46.7)	38.6 (36.1 – 43.9)
	Number of autumn freeze-thaw events	↓	33.1	30.5 (26.9 – 32.7)	28.9 (26.9 – 31.5)	28.7 (24.3 – 31.0)	25.8 (21.9 – 27.8)
	Winter frost index (°C • days)	↓	1346	1020 (784 – 1112)	924 (771 – 1040)	863 (627 – 938)	695 (488 – 761)
Precipitation (mm)	Total winter solid precipitation	↑?	206.9	221.5 (185.1 – 234.8)	225.1 (198.9 – 239.0)	209.6 (175.0 – 229.7)	200.1 (174.9 – 244.3)
	Total spring solid precipitation	↓	81.2	71.6 (56.7 – 91.6)	69.5 (51.3 – 90.0)	59.1 (45.0 – 83.0)	55.0 (42.1 – 71.2)
	Total autumn solid precipitation	↓	47.7	33.8 (23.4 – 46.9)	31.4 (22.9 – 44.0)	31.0 (19.9 – 36.2)	20.6 (14.4 – 33.2)
	Total winter liquid precipitation	↑	40.7	63.1 (43.4 – 99.8)	61.7 (48.9 – 80.7)	75.5 (53.6 – 112.2)	93.6 (74.2 – 131.4)
	Total spring liquid precipitation	↑	162.0	194.3 (166.5 – 225.4)	189.7 (175.6 – 214.9)	205.9 (181.0 – 247.7)	220.2 (205.5 – 245.4)
	Total summer liquid precipitation	↑	284.7	301.8 (286.1 – 326.9)	306.6 (294.0 – 320.1)	307.4 (287.2 – 317.5)	312.9 (291.3 – 326.6)
	Total autumn liquid precipitation	↑	247.6	278.6 (259.5 – 300.2)	276.1 (257.1 – 293.9)	276.7 (266.6 – 319.7)	300.5 (288.1 – 333.8)
	Annual maximum five-day accumulated precipitation	↑	73.4	83.0 (78.0 – 88.4)	80.0 (77.4 – 90.3)	82.5 (77.8 – 92.6)	89.0 (81.4 – 96.3)
	Maximum five-day accumulated precipitation from April to September	↑	66.1	75.2 (67.0 – 51.3)	73.2 (68.5 – 84.2)	73.3 (70.2 – 84.9)	80.2 (70.5 – 86.3)

Capitale-Nationale

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	1.7	3.7 (3.0 – 5.0)	4.2 (3.4 – 5.1)	4.8 (4.1 – 6.4)	6.0 (5.4 7.3)
	Mean winter temperature	↑	-12.1	-9.5 (-10.4 – -7.3)	-8.6 (-10.1 – -7.5)	-8.1 (-9.0 – -6.1)	-6.6 (-7.8 – -4.7)
	Mean spring temperature	↑	-0.5	1.5 (0.8 – 2.4)	1.7 (0.9 – 2.4)	2.3 (1.2 – 3.4)	3.8 (2.5 – 4.2)
	Mean summer temperature	↑	15.1	17.1 (16.4 – 18.2)	17.3 (16.7 – 18.4)	17.7 (17.1 – 19.6)	19.0 (18.1 – 20.6)
	Mean autumn temperature	↑	4.0	5.7 (5.2 – 6.9)	6.1 (5.6 – 7.1)	6.6 (6.1 – 8.0)	7.7 (7.2 – 9.0)
	Annual number of heatwaves	↑	0.0	0.0 (0.0 – 0.2)	0.1 (0.0 – 0.3)	0.1 (0.0 – 0.3)	0.3 (0.1 – 0.8)
	Annual number of days >30°C (days)	↑	1	3 (2 – 6)	3 (2 – 7)	5 (3 – 10)	10 (5 – 22)
	Total annual growing degree days (GDD)	↑	1412	1756 (1643 – 1916)	1787 (1696 – 1958)	1881 (1777 – 2166)	2116 (1986 – 2376)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	98.0	96.5 (91.3 – 100.5)	94.9 (89.9 – 100.0)	96.0 (88.1 – 98.9)	92.3 (85.4 – 100.3)
	Number of winter freeze-thaw events	↑	12.2	16.7 (13.0 – 21.6)	17.1 (13.8 -22.6)	20.2 (14.5 – 24.1)	23.0 (17.5 – 28.3)
	Number of spring freeze-thaw events	↓	49.5	45.9 (42.8 – 49.4)	44.8 (42.4 – 49.8)	43.9 (41.3 – 47.9)	41.7 (38.1 – 46.1)
	Number of autumn freeze-thaw events	↓	34.5	32.3 (28.8 – 33.8)	30.8 (28.3 – 33.5)	30.3 (26.1 – 32.3)	28.1 (23.6 – 29.5)
	Winter frost index (°C • days)	↓	1510	1172 (907 – 1277)	1057 (913 – 1226)	1009 (754 – 1098)	789 (610 – 922)
Precipitation (mm)	Total winter solid precipitation	↑?	222.9	237.6 (211.5 – 252.3)	245.1 (218.3 – 254.4)	235.4 (204.1 – 249.0)	226.7 (219.9 – 260.9)
	Total spring solid precipitation	↓	94.8	86.0 (63.1 – 97.4)	82.8 (64.1 – 98.3)	74.4 (55.5 – 92.9)	66.2 (53.3 – 81.9)
	Total autumn solid precipitation	↓	64.9	48.2 (36.7 – 68.4)	48.0 (37.3 – 58.9)	42.9 (31.5 – 53.9)	34.7 (24.4 – 43.6)
	Total winter liquid precipitation	↑	36.1	56.3 (41.0 – 86.5)	55.1 (41.4 – 76.2)	65.5 (53.7 – 101.8)	89.6 (64.2 – 123.6)
	Total spring liquid precipitation	↑	180.6	219.2 (198.1 – 249.4)	214.2 (195.4 – 235.7)	231.7 (201.3 – 267.4)	251.5 (236.2 – 278.1)
	Total summer liquid precipitation	↑?	351.8	377.8 (345.1 – 386.2)	367.8 (353.1 – 406.1)	372.1 (351.1 – 409.7)	357.8 (345.5 – 388.0)
	Total autumn liquid precipitation	↑?	281.5	322.6 (288.3 – 337.6)	311.5 (287.5 – 336.4)	319.7 (299.3 – 360.1)	341.3 (332.0 – 376.6)
	Annual maximum five-day accumulated precipitation	↑	83.8	93.1 (87.7 – 101.4)	91.5 (85.6 – 104.1)	93.7 (89.1 – 113.0)	94.8 (88.6 – 105.0)
	Maximum five-day accumulated precipitation from April to September	↑	76.1	83.1 (76.8 – 90.4)	81.1 (77.3 – 93.6)	84.6 (79.0 – 99.8)	82.7 (76.2 – 94.6)

Centre-du-Québec

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	5.7	7.8 (7.1 - 9.0)	8.2 (7.5 - 9.1)	8.8 (8.1 - 10.3)	10.0 (9.5 - 11.3)
	Mean winter temperature	↑	-8.5	-5.7 (-6.8 - -3.9)	-4.9 (-6.5 - -3.9)	-4.4 (-5.4 - -2.7)	-2.7 (-4.3 - -1.3)
	Mean spring temperature	↑	4.3	6.2 (5.7 - 7.1)	6.6 (5.8 - 7.2)	7.2 (6.0 - 8.2)	8.5 (7.4 - 9.1)
	Mean summer temperature	↑	19.0	20.9 (20.3 - 22.0)	21.2 (20.6 - 22.2)	21.6 (20.9 - 23.3)	23.0 (21.9 - 24.5)
	Mean autumn temperature	↑	7.7	9.5 (8.9 - 10.5)	9.8 (9.3 - 10.8)	10.5 (9.7 - 11.6)	11.6 (10.8 - 12.6)
	Annual number of heatwaves	↑	0.1	0.7 (0.4 - 2.1)	0.9 (0.5 - 1.5)	1.2 (0.7 - 2.4)	2.7 (1.3 - 3.7)
	Annual number of days >30°C (days)	↑	6	17 (11 - 27)	20 (12 - 30)	22 (14 - 40)	38 (23 - 61)
	Total annual growing degree days (GDD)	↑	2182	2609 (2458 - 2780)	2664 (2533 - 2832)	2757 (2640 -3053)	3062 (2909 - 3318)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↑?	87.6	88.6 (83.0 - 93.0)	88.3 (81.7 - 92.6)	89.1 (86.6 - 92.9)	86.3 (74.9 - 92.5)
	Number of winter freeze-thaw events	↑	24.4	32.8 (26.2 - 35.9)	33.3 (29.2 - 36.4)	37.4 (30.2 - 42.8)	41.2 (33.2 - 42.6)
	Number of spring freeze-thaw events	↓	36.1	33.3 (30.2 - 36.8)	33.2 (29.8 - 36.8)	31.1 (29.8 - 36.4)	29.0 (26.3 - 32.2)
	Number of autumn freeze-thaw events	↓	27.4	23.1 (18.7 - 26.7)	22.4 (16.6 - 25.5)	21.4 (16.0 - 24.9)	17.3 (13.4 - 21.2)
	Winter frost index (°C • days)	↓	994	702 (506 - 789)	620 (500 - 775)	569 (388 - 646)	398 (302 - 536)
Precipitation (mm)	Total winter solid precipitation	↓	202.1	191.0 (154.1 - 216.5)	201.6 (172.5 - 218.7)	178.4 (146.8 - 202.4)	166.5 (141.3 - 198.8)
	Total spring solid precipitation	↓	48.8	40.7 (28.8 - 54.5)	40.6 (25.5 - 52.7)	37.4 (26.4 - 46.4)	27.4 (18.2 - 34.0)
	Total autumn solid precipitation	↓	21.7	14.8 (8.2 - 24.5)	12.9 (7.7 - 21.4)	13.7 (8.3 - 19.1)	9.4 (3.4 - 13.0)
	Total winter liquid precipitation	↑	89.4	129.7 (105.1 - 179.8)	133.0 (103.9 - 172.5)	157.2 (123.0 - 203.7)	188.6 (155.8 - 245.6)
	Total spring liquid precipitation	↑	226.8	264.8 (231.5 - 296.8)	261.7 (245.1 - 283.0)	274.7 (247.4 - 310.9)	294.3 (277.3 - 315.6)
	Total summer liquid precipitation	↑?	328.6	349.8 (329.9 - 365.0)	344.6 (321.4 - 370.4)	346.1 (329.6 - 386.2)	339.3 (315.1 - 359.4)
	Total autumn liquid precipitation	↑?	287.4	312.2 (285.7 - 336.4)	307.1 (280.0 - 326.8)	306.1 (284.6 - 328.3)	319.0 (307.8 - 354.8)
	Annual maximum five-day accumulated precipitation	↑	82.2	90.4 (82.4 - 100.1)	91.5 (85.8 - 103.8)	93.5 (85.7 - 106.4)	94.0 (86.5 - 106.1)
	Maximum five-day accumulated precipitation from April to September	↑	74.6	80.8 (73.7 - 92.5)	82.7 (73.9 - 92.2)	84.1 (75.1 - 94.3)	84.8 (75.0 - 93.3)

Chaudière–Appalaches

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	4.1	6.2 (5.5 – 7.5)	6.6 (5.9 – 7.5)	7.2 (6.5 – 8.7)	8.4 (7.8 –9.7)
	Mean winter temperature	↑	-9.4	-6.8 (-7.7 – -4.7)	-5.9 (-7.4 – -4.9)	-5.4 (-6.3 – -3.7)	-3.8 (-5.3 – -2.2)
	Mean spring temperature	↑	1.9	3.8 (3.2 – 4.7)	4.1 (3.3 – 4.8)	4.6 (3.5 – 5.7)	6.0 (4.9 – 6.6)
	Mean summer temperature	↑	17.5	19.4 (18.7 – 20.5)	19.7 (19.1 – 20.7)	20.1 (19.4 – 21.9)	21.4 (20.4 – 23.0)
	Mean autumn temperature	↑	6.3	8.0 (7.4 – 9.1)	8.4 (8.0 – 9.4)	9.0 (8.3 – 10.3)	10.1 (9.4 – 11.3)
	Annual number of heatwaves	↑	0.0	0.2 (0.1 – 0.9)	0.3 (0.1 – 0.9)	0.4 (0.2 – 1.1)	1.2 (0.5 – 2.1)
	Annual number of days >30°C (days)	↑	2	9 (5 – 15)	9 (6 – 17)	12 (7 – 24)	23 (12 – 42)
	Total annual growing degree days (GDD)	↑	1827	2215 (2072 – 2383)	2255 (2148 – 2427)	2351 (2234 – 2643)	2621 (2469 – 2886)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	95.9	96.6 (91.8 – 102.0)	94.6 (91.1 – 101.1)	96.6 (93.1 – 100.2)	93.1 (85.2 – 99.6)
	Number of winter freeze-thaw events	↑	19.6	26.6 (20.7 – 31.7)	27.6 (22.6 – 32.0)	31.1 (23.6 – 35.4)	34.1 (28.0 – 39.3)
	Number of spring freeze-thaw events	↓	45.3	41.5 (39.8 – 45.6)	41.3 (38.8 – 46.0)	39.8 (37.4 – 44.8)	36.4 (34.9 – 41.5)
	Number of autumn freeze-thaw events	↓	31.1	27.8 (24.1 – 30.6)	26.1 (23.4 – 29.3)	25.7 (21.0 – 27.8)	22.0 (18.7 – 25.0)
	Winter frost index (°C • days)	↓	1128	822 (597 – 916)	734 (604 – 888)	684 (480 – 761)	497 (368 – 632)
Precipitation (mm)	Total winter solid precipitation	↓	225.5	225.2 (185.3 – 251.5)	233.8 (206.1 – 246.6)	214.2 (181.0 – 237.3)	204.4 (182.0 – 246.4)
	Total spring solid precipitation	↓	70.6	64.0 (42.2 – 79.6)	59.0 (40.8 – 73.1)	53.6 (39.5 – 67.0)	43.6 (28.1 – 52.8)
	Total autumn solid precipitation	↓	36.6	25.5 (15.5 – 39.8)	25.8 (16.3 – 33.1)	21.1 (15.2 – 30.9)	15.5 (8.4 – 21.8)
	Total winter liquid precipitation	↑	71.3	103.3 (90.1 – 153.5)	104.5 (82.2 – 140.9)	126.8 (105.2 – 175.5)	157.8 (128.3 – 214.9)
	Total spring liquid precipitation	↑	213.8	260.9 (226.2 – 278.4)	249.9 (228.6 – 268.3)	267.7 (235.4 – 313.9)	289.8 (274.2 – 312.6)
	Total summer liquid precipitation	?	354.4	382.3 (357.2 – 398.3)	377.2 (351.8 – 416.3)	374.5 (355.0 – 407.5)	371.8 (351.4 – 404.3)
	Total autumn liquid precipitation	?	290.2	319.7 (295.4 – 343.9)	315.0 (289.6 – 333.7)	311.5 (296.4 – 352.2)	332.8 (323.1 – 372.9)
	Annual maximum five-day accumulated precipitation	↑	84.4	94.9 (88.3 – 102.9)	94.9 (88.2 – 110.5)	95.0 (88.1 – 108.7)	97.1 (88.7 – 111.3)
	Maximum five-day accumulated precipitation from April to September	↑	76.8	83.6 (77.4 – 94.3)	84.1 (76.0 – 96.5)	86.3 (77.4 – 97.5)	86.5 (76.8 – 101.8)

Côte-Nord

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991-2020	2041-2070 projections		2071-2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	-1.6	0.3 (-0.4 - 1.8)	0.8 (0.1 - 1.9)	1.2 (0.8 - 3.5)	2.6 (1.9 - 4.1)
	Mean winter temperature	↑	-16.4	-13.7 (-14.6 - -11.7)	-13.2 (-14.1 - -11.6)	-12.5 (-13.1 - -9.9)	-10.7 (-11.7 - -8.6)
	Mean spring temperature	↑	-4.3	-2.5 (-3.9 - -1.3)	-2.4 (-3.3 - -1.1)	-2.1 (-2.9 - 0.4)	-0.6 (-1.5 - 0.7)
	Mean summer temperature	↑	12.8	14.6 (13.9 - 15.7)	14.9 (14.1 - 15.8)	15.3 (14.6 - 17.5)	16.4 (15.7 - 18.1)
	Mean autumn temperature	↑	1.4	3.1 (2.4 - 4.1)	3.5 (3.0 - 4.4)	3.9 (3.3 - 5.5)	5.0 (4.4 - 6.1)
	Annual number of heatwaves	==	0.0	0.0 (0.0 - 0.1)	0.0 (0.0 - 0.1)	0.0 (0.0 - 0.1)	0.0 (0.0 - 0.3)
	Annual number of days >30°C (days)	↑	0.2	0.8 (0.4 - 2.1)	0.9 (0.7 - 2.9)	1.1 (0.6 - 5.1)	2.9 (1.1 - 10.5)
	Total annual growing degree days (GDD)	↑	1023	1278 (1180 - 1446)	1313 (1212 - 1453)	1394 (1286 - 1699)	1567 (1463 - 1804)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	85.7	83.3 (74.5 - 88.1)	81.2 (74.8 - 87.5)	80.9 (73.4 - 89.9)	78.1 (71.3 - 86.9)
	Number of winter freeze-thaw events	↑	5.4	6.9 (5.2 - 9.9)	6.7 (6.0 - 10.0)	7.2 (5.7 - 11.8)	9.7 (7.1 - 13.1)
	Number of spring freeze-thaw events	↓	43.1	42.0 (36.5 - 44.7)	41.8 (36.3 - 44.8)	41.1 (35.4 - 44.3)	39.7 (35.0 - 43.6)
	Number of autumn freeze-thaw events	↓	32.8	30.7 (28.2 - 33.2)	30.4 (26.4 - 32.4)	30.2 (26.8 - 33.2)	28.0 (24.4 - 31.2)
	Winter frost index (°C • days)	↓	2199	1791 (1506 - 1947)	1713 (1474 - 1861)	1644 (1203 - 1699)	1357 (1092 - 1493)
Precipitation (mm)	Total winter solid precipitation	↑?	189.8	205.0 (194.5 - 213.4)	206.2 (202.4 - 213.5)	204.5 (192.8 - 217.4)	214.0 (198.3 - 230.3)
	Total spring solid precipitation	↓	120.6	116.2 (99.2 - 132.8)	117.7 (99.0 - 130.3)	106.2 (84.3 - 129.5)	102.1 (85.5 - 123.3)
	Total autumn solid precipitation	↓	88.7	73.8 (63.3 - 84.7)	71.7 (62.2 - 86.4)	71.6 (53.9 - 79.9)	60.3 (46.7 - 69.7)
	Total winter liquid precipitation	↑	12.8	18.0 (13.4 - 36.0)	20.2 (16.0 - 31.5)	24.4 (17.8 - 53.5)	31.9 (26.2 - 58.7)
	Total spring liquid precipitation	↑	101.3	132.2 (103.9 - 163.3)	130.6 (117.1 - 144.9)	136.5 (115.8 - 183.3)	155.8 (135.0 - 183.6)
	Total summer liquid precipitation	↑	333.3	350.0 (337.7 - 364.3)	358.4 (335.3 - 374.0)	356.1 (336.1 - 382.3)	362.0 (339.7 - 379.8)
	Total autumn liquid precipitation	↑	226.9	266.3 (251.2 - 278.1)	262.6 (250.1 - 285.0)	272.7 (258.9 - 305.4)	294.3 (274.0 - 324.9)
	Annual maximum five-day accumulated precipitation	↑	74.1	81.7 (77.9 - 90.5)	82.2 (77.5 - 87.6)	83.1 (78.5 - 93.4)	86.8 (80.7 - 93.3)
	Maximum five-day accumulated precipitation from April to September	↑	68.9	74.7 (70.9 - 83.6)	74.4 (70.4 - 81.6)	74.9 (72.9 - 84.4)	79.0 (72.9 - 83.0)

Eeyou Istchee James Bay Territory

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	-1.9	0.4 (-0.3 – 1.7)	0.8 (0.1 – 1.8)	1.2 (0.7 – 3.6)	2.8 (2.0 – 4.2)
	Mean winter temperature	↑	-17.9	-14.8 (-15.6 – -12.6)	-14.0 (-14.9 – -12.6)	-13.3 (-14.1 – -10.3)	-11.5 (-12.3 – -9.3)
	Mean spring temperature	↑	-5.1	-3.2 (-4.0 – -1.9)	-2.9 (-3.7 – -1.9)	-2.6 (-3.3 – 0.3)	-0.7 (-1.8 – 0.7)
	Mean summer temperature	↑	13.5	15.4 (14.7 – 16.3)	15.6 (15.0 – 16.6)	16.2 (15.4 – 18.1)	17.5 (16.4 – 18.9)
	Mean autumn temperature	↑	1.7	3.5 (3.0 – 4.6)	3.9 (3.4 – 4.9)	4.5 (3.9 – 6.0)	5.7 (4.8 – 6.7)
	Annual number of heatwaves	↑	0.1	0.3 (0.1 – 0.9)	0.3 (0.1 – 1.0)	0.4 (0.2 – 2.3)	1.5 (0.6 – 4.4)
	Annual number of days >30°C (days)	↑	1	3 (2 – 6)	3 (2 – 7)	4 (2 – 11)	8 (4 – 19)
	Total annual growing degree days (GDD)	↑	1130	1413 (1329 – 1548)	1432 (1357 – 1587)	1529 (1427 – 1840)	1734 (1592 – 1961)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	72.3	70.5 (64.9 – 77.2)	68.0 (64.3 – 75.6)	68.5 (63.6 – 77.4)	64.7 (61.3 – 75.5)
	Number of winter freeze-thaw events	↑	3.4	4.5 (3.7 – 7.1)	4.9 (4.2 – 6.3)	5.7 (4.2 – 8.4)	6.8 (5.1 – 9.8)
	Number of spring freeze-thaw events	↓	37.5	37.0 (33.2 – 41.4)	36.9 (32.8 – 41.8)	36.9 (30.6 – 41.9)	35.9 (31.2 – 41.2)
	Number of autumn freeze-thaw events	↓	28.8	25.8 (23.9 – 28.9)	25.4 (22.9 – 26.6)	25.1 (22.6 – 27.1)	22.7 (20.4 – 24.3)
	Winter frost index (°C • days)	↓	2428	1969 (1623 – 2068)	1856 (1615 – 1984)	1790 (1269 – 1882)	1482 (1162 – 1580)
Precipitation (mm)	Total winter solid precipitation	↑	146.4	168.5 (157.4 – 178.5)	169.8 (161.8 – 182.2)	176.1 (162.2 – 182.8)	189.8 (177.7 – 196.9)
	Total spring solid precipitation	↓	87.6	86.9 (75.5 – 97.3)	84.2 (75.4 – 95.8)	81.4 (72.6 – 94.7)	77.6 (66.0 – 89.6)
	Total autumn solid precipitation	↓	94.4	77.4 (67.6 – 87.1)	75.4 (65.5 – 87.1)	73.2 (57.2 – 80.9)	59.3 (51.2 – 69.2)
	Total winter liquid precipitation	↑	5.9	9.5 (6.0 – 20.6)	10.7 (7.2 – 17.0)	12.9 (7.4 – 23.8)	17.2 (12.1 – 32.4)
	Total spring liquid precipitation	↑	83.1	104.7 (91.8 – 121.9)	105.9 (90.4 – 114.5)	111.7 (99.5 – 134.5)	127.6 (114.1 – 138.1)
	Total summer liquid precipitation	↑	341.0	357.4 (325.4 – 375.2)	353.7 (319.8 – 378.5)	361.1 (321.9 – 370.7)	347.5 (315.8 – 386.0)
	Total autumn liquid precipitation	↑	238.6	281.2 (263.2 – 302.2)	281.8 (260.5 – 308.2)	292.8 (281.6 – 318.8)	317.2 (294.5 – 340.8)
	Annual maximum five-day accumulated precipitation	?	71.7	80.9 (73.6 – 85.9)	80.3 (72.0 – 90.3)	78.9 (76.6 – 85.9)	83.8 (74.8 – 87.4)
	Maximum five-day accumulated precipitation from April to September	?	69.3	77.1 (71.0 – 83.0)	77.6 (67.5 – 84.4)	75.8 (72.8 – 82.3)	77.4 (70.6 – 84.1)

Estrie

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	5.5	7.5 (6.8 – 8.8)	7.9 (7.2 – 8.8)	8.5 (7.9 – 9.9)	9.7 (9.2 – 11.0)
	Mean winter temperature	↑	-7.6	-4.9 (-6.0 – -3.3)	-4.3 (-5.8 – -3.1)	-3.6 (-4.7 – -2.2)	-2.0 (-3.6 – -0.9)
	Mean spring temperature	↑	3.8	5.7 (5.2 – 6.6)	6.0 (5.3 – 6.7)	6.6 (5.6 – 7.6)	7.8 (7.0 – 8.5)
	Mean summer temperature	↑	18.1	20.0 (19.4 – 21.1)	20.3 (19.7 – 21.3)	20.6 (20.0 – 22.3)	22.2 (21.0 – 23.6)
	Mean autumn temperature	↑	7.4	9.1 (8.5 – 10.2)	9.5 (9.0 – 10.5)	10.2 (9.3 – 11.2)	11.3 (10.5 – 12.3)
	Annual number of heatwaves	↑	0.1	0.4 (0.2 – 1.2)	0.5 (0.2 – 1.1)	0.7 (0.4 – 1.6)	1.8 (0.7 – 2.6)
	Annual number of days >30°C (days)	↑	3	10 (7 – 18)	12 (7 – 20)	14 (9 – 27)	26 (14 – 46)
	Total annual growing degree days (GDD)	↑	2039	2463 (2313 – 2463)	2508 (2395 – 2681)	2608 (2481 – 2891)	2911 (2742 – 3167)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓?	92.3	93.0 (87.7 – 97.5)	92.5 (86.4 – 97.5)	93.2 (90.4 – 97.0)	89.9 (79.4 – 94.0)
	Number of winter freeze-thaw events	↑	25.4	34.0 (27.4 – 37.2)	33.7 (29.9 – 38.4)	38.1 (31.3 – 42.4)	40.9 (34.2 – 42.1)
	Number of spring freeze-thaw events	↓	39	36.2 (33.2 – 39.1)	35.2 (32.9 – 39.4)	33.4 (32.5 – 39.2)	31.6 (28.9 – 35.3)
	Number of autumn freeze-thaw events	↓	27.7	23.8 (20.2 – 27.3)	22.9 (18.7 – 26.1)	21.7 (17.2 – 24.7)	17.9 (14.9 – 21.4)
	Winter frost index (°C • days)	↓	924	637 (473 – 725)	571 (443 – 713)	512 (357 – 594)	356 (2810 – 491)
Precipitation (mm)	Total winter solid precipitation	↓	189.3	181.6 (144.6 – 205.4)	184.0 (154.5 – 207.7)	162.4 (140.0 – 190.0)	154.5 (123.3 – 187.8)
	Total spring solid precipitation	↓	55.7	43.3 (29.6 – 59.5)	42.5 (26.1 – 55.4)	39.4 (30.1 – 49.2)	29.2 (18.3 – 38.4)
	Total autumn solid precipitation	↓	26.9	17.7 (11.7 – 29.5)	17.1 (10.1 – 22.7)	15.2 (10.1 – 21.5)	10.4 (5.2 – 15.8)
	Total winter liquid precipitation	↑	92.6	136.8 (111.9 – 178.8)	139.9 (112.0 – 178.7)	165.8 (126.4 – 203.8)	195.5 (164.5 – 249.2)
	Total spring liquid precipitation	↑	238.1	278.3 (237.9 – 301.6)	276.7 (248.3 – 291.8)	280.0 (259.6 – 326.3)	303.2 (290.3 – 324.8)
	Total summer liquid precipitation	?	354.5	378.0 (358.6 – 399.9)	373.8 (351.8 – 401.6)	377.9 (356.1 – 407.2)	365.0 (337.5 – 405.5)
	Total autumn liquid precipitation	?	296.3	318.5 (301.0 – 356.9)	319.5 (289.1 – 344.0)	316.2 (300.8 – 343.8)	329.6 (321.5 – 362.9)
	Annual maximum five-day accumulated precipitation	↑	85.2	93.5 (85.8 – 103.9)	95.1 (84.9 – 107.8)	95.4 (87.2 – 110.8)	96.1 (86.7 – 109.5)
	Maximum five-day accumulated precipitation from April to September	↑	77.7	85.5 (78.1 – 96.0)	86.3 (78.3 – 94.0)	88.6 (76.8 – 99.4)	88.4 (76.5 – 98.3)

Gaspésie

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	1.9	3.8 (3.1 – 5.2)	4.4 (3.7 – 5.2)	4.7 (4.2 – 6.7)	6.1 (5.4 – 7.4)
	Mean winter temperature	↑	-11.3	-8.7 (-9.6 – -6.9)	-8.1 (-9.0 – -7.0)	-7.4 (-8.1 – -5.6)	-6.1 (-6.9 – -4.3)
	Mean spring temperature	↑	-0.8	1.1 (0.0 – 2.2)	1.3 (0.6 – 2.4)	1.7 (1.0 – 3.6)	3.2 (2.3 – 4.1)
	Mean summer temperature	↑	15.1	17.0 (16.2 – 18.3)	17.3 (16.6 – 18.3)	17.7 – (17.0 – 19.9)	18.8 (18.2 – 20.7)
	Mean autumn temperature	↑	4.3	6.0 (5.3 – 7.1)	6.4 (5.9 – 7.3)	6.8 (6.3 – 8.4)	8.0 (7.2 – 9.1)
	Annual number of heatwaves	↑	0.0	0.1 (0.0 – 0.1)	0.1 (0.0 – 0.2)	0.1 (0.0 – 0.4)	0.4 (0.1 – 0.9)
	Annual number of days >30°C (days)	↑	1	3 (2 – 7)	4 (2 – 7)	5 (2 – 12)	11 (5 – 22)
	Total annual growing degree days (GDD)	↑	1378	1697 (1559 – 1908)	1737 (1631 – 1907)	1891 (1718 – 2182)	2039 (1922 – 2326)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	101.5	100.0 (94.8 – 105.1)	98.9 (91.2 – 102.7)	99.1 (93.2 – 102.6)	97.5 (89.1 – 103.0)
	Number of winter freeze-thaw events	↑	12.3	17.1 (13.4 – 22.1)	17.8 (16.0 – 22.0)	19.6 (15.6 – 25.4)	25.3 (19.5 – 31.6)
	Number of spring freeze-thaw events	↓	51.0	47.2 (45.2 – 50.8)	47.3 (44.2 – 50.6)	45.5 (43.0 – 48.8)	43.6 (40.2 – 46.9)
	Number of autumn freeze-thaw events	↓	36.2	33.5 (30.2 – 34.9)	32.0 (29.8 – 34.8)	32.1 (27.8 – 34.7)	28.8 (24.9 – 31.8)
	Winter frost index (°C • days)	↓	1400	1051 (839 – 1173)	969 (821 – 1095)	890 (667 – 983)	716 (538 – 802)
Precipitation (mm)	Total winter solid precipitation	↓?	233.8	238.5 (211.8 – 257.1)	250.7 (219.5 – 264.2)	231.1 (198.0 – 255.8)	225.7 (199.5 – 269.9)
	Total spring solid precipitation	↓	101.8	85.3 (67.3 – 110.6)	86.1 (59.4 – 107.2)	67.1 (55.9 – 98.5)	64.9 (49.0 – 87.5)
	Total autumn solid precipitation	↓	58	40.7 (27.7 – 52.8)	38.4 (28.3 – 53.6)	37.5 (24.5 – 43.4)	25.1 (16.8 – 40.7)
	Total winter liquid precipitation	↑	36.0	59.5 (40.7 – 93.0)	59.3 (43.7 – 81.4)	72.8 (53.3 – 112.6)	90.6 (69.4 – 123.5)
	Total spring liquid precipitation	↑	156.0	194.7 (161.2 – 227.8)	196.9 (170.2 – 225.8)	210.4 (180.8 – 249.0)	223.9 (209.5 – 252.4)
	Total summer liquid precipitation	↑	291.2	313.8 (296.7 – 342.0)	321.9 (296.6 – 333.1)	317.8 (299.1 – 328.0)	323.2 (302.8 – 354.1)
	Total autumn liquid precipitation	↑	256.2	290.7 (270.5 – 317.9)	291.0 (271.6 – 306.6)	290.3 (281.6 – 338.5)	319.8 (294.1 – 347.6)
	Annual maximum five-day accumulated precipitation	↑	82.6	92.7 (85.2 – 100.1)	92.1 (87.1 – 100.5)	91.7 (86.6 – 107.3)	97.5 (90.5 – 108.4)
	Maximum five-day accumulated precipitation from April to September	↑	70.9	79.9 (74.9 – 88.9)	81.5 (73.7 – 87.7)	80.7 (75.1 – 90.7)	83.9 (75.8 – 96.1)

Îles-de-la-Madeleine

Category	Climate variables and indicators	Regional trends	Climate normals and anticipated change: 1991–2020	2041–2070 projections SSP2-4.5	2041–2070 projections SSP3-7.0	2071–2100 projections SSP2-4.5	2071–2100 projections SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	5.6	7.5 (6.6 – 8.7)	7.9 (7.2 – 8.7)	8.2 (7.6 – 9.7)	9.4 (8.7 – 10.3)
	Mean winter temperature	↑	-3.3	-1.1 (-2.0 – 0.0)	-0.9 (-1.4 – 0.1)	-0.1 (-0.9 – 1.0)	0.8 (0.1 – 1.8)
	Mean spring temperature	↑	0.9	2.7 (1.6 – 4.0)	3.1 (2.3 – 3.8)	3.3 (2.5 – 4.7)	4.5 (3.6 – 5.3)
	Mean summer temperature	↑	15.0	17.0 (15.9 – 18.3)	17.2 (16.5 – 18.2)	17.6 (16.9 – 19.6)	18.8 (18.2 – 20.1)
	Mean autumn temperature	↑	9.6	11.4 (10.6 – 12.4)	11.6 (11.1 – 12.5)	12.0 (11.4 – 13.5)	13.3 (12.6 – 14.3)
	Annual number of heatwaves	==	0.0	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)
	Annual number of days >30°C (days)	==	0.0	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)
	Total annual growing degree days (GDD)	↑	1604	1999 (1798 – 2244)	2032 (1920 – 2246)	2135 (2005 – 2536)	2398 (2260 – 2637)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	57.7	55.8 (50.2 – 57.2)	53.3 (51.4 – 56.7)	52.5 (46.5 – 56.7)	48.7 (39.9 – 53.6)
	Number of winter freeze-thaw events	↑	28.8	31.3 (29.4 – 33.8)	32.3 (29.9 – 34.2)	32.0 (29.5 – 33.8)	31.1 (28.3 – 34.2)
	Number of spring freeze-thaw events	↓	24.8	21.8 (17.3 – 24.7)	20.1 (17.0 – 24.1)	19.5 (13.9 – 23.4)	16.1 (12.7 – 19.8)
	Number of autumn freeze-thaw events	↓	3.9	1.2 (0.7 – 1.9)	0.9 (0.5 – 1.4)	0.6 (0.1 – 1.0)	0.2 (0.0 – 0.6)
	Winter frost index (°C • days)	↓	468	252 (151 – 348)	238 (153 – 289)	177 (95 – 255)	123 (56 – 164)
Precipitation (mm)	Total winter solid precipitation	↓	225.1	159.4 (112.5 – 209.4)	163.6 (127.0 – 191.3)	128.7 (88.1 – 188.7)	97.8 (73.5 – 139.7)
	Total spring solid precipitation	↓	98.9	58.4 (39.0 – 91.4)	57.1 (35.5 – 85.0)	43.6 (23.7 – 75.7)	25.1 (16.3 – 49.4)
	Total autumn solid precipitation	↓	3.7	0.7 (0.2 – 1.6)	0.5 (0.2 – 1.0)	0.3 (0.0 – 0.6)	0.0 (0.0 – 0.5)
	Total winter liquid precipitation	↑	145.5	222.6 (197.8 – 283.6)	242.7 (201.0 – 279.4)	275.4 (226.9 – 327.7)	314.9 (280.4 – 369.5)
	Total spring liquid precipitation	↑	166.7	225.7 (198.6 – 254.3)	227.0 (205.7 – 251.1)	244.1 (218.6 – 278.6)	270.1 (248.8 – 308.5)
	Total summer liquid precipitation	↑	233.8	255.6 (239.8 – 266.1)	246.5 (227.1 – 265.9)	256.6 (226.5 – 274.4)	252.7 (220.9 – 291.2)
	Total autumn liquid precipitation	↑	326.5	341.1 (326.4 – 381.7)	343.3 (329.2 – 371.7)	342.0 (323.1 – 371.7)	349.8 (329.2 – 371.3)
	Annual maximum five-day accumulated precipitation	↑	78.7	85.3 (78.8 – 92.0)	86.7 (81.3 – 94.3)	89.3 (81.6 – 96.5)	89.0 (82.6 – 100.0))
	Maximum five-day accumulated precipitation from April to September	↑	66.1	71.7 (65.2 – 81.4)	73.3 (67.3 – 77.0)	73.8 (67.5 – 82.6)	73.2 (68.9 – 87.0)

Kativik

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991-2020	2041-2070 projections		2071-2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	-6.3	-3.9 (-4.7 - -2.4)	-3.4 (-4.2 - -2.3)	-3.0 (-3.7 - -0.1)	-1.1 (-2.2 - 0.6)
	Mean winter temperature	↑	-22.3	-18.5 (-19.5 - -15.7)	-17.7 (-18.8 - -15.5)	-16.9 (-17.9 - -12.7)	-13.9 (-15.6 - -11.2)
	Mean spring temperature	↑	-10.2	-8.2 (-9.4 - -6.5)	-7.9 (-8.8 - -6.3)	-7.5 (-8.9 - -3.9)	-5.6 (-7.5 - -3.0)
	Mean summer temperature	↑	9.3	10.9 (10.4 - 12.1)	11.3 (10.5 - 11.7)	11.5 (11.2 - 13.8)	12.7 (12.3 - 14.1)
	Mean autumn temperature	↑	-2.3	-0.5 (-0.9 - 0.5)	0.2 (-0.6 -0.6)	0.4 (-0.3 - 1.5)	1.7 (0.8 - 2.5)
	Annual number of heatwaves	==	0.0	0.0 (0.0 - 0.1)	0.0 (0.0 - 0.1)	0.0 (0.0 - 0.3)	0.1 (0.0 - 0.7)
	Annual number of days >30°C (days)	==	0	0 (0 - 2)	1 (0 - 2)	1 (0 - 3)	1 (0 - 5)
	Total annual growing degree days (GDD)	↑	603.1	776 (734 - 902)	822 (738 - 868)	875 (804 - 1081)	1014 (929 - 1163)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↑=	66.8	60.2 (57.4 - 73.7)	59.4 (55.1 - 73.5)	58.6 (53.3 - 77.1)	60.0 (50.3 - 75.3)
	Number of winter freeze-thaw events	↑	0.6	0.9 (0.3 - 2.2)	0.9 (0.2 - 1.9)	0.9 (0.3 - 2.7)	1.3 (0.5 - 3.5)
	Number of spring freeze-thaw events	↑?	24.6	24.9 (20.1 - 30.8)	25.0 (19.0 - 31.6)	25.0 (19.3 - 35.0)	24.8 (19.5 - 37.0)
	Number of autumn freeze-thaw events	↓	28.3	27.5 (25.5 - 29.7)	26.5 (24.7 - 29.8)	26.8 (24.0 - 30.1)	26.3 (23.4 - 29.7)
	Winter frost index (°C • days)	↓	3350	2718 (2295 - 2928)	2594 (2230 - 2594)	2457 (1726 - 2695)	2027 (1534 - 2278)
Precipitation (mm)	Total winter solid precipitation	↑	103.8	120.3 (113.7 - 138.5)	120.7 (115.2 - 139.1)	126.1 (118.4 - 144.6)	138.6 (133.5 - 157.2)
	Total spring solid precipitation	↑?	110.5	111.3 (97.6 - 124.2)	113.3 (100.5 - 125.3)	112.0 (97.1 - 124.1)	111.8 (95.8 - 122.3)
	Total autumn solid precipitation	↓	120.6	109.2 (97.2 - 124.4)	107.5 (97.6 - 112.9)	105.8 (84.5 - 115.4)	90.9 (81.9 - 100.7)
	Total winter liquid precipitation	↑	0.4	0.9 (0.2 - 2.6)	1.0 (0.2 - 3.1)	1.3 (0.3 - 4.8)	2.5 (0.7 - 5.5)
	Total spring liquid precipitation	↑	25.4	40.0 (27.5 - 50.2)	43.0 (35.6 - 49.6)	47.8 (33.9 - 64.7)	56.3 (43.1 - 72.8)
	Total summer liquid precipitation	↑	256.0	274.3 (256.0 - 292.7)	273.8 (257.8 - 287.1)	283.9 (262.6 - 294.2)	283.9 (260.9 - 304.0)
	Total autumn liquid precipitation	↑	146.0	178.3 (171.0 - 202.1)	188.8 (178.3 -201.3)	197.7 (186.6 - 224.4)	224.2 (210.1 -254.9)
	Annual maximum five-day accumulated precipitation	↑	59.9	65.6 (61.7 - 72.1)	66.6 (64.3 - 72.7)	67.3 (64.9 - 75.6)	70.2 (66.2 - 77.8)
	Maximum five-day accumulated precipitation from April to September	↑	58.0	63.5 (59.1 - 70.4)	63.8 (61.8 - 70.5)	65.0 (62.9 - 73.5)	66.8 (63.4 - 74.3)

Lanaudière

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	3.6	5.6 (5.0 – 6.8)	6.2 (5.3 – 6.9)	6.6 (6.0 – 8.2)	7.9 (7.3 – 9.1)
	Mean winter temperature	↑	-10.5	-7.8 (-8.8 --5.9)	-7.0 (-8.5 --6.0)	-6.5 (-7.4 – -4.7)	-4.8 (-6.3 – 3.2)
	Mean spring temperature	↑	1.6	3.6 (3.1 – 4.4)	3.9 (3.1 – 4.6)	4.5 (3.4 – 5.6)	6.0 (4.8 – 6.4)
	Mean summer temperature	↑	17.1	19.0 (18.4 – 20.1)	19.4 (18.7 – 20.4)	19.7 (19.1 – 21.5)	21.2 (20.0 – 22.5)
	Mean autumn temperature	↑	5.7	7.4 (6.8 – 8.5)	7.8 (7.4 – 8.8)	8.4 (7.6 – 9.6)	9.5 (8.8 – 10.6)
	Annual number of heatwaves	↑	0.0	0.1 (0.0 – 0.3)	0.1 (0.0 – 0.3)	0.1 (0.1 – 0.4)	0.4 (0.1 – 0.7)
	Annual number of days >30°C (days)	↑	3	10 (6 – 15)	11 (7 – 17)	13 (8 – 24)	23 (13 –41)
	Total annual growing degree days (GDD)	↑	1768	2148 (2025 – 2303)	2194 (2083 – 2364)	2286 (2174 – 2573)	2549 (2420 – 2806)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	94.5	94.5 (89.2 – 100.2)	94.0 (87.9 – 98.6)	94.7 (88.1 – 100.2)	92.1 (86.1 – 96.9)
	Number of winter freeze-thaw events	↑	17.2	22.9 (18.4 – 27.9)	23.9 (20.0 – 29.5)	27.9 (20.8 – 31.6)	31.2 (25.1 – 36.4)
	Number of spring freeze-thaw events	↓	45.1	41.5 (39.8 – 45.3)	41.2 (38.4 – 46.2)	40.3 (37.6 – 44.9)	37.1 (34.8 – 42.2)
	Number of autumn freeze-thaw events	↓	32.6	29.3 (25.2 – 31.9)	27.7 (25.1 – 30.3)	26.7 (23.2 – 29.0)	23.6 (20.3 – 26.5)
	Winter frost index (°C • days)	↓	1267	947 (714 – 1030)	848 (719 – 1022)	793 (583 – 876)	599 (446 – 743)
Precipitation (mm)	Total winter solid precipitation	↓?	190.1	191.4 (173.0 – 210.7)	201.5 (174.6 – 204.8)	189.5 (157.1 – 203.9)	176.1 (165.7 – 202.9)
	Total spring solid precipitation	↓	60.4	55.2 (37.9 – 60.7)	50.7 (37.1 – 61.7)	45.7 (35.0 – 59.5)	39.0 (26.8 – 45.9)
	Total autumn solid precipitation	↓	32.0	27.4 (18.5 – 44.8)	27.1 (19.6 – 36.2)	22.6 (18.3 – 34.3)	19.0 (12.2 – 26.1)
	Total winter liquid precipitation	↑	47.4	67.4 (51.2 – 97.5)	70.7 (53.6 – 102.7)	90.4 (65.1 – 119.7)	108.6 (89.1 – 146.8)
	Total spring liquid precipitation	↑	188.2	218.8 (193.6 – 255.1)	219.5 (201.3 – 237.2)	237.0 (202.4 – 264.6)	253.3 (238.3 – 269.7)
	Total summer liquid precipitation	?	313.2	325.1 (300.8 – 337.5)	322.8 (304.9 – 351.0)	324.5 (310.0 – 358.5)	314.7 (287.8 – 337.0)
	Total autumn liquid precipitation	?	270.9	301.2 (274.8 – 324.5)	293.2 (276.3 – 306.8)	301.2 (278.4 – 324.2)	322.0 (306.7 – 338.9)
	Annual maximum five-day accumulated precipitation	↑	79.8	84.4 (80.4 – 93.6)	85.9 (80.5 –94.0)	87.6 (83.4 – 99.6)	87.5 (82.3 – 102.7)
	Maximum five-day accumulated precipitation from April to September	↑	72.5	76.1 (72.9 – 82.3)	77.7 (73.1 – 87.1)	79.9 (71.3 – 90.8)	76.6 (72.2 – 92.4)

Laurentides

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	3.5	5.6 (5.0 - 6.8)	6.1 (5.2 - 6.9)	6.6 (6.0 - 8.2)	7.8 (7.4 - 9.1)
	Mean winter temperature	↑	-10.4	-7.7 (-8.6 - -5.7)	-6.8 (-8.4 - -5.8)	-6.3 (-7.2 - -4.5)	-4.6 (-6.0 - -3.1)
	Mean spring temperature	↑	1.5	3.4 (2.9 - 4.2)	3.7 (2.9 - 4.5)	4.3 (3.3 - 5.4)	5.8 (4.6 - 6.3)
	Mean summer temperature	↑	16.9	18.9 (18.2 - 19.9)	19.2 (18.6 - 20.2)	19.6 (18.9 - 21.4)	21.0 (19.9 - 22.4)
	Mean autumn temperature	↑	5.7	7.4 (6.8 - 8.5)	7.8 (7.3 - 8.8)	8.4 (7.6 - 9.6)	9.5 (8.8 - 10.6)
	Annual number of heatwaves	↑	0.0	0.0 (0.0 - 0.2)	0.0 (0.0 - 0.2)	0.1 (0.0 - 0.2)	0.2 (0.1 - 0.6)
	Annual number of days >30°C (days)	↑	2	8 (5 - 13)	9 (5 - 16)	12 (7 - 22)	22 (11 - 40)
	Total annual growing degree days (GDD)	↑	1741	2120 (1998 - 2271)	2164 (2061 - 2337)	2258 (2144 - 2544)	2523 (2390 -2773)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	98.6	98.9 (93.3 - 104.5)	97.6 (91.7 - 103.7)	98.8 (93.2 -104.6)	97.3 (89.6 - 101.7)
	Number of winter freeze-thaw events	↑	18.1	24.9 (19.6 - 28.5)	25.8 (22.0 - 29.8)	29.8 (22.6 - 33.1)	32.0 (27.4 - 37.2)
	Number of spring freeze-thaw events	↓	47.8	43.8 (42.0 - 47.5)	43.6 (41.0 - 48.7)	42.8 (39.5 - 47.2)	39.7 (37.1 - 44.6)
	Number of autumn freeze-thaw events	↓	33.2	29.5 (25.6 - 32.2)	28.0 (25.2 - 30.9)	27.1 (23.6 - 29.2)	24.4 (20.7 - 27.2)
	Winter frost index (°C • days)	↓	1253	935 (704 - 1009)	834 (707 - 1008)	779 (567 - 859)	582 (438 - 732)
Precipitation (mm)	Total winter solid precipitation	↓	199.3	200.6 (181.2 - 220.2)	208.4 (184.1 - 215.8)	199.8 (162.7 - 212.1)	184.6 (167.3 - 210.2)
	Total spring solid precipitation	↓	57.7	53.8 (36.3 - 59.9)	49.3 (34.3 - 59.7)	45.6 (33.9 - 57.5)	37.7 (25.1 - 43.2)
	Total autumn solid precipitation	↓	41.9	29.7 (20.5 - 46.2)	30.5 (22.0 - 38.6)	24.5 (19.5 - 37.3)	20.7 (13.7 - 27.9)
	Total winter liquid precipitation	↑	51.0	73.8 (53.9 - 104.7)	75.5 (59.1 - 108.6)	99.0 (69.9 - 130.6)	121.4 (96.0 - 160.9)
	Total spring liquid precipitation	↑	190.6	222.9 (195.3 - 257.1)	222.6 (203.6 - 239.0)	238.8 (204.1 - 266.1)	256.9 (241.9 - 273.1)
	Total summer liquid precipitation	↑?	322.3	335.8 (303.6 - 343.0)	333.3 (309.9 - 358.1)	329.4 (315.5 - 363.0)	320.9 (289.7 - 342.8)
	Total autumn liquid precipitation	↑	289.7	323.3 (290.1 - 349.8)	312.3 (301.2 - 329.7)	325.3 (300.2 - 341.4)	342.1 (328.8 - 362.7)
	Annual maximum five-day accumulated precipitation	↑	80.6	86.9 (83.4 - 95.5)	88.7 (82.4 - 94.1)	88.7 (85.5 - 102.3)	91.4 (84.9 - 107.8)
	Maximum five-day accumulated precipitation from April to September	↑	73.8	79.3 (73.9 - 84.9)	80.2 (72.8 - 87.7)	81.3 (72.7 - 93.6)	78.0 (72.0 - 91.7)

Mauricie

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	2.4	4.5 (3.9 – 5.7)	5.0 (4.2 – 5.8)	5.5 (4.9 – 7.1)	6.8 (6.2 – 8.0)
	Mean winter temperature	↑	-11.9	-9.3 (-10.3 – -7.2)	-8.3 (-9.8 – -7.4)	-7.9 (-8.7 – -6.0)	-6.3 (-7.5 – -4.7)
	Mean spring temperature	↑	0.2	2.3 (1.5 – 3.0)	2.4 (1.5 – 3.2)	3.0 (1.9 – 4.1)	4.6 (3.3 – 4.9)
	Mean summer temperature	↑	16.3	18.3 (17.6 – 19.3)	18.5 (17.9 – 19.5)	18.9 (18.2 – 20.7)	20.2 (19.2 – 21.7)
	Mean autumn temperature	↑	4.9	6.7 (6.1 – 7.8)	7.0 (6.5 – 8.1)	7.6 (7.0 – 9.0)	8.7 (8.1 – 9.9)
	Annual number of heatwaves	↑	0.0	0.1 (0.1 – 0.5)	0.2 (0.1 – 0.6)	0.2 (0.1 – 0.6)	0.6 (0.3 – 1.4)
	Annual number of days >30°C (days)	↑	2	6 (4 – 10)	7 (4 – 12)	9 (5 – 17)	17 (8 – 32)
	Total annual growing degree days (GDD)	↑	1597	1953 (1843 – 2114)	1992 (1894 – 2173)	2087 (1980 – 2380)	2334 (2210 – 2595)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	91.4	90.9 (83.6 – 96.0)	88.2 (83.2 – 92.5)	89.8 (80.6 – 94.0)	86.7 (77.1 – 91.8)
	Number of winter freeze-thaw events	↑	13.0	17.7 (13.8 – 21.5)	18.1 (15.2 – 21.8)	20.8 (15.0 – 23.7)	23.7 (18.9 – 27.8)
	Number of spring freeze-thaw events	↓	47.3	43.2 (40.6 – 47.7)	42.1 (40.2 – 47.9)	41.7 (38.7 – 46.6)	38.6 (35.0 – 44.0)
	Number of autumn freeze-thaw events	↓	31.4	28.3 (24.3 – 30.8)	26.8 (24.2 – 29.2)	26.5 (21.9 – 28.6)	23.6 (19.4 – 25.5)
	Winter frost index (°C • days)	↓	1459	1127 (879 – 1211)	1009 (879 – 1188)	968 (727 – 1046)	747 (596 – 879)
Precipitation (mm)	Total winter solid precipitation	?	175.5	182.9 (163.2 – 198.2)	189.1 (168.3 – 198.8)	185.9 (150.5 – 192.2)	177.3 (166.7 – 198.2)
	Total spring solid precipitation	↓	66.4	61.3 (43.3 – 67.9)	58.2 (44.9 – 69.0)	53.8 (40.5 – 70.2)	46.8 (35.7 – 56.8)
	Total autumn solid precipitation	↓	45.8	34.0 (24.1 – 46.6)	32.9 (25.3 – 41.2)	29.0 (19.6 – 39.2)	24.0 (14.7 – 31.0)
	Total winter liquid precipitation	↑	32.1	48.9 (32.7 – 73.2)	50.8 (36.9 – 71.5)	61.1 (44.2 – 91.1)	77.9 (58.8 – 109.5)
	Total spring liquid precipitation	↑	158.1	188.7 (165.7 – 216.5)	185.8 (175.5 – 204.0)	203.5 (173.5 – 236.3)	218.6 (209.5 – 239.2)
	Total summer liquid precipitation	?	320.2	333.6 (309.5 – 345.9)	331.7 (313.8 -350.7)	329.6 (318.1 – 362.1)	320.7 (298.6 – 352.2)
	Total autumn liquid precipitation	↑	261.2	297.0 (265.3 – 307.5)	284.8 (267.7 – 302.5)	295.6 (282.5 – 318.2)	312.4 (303.0 – 330.0)
	Annual maximum five-day accumulated precipitation	↑	74.4	80.2 (76.2 – 87.2)	81.7 (76.3 – 88.0)	82.3 (77.8 – 94.6)	83.5 (77.1 – 93.7)
	Maximum five-day accumulated precipitation from April to September	↑	68.6	74.6 (70.6 – 79.8)	74.1 (68.9 – 81.1)	76.0 (70.7 – 88.2)	74.0 (67.9 – 84.4)

Montérégie

	Climate variables and indicators	Regional trends	1991–2020	2041–2070 projections SSP2-4.5	2041–2070 projections SSP3-7.0	2071–2100 projections SSP2-4.5	2071–2100 projections SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	6.8	8.9 (8.3 – 10.1)	9.3 (8.6 – 10.2)	9.9 (9.3 – 11.3)	11.1 (10.7 – 12.4)
	Mean winter temperature	↑	-7.5	-4.7 (-5.7 – -3.2)	-4.0 (-5.6 – -2.9)	-3.4 (-4.5 – -1.9)	-1.7 (-3.4 – -0.6)
	Mean spring temperature	↑	5.6	7.6 (7.1 – 8.4)	7.9 (7.2 – 8.5)	8.4 (7.5 – 9.5)	9.8 (8.8 – 10.4)
	Mean summer temperature	↑	20.0	22.0 (21.3 – 23.1)	22.3 (21.7 – 23.3)	22.7 (22.0 – 24.3)	24.2 (22.9 – 25.6)
	Mean autumn temperature	↑	8.8	10.6 (10.0 – 11.6)	11.0 (10.5 – 11.9)	11.6 (10.8 – 12.7)	12.8 (11.9 – 13.7)
	Annual number of heatwaves	↑	0.0	0.3 (0.2 – 1.2)	0.4 (0.2 – 1.1)	0.5 (0.3 – 1.5)	1.7 (0.6 – 2.4)
	Annual number of days >30°C (days)	↑	8	23 (16 – 34)	26 (17 – 37)	29 (20 – 49)	46 (30 – 69)
	Total annual growing degree days (GDD)	↑	2430	2879 (2729 – 3058)	2953 (2802 – 3112)	3032 (2908 – 3339)	3365 (3197 – 3621)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	80.2	80.6 (75.6 – 86.9)	80.8 (74.9 – 85.3)	80.8 (75.6 – 86.1)	78.1 (67.7 – 83.0)
	Number of winter freeze-thaw events	↑	27.7	35.9 (29.9 – 37.9)	36.6 (32.6 – 39.2)	38.7 (33.7 – 44.1)	41.9 (33.5 – 44.4)
	Number of spring freeze-thaw events	↓	30.1	27.3 (24.2 – 31.9)	26.7 (23.7 – 31.3)	25.4 (23.3 – 29.2)	23.2 (20.2 – 26.5)
	Number of autumn freeze-thaw events	↓	22.6	18.6 (13.5 – 21.8)	17.8 (12.6 – 20.4)	16.2 (12.1 – 19.4)	13.1 – 9.4 – 16.6)
	Winter frost index (°C • days)	↓	876	597 (445 – 671)	533 (411 – 681)	474 (320 – 556)	324 (261 – 444)
Precipitation (mm)	Total winter solid precipitation	↓	172.6	159.3 (126.9 – 181.8)	159.4 (137.0 – 183.5)	143.5 (114.2 – 168.0)	133.7 (103.5 – 157.8)
	Total spring solid precipitation	↓	39.5	31.5 (20.8 – 42.3)	32.0 (18.2 – 40.9)	27.1 (18.6 – 35.6)	20.1 (12.4 – 25.3)
	Total autumn solid precipitation	↓	14.0	9.3 (5.2 – 17.0)	7.0 (3.8 – 13.1)	8.1 (4.2 – 13.1)	6.1 (1.8 – 8.4)
	Total winter liquid precipitation	↑	90.8	135.7 (105.3 – 175.2)	136.6 (108.3 – 177.5)	165.6 (126.8 (194.7)	188.5 (160.0 – 243.1)
	Total spring liquid precipitation	↑	225.5	256.7 (227.6 – 292.8)	259.5 (238.0 – 282.4)	264.5 (244.2 – 299.9)	285.2 (272.9 – 304.2)
	Total summer liquid precipitation	?	287.4	299.2 (281.9 – 319.8)	298.3 (281.3 – 327.6)	299.3 (287.3 – 342.2)	292.6 (266.4 – 311.6)
	Total autumn liquid precipitation	?	271.2	295.0 (269.5 – 324.3)	293.6 (264.8 – 308.0)	290.9 (271.4 – 290.9)	301.5 (293.5 – 327.6)
	Annual maximum five-day accumulated precipitation	↑	79.6	87.0 (81.7 –97.4)	90.2 (84.1 – 100.2)	90.9 (85.0 – 101.3)	90.8 (85.2 – 102.2)
	Maximum five-day accumulated precipitation from April to September	↑	71.1	76.1 (69.9 – 87.8)	79.5 (71.2 – 87.9)	81.0 (71.1 – 91.5)	82.3 (72.1 – 88.9)

Climate normals and anticipated change

Montréal and Laval

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991-2020	2041-2070 projections		2071-2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	7.1	9.2 (8.5 - 10.4)	9.6 (8.8 - 10.5)	10.2 (9.6 - 11.6)	11.4 (10.9 - 12.7)
	Mean winter temperature	↑	-7.3	-4.5 (-5.5 - -3.0)	-3.8 (-5.4 - -2.7)	-3.2 (-4.3 - -1.7)	-1.5 (-3.2 - -0.4)
	Mean spring temperature	↑	5.7	7.7 (7.2 - 8.5)	8.0 (7.2 - 8.6)	8.5 (7.6 - 9.6)	9.9 (8.9 - 10.5)
	Mean summer temperature	↑	20.4	22.3 (21.7 - 23.5)	22.7 (22.0 - 23.7)	23.1 (22.4 - 24.8)	24.6 (23.3 - 26.0)
	Mean autumn temperature	↑	9.1	10.9 (10.3 - 11.9)	11.3 (10.8 - 12.2)	11.9 (11.1 - 13.0)	13.1 (12.3 - 14.0)
	Annual number of heatwaves	↑	0.0	0.4 (0.3 - 1.4)	0.6 (0.3 - 1.4)	0.7 (0.4 - 2.0)	2.1 (0.7 - 3.0)
	Annual number of days >30°C (days)	↑	10	25 (17 - 37)	28 (19 - 40)	31 (22 - 53)	50 (33 - 72)
	Total annual growing degree days (GDD)	↑	2480	2930 (2782 - 3115)	3008 (2856 - 3169)	3085 (2963 - 3403)	3421 (3259 - 3682)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	77.3	77.0 (72.2 - 84.2)	77.0 (71.2 - 83.1)	77.1 (71.9 - 83.1)	75.0 (64.6 - 80.1)
	Number of winter freeze-thaw events	↑	26.8	34.8 (29.0 - 37.1)	36.2 (31.6 - 38.2)	38.0 (32.7 - 43.2)	41.1 (33.3 - 43.6)
	Number of spring freeze-thaw events	↓	29.7	26.8 (23.9 - 31.7)	25.8 (23.0 - 30.9)	24.5 (22.1 - 28.4)	21.9 (19.2 - 25.7)
	Number of autumn freeze-thaw events	↓	20.8	16.8 (11.6 - 20.1)	16.3 (10.8 - 18.7)	14.4 (10.4 - 17.0)	11.5 (8.0 - 15.0)
	Winter frost index (°C • days)	↓	843	570 (420 - 642)	504 (388 - 653)	450 (298 - 531)	305 (240 - 421)
Precipitation (mm)	Total winter solid precipitation	↓	169.7	154.6 (119.6 - 180.9)	155.5 (131.7 - 182.1)	138.2 (107.9 - 166.2)	124.7 (98.2 - 153.1)
	Total spring solid precipitation	↓	35.3	27.8 (19.0 - 39.1)	29.9 (15.5 - 36.2)	25.7 (15.8 - 32.5)	17.3 (10.7 - 23.3)
	Total autumn solid precipitation	↓	12.3	8.4 (4.2 - 15.2)	6.4 (3.0 - 11.2)	7.2 (3.0 - 13.1)	6.3 (1.4 - 7.5)
	Total winter liquid precipitation	↑	95.1	138.3 (107.3 - 181.4)	144.7 (112.9 - 186.9)	169.8 (131.1 - 200.7)	194.3 (170.4 - 249.1)
	Total spring liquid precipitation	↑	224.5	254.3 (226.5 - 290.5)	256.2 (237.0 - 281.1)	262.4 (242.8 - 293.2)	283.0 (269.2 - 301.1)
	Total summer liquid precipitation	↑	273.1	283.2 (266.5 - 301.7)	284.9 (264.7 - 314.9)	282.8 (271.8 - 327.8)	278.3 (250.8 - 299.4)
	Total autumn liquid precipitation	↑	271.0	296.2 (270.4 - 325.3)	294.7 (268.6 - 308.7)	295.2 (271.0 - 305.1)	304.9 (298.6 - 332.6)
	Annual maximum five-day accumulated precipitation	↑	81.1	89.1 (83.1 - 101.6)	92.7 (86.1 - 103.3)	92.2 (85.3 - 103.8)	93.4 (88.9 -107.1)
	Maximum five-day accumulated precipitation from April to September	↑	70.6	76.9 (68.9 - 87.5)	80.0 (70.9 - 88.9)	80.8 (69.8 - 92.3)	80.9 (71.8 - 91.3)

Outaouais

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	4.2	6.2 (5.6 - 7.4)	6.8 (5.9 - 7.5)	7.3 (6.7 - 8.8)	8.5 (8.0 - 9.7)
	Mean winter temperature	↑	-9.8	-7.0 (-7.9 --5.2)	-6.2 (-7.8 - -5.3)	-5.7 (-6.7 - -4.0)	-4.0 (-5.5 - -2.7)
	Mean spring temperature	↑	2.2	4.2 (3.6 - 4.9)	4.4 (3.7 - 5.2)	4.9 (4.0 - 6.1)	6.5 (5.4 - 7.0)
	Mean summer temperature	↑	17.7	19.6 (19.0 - 20.6)	19.9 (19.3 - 21.0)	20.4 (19.7 - 22.1)	21.9 (20.6 - 23.1)
	Mean autumn temperature	↑	6.3	8.0 (7.4 - 9.1)	8.3 (7.9 - 9.5)	9.0 (8.2 - 10.2)	10.2 (9.4 - 11.2)
	Annual number of heatwaves	↑	0.1	0.4 (0.2 - 1.2)	0.5 (0.2 - 1.2)	0.7 (0.4 - 0.7)	1.7 (0.8 -2.5)
	Annual number of days >30°C (days)	↑	3.5	11.3 (7.3 -18.0)	12.4 (8.1 - 20.5)	16.3 (10.3 -28.5)	28.1 (15.3 - 47.2)
	Total annual growing degree days (GDD)	↑	1880	2273 (2141 - 2428)	2317 (2226 - 2500)	2416 (2292 - 2707)	2697 (2546 - 2946)
Freeze-thaw events (days)	Annual number of freeze-thaw events	?	94.4	93.7 (87.5 - 99.4)	93.1 (86.7 - 98.6)	94.6 (87.1 - 100.0)	91.9 (83.8 - 96.7)
	Number of winter freeze-thaw events	↑	19.1	25.9 (20.2 - 28.9)	26.7 (24.0 - 30.1)	30.7 (23.8 - 33.5)	31.6 (28.8 - 37.0)
	Number of spring freeze-thaw events	↓	45.5	41.5 (39.3 - 45.0)	41.3 (38.6 - 46.4)	39.9 (37.0 - 44.9)	37.0 (34.4 - 42.0)
	Number of autumn freeze-thaw events	↓	29.8	26.0 (22.0 - 29.6)	24.8 (21.4 - 27.4)	23.9 (20.1 - 26.0)	20.6 (17.2 - 24.0)
	Winter frost index (°C • days)	↓	1168	862 (648 - 934)	764 (647 - 930)	712 (515 - 793)	529 (399 - 661)
Precipitation (mm)	Total winter solid precipitation	↓	166.7	168.3 (147.5 - 184.7)	174.2 (152.9 - 182.1)	164.8 (134.4 - 179.6)	153.3 (131.5 - 174.4)
	Total spring solid precipitation	↓	48.4	44.6 (29.6 - 50.3)	40.6 (26.6 - 48.5)	37.2 (27.5 - 46.3)	30.6 (19.2 - 35.0)
	Total autumn solid precipitation	↓	35.1	25.1 (15.7 - 35.8)	23.6 (17.1 - 31.8)	19.3 (15.0 -29.0)	16.6 (10.5 - 21.4)
	Total winter liquid precipitation	↑	47.5	70.5 (51.4 - 98.9)	71.0 (59.7 - 98.7)	92.4 (66.4 - 119.1)	114.0 (88.7 - 147.6)
	Total spring liquid precipitation	↑	177.2	207.7 (182.4 - 235.4)	206.0 (192.3 - 220.3)	219.5 (192.1 - 243.0)	237.3 (224.1 - 255.4)
	Total summer liquid precipitation	?	294.0	306.8 (275.8 - 321.1)	305.1 (280.0 - 326.6)	298.7 (286.0 - 331.9)	292.1 (261.7 - 306.4)
	Total autumn liquid precipitation	?	266.7	298.6 (265.4 -322.8)	288.1 (278.4 - 297.1)	297.6 (279.4 - 312.5)	316.0 (302.0 - 334.3)
	Annual maximum five-day accumulated precipitation	↑	75.9	83.1 (77.0 - 89.9)	84.7 (77.1 - 90.8)	84.3 (79.8 - 93.6)	85.9 (80.6 - 103.8)
	Maximum five-day accumulated precipitation from April to September	?	69.2	74.5 (69.9 - 82.6)	76.8 (67.8 - 82.8)	77.2 (69.5 - 86.8)	74.6 (67.4 - 89.8)

Saguenay–Lac-Saint-Jean

	Climate variables and indicators	Regional trends	Climate normals and anticipated change				
			1991–2020	2041–2070 projections		2071–2100 projections	
				SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Temperature (°C)	Mean annual temperature	↑	0.0	2.1 (1.4 – 3.4)	2.5 (1.8 – 3.5)	3.0 (2.5 – 5.0)	4.4 (3.8 – 5.6)
	Mean winter temperature	↑	-15.1	-12.4 (-13.3 – - 10.3)	-11.6 (-12.7 – - 10.4)	-10.9 (-11.7 – -8.9)	-9.6 (-10.2 – -7.5)
	Mean spring temperature	↑	-2.5	-0.6 (-1.5 – 0.4)	-0.4 (-1.2 – 0.6)	-0.1 (-0.9 – 1.9)	1.7 (0.7 – 2.2)
	Mean summer temperature	↑	14.5	16.5 (15.7 – 17.4)	16.7 (16.1 – 17.7)	17.3 (16.4 – 19.0)	18.4 (17.4 – 19.9)
	Mean autumn temperature	↑	2.9	4.8 (4.2 – 5.8)	5.1 (4.6 – 6.2)	5.7 (5.1 – 7.2)	6.7 (6.1 – 8.0)
	Annual number of heatwaves	↑	0.0	0.0 (0.0 – 0.1)	0.0 (0.0 – 0.2)	0.1 (0.0 – 0.3)	0.2 (0.1 – 0.8)
	Annual number of days >30°C (days)	↑	1	2 (1 – 4)	2 (2 – 5)	3 (2 – 8)	7 (3 – 15)
	Total annual growing degree days (GDD)	↑	1271	1579 (1488 – 1738)	1606 (1526 – 1781)	1715 (1600 – 2019)	191 (1795 – 2154)
Freeze-thaw events (days)	Annual number of freeze-thaw events	↓	85	82.0 (75.9 – 85.7)	79.7 (75.7 – 83.5)	79.0 (71.8 – 84.6)	76.2 (69.0 – 81.3)
	Number of winter freeze-thaw events	↑	7.0	9.5 (7.5 – 12.3)	9.9 (7.8 – 12.0)	11.5 (8.5 – 13.5)	12.9 (10.5 – 15.2)
	Number of spring freeze-thaw events	↓	46.2	42.8 (40.5 – 46.8)	42.2 (28.9 – 46.6)	40.2 (38.0 – 46.3)	37.3 (34.5 – 43.3)
	Number of autumn freeze-thaw events	↓	29.8	27.4 (25.4 – 30.1)	26.6 (24.5 – 28.6)	26.1 (23.3 – 28.0)	23.4 (20.7 – 25.6)
	Winter frost index (°C • days)	↓	1928	1555 (1275 – 1665)	1442 (1268 – 1583)	1386 (1055 – 1457)	1155 (936 – 1235)
Precipitation (mm)	Total winter solid precipitation	↑	174.8	191.5 (177.1 – 206.7)	192.4 (180.9 – 204.8)	195.6 (165.8 – 207.8)	201.0 (187.1 – 218.4)
	Total spring solid precipitation	↓	87.5	83.8 (68.4 – 93.5)	80.8 (67.8 – 91.3)	75.4 (61.1 – 94.4)	70.9 (63.1 – 85.2)
	Total autumn solid precipitation	↓	78.4	61.0 (50.8 – 73.2)	59.4 (47.6 – 73.5)	56.2 (39.7 – 66.0)	45.4 (35.8 – 56.8)
	Total winter liquid precipitation	↑	17.1	23.2 (15.7 – 43.9)	26.7 (20.7 – 37.5)	31.2 (23.5 – 51.9)	41.6 (28.5 – 63.4)
	Total spring liquid precipitation	↑	131.0	166.3 (140.4 – 186.8)	160.5 (142.6 – 175.7)	172.3 (149.3 – 202.2)	187.7 (172.2 – 213.4)
	Total summer liquid precipitation	↑	366.5	381.2 (368.0 – 398.0)	386.3 (362.0 – 404.7)	382.1 (358.6 – 412.7)	369.6 (357.2 – 412.0)
	Total autumn liquid precipitation	↑	261.7	307.9 (278.8 – 316.6)	300.9 (281.7 – 320.7)	312.0 (297.6 – 340.0)	327.8 (315.9 – 360.7)
	Annual maximum five-day accumulated precipitation	↑	75.8	85.1 (81.1 – 94.2)	83.8 (79.5 – 92.8)	86.9 (78.8 – 95.0)	87.8 (80.2 – 93.8)
	Maximum five-day accumulated precipitation from April to September	↑	71.9	81.2 (76.0 – 89.8)	79.9 (73.1 – 85.8)	81.4 (72.8 – 90.9)	82.5 (72.7 – 84.9)

Climate hazards and examples of their impacts

Table B1: Climate hazards and examples of their impacts

Potential impacts	Climate hazards														
	Heatwaves and higher tempera-tures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and floo-ding	Landslides	Fluvial floods [D]	Pluvial floods	The pre-sence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Per-mafrost thaw	Cold episodes
Infrastructure															
Damage to the road network, drinking water distribution network, and wastewater system (saturation, backflow, overflow) [1 2 3 4 5 6 7 8 9]	X	X	X	X	X	X	X	X			X	X	X	X	X
Damage to buildings [2 3 4 5 7 8 9 10 11]	X	X	X	X	X	X	X	X					X	X	X
The increasing complexity of air conditioning and heating buildings [12]	X														X
Service disturbances and interruptions associated with the infrastructure affected, e.g., power outages, air transport, supply chain, and drinking water [6 7]	X	X	X	X	X	X	X	X					X	X	X

[A] Tornados, storms, violent winds, snowstorm, post-tropical storms, ice storms
[B] Liquid, solid and mixed
[C] freeze-thaw events, rain on snow events, reduced ice and snow cover, shortened freeze period
[D] Open water, ice jams
[E] Ticks carrying Lyme disease, mosquitoes carrying West Nile virus

APPENDIX B

Potential impacts	Climate hazards														
	Heatwaves and higher temperatures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and flooding	Landslides	Fluvial floods [D]	Pluvial floods	The presence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Permafrost thaw	Cold episodes
Population															
Health problems related to increased mould [8]	X	X	X				X	X		X					
Psychological distress [8,13]	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Diseases related to the contamination of drinking water and swimming [8]	X	X	X				X	X		X	X	X	X		
Vector-borne diseases [8]	X		X	X						X					
Accidents, injuries, diseases, mortality, and compromised security [8,13]	X	X		X	X	X	X	X	X	X			X	X	X
Road accidents [8]		X	X	X											
Difficulties in the movement of individuals and emergency services [8]		X	X	X	X	X	X	X					X	X	
Increased seasonal allergies [14]	X	X							X		X				
Health problems related to air pollution [8,9,11,15]	X												X		
Heat stroke, dehydration, cardiovascular and respiratory problems [1,7,15]	X										X				

APPENDIX B

Potential impacts	Climate hazards														
	Heatwaves and higher tempera-tures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and floo-ding	Landslides	Fluvial floods [D]	Pluvial floods	The pre-sence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Per-mafrost thaw	Cold episodes
Local economy															
Higher insurance premiums or reduced or lost insurance coverage [8]		X			X	X	X	X			X		X		
Costs related to infrastructure-related damage and maintenance [8]	X	X	X	X	X	X	X	X			X	X	X	X	X
Agricultural and forest losses	X	X	X	X	X	X	X	X		X	X		X		X
Reduced profitability of winter tourism [16]	X	X	X	X	X	X	X	X			X	X	X		X
Reduced land values					X	X	X	X							
Power outages [17]	X	X		X	X								X		X
Interruption or reduction of business activities	X	X			X	X	X	X	X	X			X	X	X
Increased costs related to was-tewater treatment and the production of drinking water [8]	X	X	X	X			X	X		X	X	X		X	
Increased costs and resources related to snow removal, increased pruning, felling, irrigation, and revegetation [18]	X	X	X	X											

APPENDIX B

Potential impacts	Climate hazards														
	Heatwaves and higher tempera-tures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and floo-ding	Landslides	Fluvial floods [D]	Pluvial floods	The pre-sence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Per-mafrost thaw	Cold episodes
Increased management costs with respect to infrastructure, parks and green spaces, and recreational activities [8]	X	X	X	X	X	X	X	X	X	X	X		X		X
The natural environment															
Habitat and biodiversity loss [9, 19]	X				X	X	X	X		X	X	X	X		
Reduced ecological services provided by ecosystems [9]		X			X	X	X	X					X		
Modification of the dormancy period of plants and the health of crops and soils [8]	X		X	X							X	X	X		
Reduced levels in lakes, watercourses, and reservoirs											X	X		X	
Reduction in the level of the water table [20]											X	X		X	
Hydric stress experienced by plants [8]											X	X			
Loss of canopy cover	X	X								X			X		
Increased distribution range and reproduction rate of pathogens [8]	X		X	X						X					

Potential impacts	Climate hazards														
	Heatwaves and higher tempera-tures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and floo-ding	Landslides	Fluvial floods [D]	Pluvial floods	The pre-sence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Per-mafrost thaw	Cold episodes
The arrival and introduction of certain insect pests earlier in the season [8]	X			X						X					
Drying of wetlands [8]	X										X	X			
Aquatic biodiversity loss related to anoxia and eutrophication in water bodies	X		X			X	X	X			X	X			
The proliferation of certain invasive alien species [7]	X										X				
Deterioration of the quality of watercourses and increased concentrations of contaminants [6 21 22]	X	X	X		X	X	X	X			X	X	X	X	
Municipal services															
Delays on construction sites [8]	X	X			X	X	X	X					X		X
Wastewater that is harder to treat [8]		X	X				X	X		X	X	X		X	
Slowing down and more frequent interruption of outdoor activities [8]	X	X	X	X	X	X	X	X	X	X	X		X	X	X

Potential impacts	Climate hazards														
	Heatwaves and higher tempera-tures	Extreme weather events [A]	Heavy, frequent rainfall [B]	Winter thaws [C]	Coastal erosion and floo-ding	Landslides	Fluvial floods [D]	Pluvial floods	The pre-sence of allergenic pollen	The presence of disease vectors [E]	Droughts	Low river flows	Forest fires	Per-mafrost thaw	Cold episodes
More difficult snow-clearing and de-icing operations		X		X										X	
Infrastructure, parks and green spaces, and recreational activities that are harder to manage [8]	X	X	X	X	X	X	X	X	X	X			X		X
Bigger crowds in certain public spaces such as libraries and swimming pools [8]	X	X													X
Increased odours related to residual materials [8, 23]	X													X	

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The advantages of properly planned adaptation

Table C1 : Examples of measures conducive to effective adaptation or that generate co-benefits

Prevent and reduce risks and costs

Modify certain regulations and practices[1]:

- Regulate or encourage the planting of plants on private land to increase at lower cost the cool areas in the municipal body's territory.
- Adopt new sustainable building construction practices bearing in mind potential bad weather to increase the resilience of urban infrastructure.

It is more profitable to invest in adaptation than to do nothing[2 3]:

- Over a period of 75 years, each dollar invested in adaptation could generate between $13 and $15 in returns.

Adopt an iterative strategy on the short-, medium-, and long-term time horizons

Implement measures in the territory that consider climate change and its impacts[4]:

- Implement specific measures according to the long-term increase in climate change impacts. In the case of municipal bodies that are vulnerable to flooding, here are some examples of measures to be implemented:
- In the short term, possible measures include ascertaining the potential dynamic of flooding, developing a weather alert system, and the protection of communications and energy and water supply infrastructure. What is more, the creation of sites to accommodate flood evacuees can be contemplated.
- In the medium term, possible measures include slowing the dynamics of flooding, e.g., by building retention ponds, permeabilizing soils, and preserving runoff.
- In the long term, the measures to be contemplated include transforming the built environment, e.g., by designing floodable ground floors that can accommodate floodwaters, building elevated living spaces, demolishing highly vulnerable houses, and relocating their occupants.

Take advantage of opportunities in light of what already exists or is already done to avoid duplicating efforts

Integrate adaptation into existing legislation, policies, and key directions based on the roles and responsibilities of each level of government [5]:

- Establish a water level surveillance system reporting to the local municipalities, which is integrated in the context of The Québec Water Strategy 2018-2030 of the MELCCFP.

Incorporate adaptation into structuring expenditures[6]:

- Incorporate adaptation measures into renovations or work that the municipal body has already contemplated to reduce costs.

Optimize resources

Allocate resources in a targeted manner according to the most urgent needs[6]:

- Respond effectively to the greatest risks.
- Facilitate the coordination of the stakeholders' initiatives.
- Maximize benefits by minimizing costs (efficiency).

Foster a just climate transition and inclusive climate action

Fairly apportion the costs and the social, economic, and environmental benefits of adaptation among the stakeholders in society and between current and future generations[7 8]:

- Carry out targeted intervention in the territory focusing, as a matter of urgency, on the most vulnerable populations.
- Promote eco-taxation to ensure equity between individuals.

Obtain the adherence of individuals, organizations, and businesses and create cohesion in the community

Involve the public in the municipal body's decisions [7]:

- Foster citizen engagement to avoid potential inequality.
- Bolster public support for innovative practices.
- Develop and accelerate behaviour that is conducive to adaptation.

Take advantage of the co-benefits related to adaptation measures whether or not the expected impacts occur

Green the territory[9] :

- Enhanced quality of life, health benefits, embellishment, a sense of belonging among individuals, ecosystem services such as water and air quality, and pollination, and enhanced social acceptability.

Consider transversality

It is important for municipal bodies to consider the transversality of climate issues throughout the adaptation process. Given the interdependence of human, ecological, socioeconomic, and built systems, a climate hazard usually affects several sectors of society, which requires planning beyond the municipal boundaries. Planning that considers such interdependence is all the more important since adaptation measures can also be of a transversal nature. They can also respond to adverse effects in several sectors and avoid contributing to maladaptation. Consideration of the transversality of issues and the measures to be adopted calls for a multidisciplinary effort based on diversified expertise so that policies and adaptation measures are properly integrated in different sectors of the municipal body.

Figure C1 provides an example of such transversality. The reduced level of a watercourse or water body is an example of a transversal issue that can affect the amount and quality of the drinking water available the territory of a municipal body. It can also impact several other sectors such as irrigation in urban parks, sports grounds, and aquatic activities such as beaches and water and other activities. However, water supply problems largely exceed climate change and can stem from overconsumption, exceeding the environment's support capacity, and deficient infrastructure.

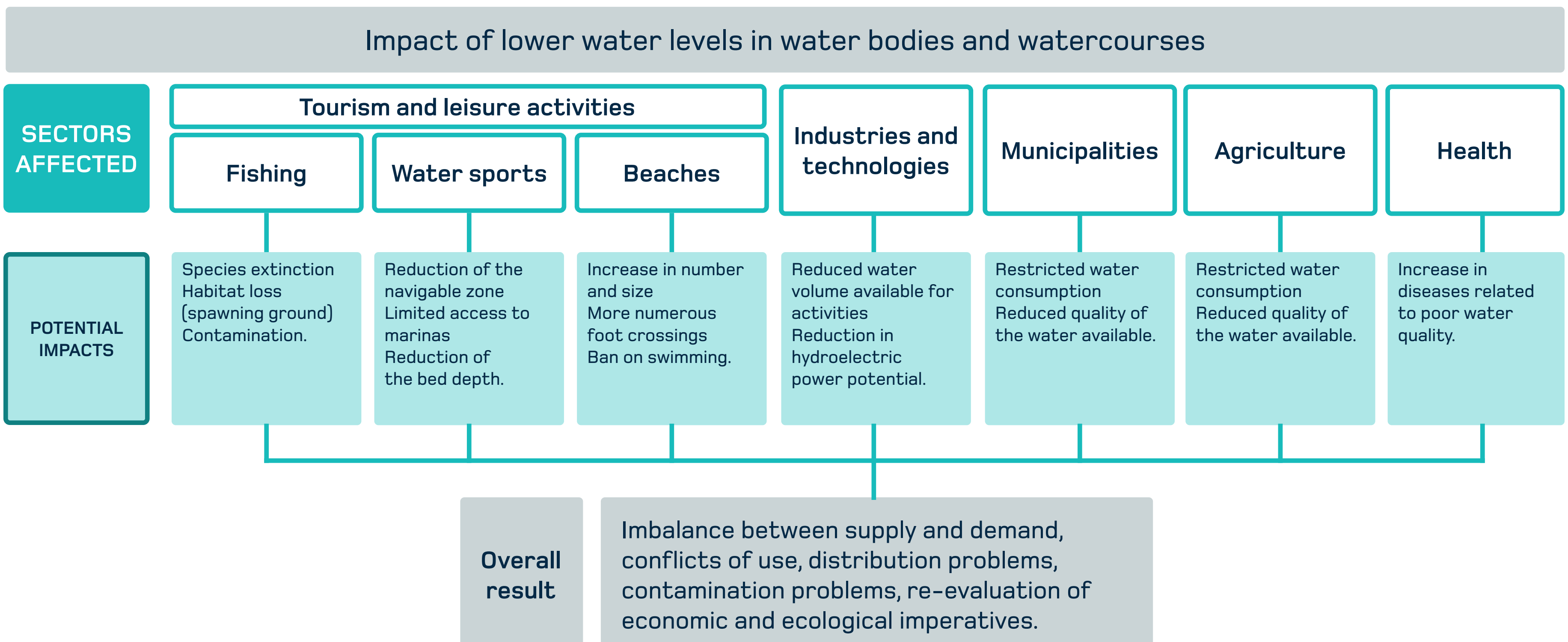

Figure C1: An example of a transversal issue

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The municipal and governmental regulatory context related to the climate change adaptation process

Municipal regulatory context

Certain fields of jurisdiction or powers are exclusive to the RCMs or the municipalities while others are shared. In this context, it is essential that municipal bodies take this into account in their adaptation process to act coherently with the key regulatory, planning, or political instruments specific to them and to promote synergy between them. To foster adaptation to climate change, it is essential to implement adaptation measures stemming from supra-local and local jurisdictions. Table D1 below presents the roles and responsibilities assumed or that can be assumed by different municipal levels related to climate change adaptation issues.

Table D1: Roles and responsibilities at the municipal level related to climate change adaptation issues

	Supralocal		Local
	Communauté métropolitaine de Montréal (CMM) and Communauté métropolitaine de Québec (CMQ)	Regional county municipalities (RCMs)	Local municipalities
Role	• The RCMs and the metropolitan communities seek to facilitate the pooling of services and the management of regional decisions that affect several municipalities. For example, the management of coastal erosion must consider the sediment dynamics of the coastal system that can span dozens of kilometres, transcending administrative boundaries, to avoid shifting the erosion problem downstream. This regional management can also apply, for example, to public transport, whose planning at the supralocal level facilitates travel by individuals from one municipality to another inside an urbanized area. The RCMs also have a role to play with regard to economic development.[1 2 3].		• The local municipalities contribute to the maintenance of living environments adapted to residents' needs and to economic deployment in the territory. • The municipalities assume responsibilities with respect to land-use planning and urban planning, housing, the construction and maintenance of road infrastructure, community and cultural development, leisure activities, public transport in urban environments, wastewater treatment, drinking water supply, and residual materials management.[1 2 3].
Areas of jurisdiction	• Land-use planning, including the identification of natural and anthropic constraint zones in their land use planning and development plan • Local and regional development, including housing • Management of watercourses, lakes, and ditches • The administration of unorganized territories (UTs) • Management of the Regulation respecting wastewater disposal systems for isolated dwellings • Residual materials management • Civil Security • The protection of wetlands and hydrous environments • The creation and management of regional parks • Interurban collective transportation • Port and airport facilities [4 5]		• Local road network • Urban planning and land-use planning • Housing and public housing • Local economic development • Community development, recreation and culture • Management of parks and green spaces • Water supply, sewers, and wastewater collection and treatment • Residual materials management • Civil security • Urban collective transportation and active transportation • Air quality monitoring • Management of contaminated soils • Industrial discharge monitoring

APPENDIX D

	Supralocal		Local
	Communauté métropolitaine de Montréal (CMM) and Communauté métropolitaine de Québec (CMQ)	Regional county municipalities (RCMs)	Local municipalities
Key mandatory regulatory, planning, or policy instruments	• Metropolitan Planning and Development Plan (MPDP) [5]	• Land use planning and development plan (SAD) • Interim control bylaw (ICB) • Regional wetlands and water bodies plans (PRMHH) • Regional disaster resilience plan (mandatory once the regulations have been adopted)	• Urban planning by-laws, including the master plan • The civil security plan (mandatory once the regulations have been adopted) [5]
Key optional regulatory, planning, or policy instruments	• Climate action plan, greenhouse gas reduction or adaptation plan • Sustainable development strategy or plan		
	• Economic development plan • Regulation respecting the quality of drinking water • Metropolitan Waste Management Plan [6 7]	• Agricultural Zone Development Plan (AZDP) • Regulations on Tree Planting and Removal • Sustainable mobility plan • Strategic development plan [4 7]	• Planning program (PP) • Tree policy • Snow-removal policy • Housing policy • Drinking water conservation strategy • Urban forestry plan • Municipal assets management plan • Site planning and architectural integration program regulations (SPAIP) • Comprehensive development program (CDP) [4 7]
Examples of adaptation measures	• Map the metropolitan territory's vulnerability faced with climate hazards • Encourage the greening of private property to combat heat islands and promote better management of heavy rainfall • Adapt the active transportation network to changing winter conditions • Implement eco-taxation measures to protect wetlands, combat heat islands, and promote better management of heavy rainfall • Adapt monitoring and surveillance of water levels and ice formation to prevent flood risk [8 9]	• Adapt the culvert and ditch rebuilding and maintenance plan bearing in mind climate projections • Adapt leisure activity offerings and infrastructure to changing winter conditions and periods of extreme heat • Elaborate a communications strategy for extreme weather events [10 11]	• Implement eco-taxation measures such as taxing impermeable surfaces to combat heat islands and heavy rainfall • Adapt oversight of the development of parking lots to limit their impermeabilization • Adapt the standards to better protect green spaces and combat heat islands by considering climate projections • Adapt regulations governing the installation of green or white roofs to combat heat islands • Select plants adapted to current and future climate conditions to green the municipal territory • Bolster regulations governing watering to better manage water resources in a context of projected increased drought [7]

Government regulatory context

Aside from the areas of jurisdiction specific to them, the municipal bodies are governed by legislation, policies, key directions, and tools at the provincial and federal levels. This government support can facilitate and guide the efforts of municipal bodies to combat climate change. To this end, Table D2 presents the main legislation, policies, and key directions that can directly or indirectly play a role in adaptation to climate change at the municipal level.

Table D2: Government oversight and tools related to the areas of jurisdiction of municipal bodies or the relevant climate change adaptation issues

Legislation, policies, or key directions	
Provincial	
Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP)	• *Act respecting the Ministère du Développement durable, de l'Environnement et des Parcs* • *Environment Quality Act* • *Sustainable Development Act* (c. D-8.1.1) • *Climate change framework policy (2030 Plan for a Green Economy* [PGE]) and implementation plans • *The 2022-2027 Climate Action Mobilization Strategy* • Transitional regime for the management of floodplains, shorelines and coastlines • *Act to affirm the collective nature of water resources and to promote better governance of water and associated environments* • *Regulation respecting the environmental impact assessment and review* • *Regulation respecting the environmental impact assessment and review of certain projects* • Guide to climate change and environmental assessment for project initiators • *The Québec Water Strategy 2018-2030* • *Water Withdrawal and Protection Regulation* • *Dam Safety Act* • *Heritage Conservation Act* • *Act respecting the conservation and development of wildlife* • *Act respecting threatened or vulnerable species* • *Act respecting the conservation of wetlands and bodies of water* 12
Ministère des Affaires municipales et de l'Habitation (MAMH)	• *Municipal Powers Act* (MPA) • *Act respecting land use planning and development* (ALUPD) • *Government land-use planning guidelines* (GLPG) • Politique nationale de l'architecture et de l'aménagement du territoire (PNAAT) and implementation plan • *Plan de protection du territoire face aux inondations* (PPTFI) • Flooding-related project offices • Coastal erosion and flooding-related project offices • Special planning zone (SPZ) 5
Ministère de la sécurité publique (MSP)	• *Civil Protection Act* • *Plan national de sécurité civile (PNSC)* • *Politique nationale de sécurité civile (2014-2024)* 1

Legislation, policies, or key directions	
Provincial	
Ministère des Transports et de la Mobilité durable (MTMD)	• Act respecting the Ministère des Transports • Act respecting Roads • Transport Act • Politique de la mobilité durable - 2030 [13]
Ministère de la Santé et des Services sociaux (MSSS)	• Act respecting health services and social services • Plan ministériel de gestion des épisodes de chaleur extrême • Government Policy of Prevention in Health (GPPH) • Public Health Act • Act respecting Cree, Inuit and Naskapi Native persons • Programme national de santé publique 2015-2025 (PNSP) [14]
Régie du bâtiment (RBQ)	• Building Act (Construction and Safety Code) [15]
Ministère des Ressources naturelle et des Forêts (MRNF)	• Sustainable Forest Development Act
Ministère de la Culture et des Communications (MCC)	• Politique nationale de l'architecture et de l'aménagement du territoire (PNAAT) and implementation plan
Ministère du Travail (MTRAV)	• Act respecting occupational health and safety (AOHS) • Act respecting industrial accidents and occupational diseases (AIAOD) [16]
Federal	
Environment and Climate Change Canada (ECCC)	• Canadian Environmental Protection Act • Canada Water Act • Canada's National Adaptation Strategy and Government of Canada Adaptation Action Plan [17]
Infrastructure Canada (INFC)	• Climate Lens [18]
Fisheries and Oceans Canada (DFO)	• Oceans Act • Coastal Fisheries Protection Act • Fishing and Recreational Harbours Act • Fisheries Act [19]

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APPENDIX D

Municipal regulatory context in the Nord-du-Québec region

The municipal system in the Nord-du-Québec administrative region has distinctive characteristics that differ from those elsewhere in Québec, which Table D3 seeks to clarify. For example, the KRG, a supralocal body is found north of the 55th parallel but there is no RCM or supralocal body between the 49th and 55th parallel. The land regime stemming from the James Bay and Northern Quebec Agreement (JBNQA) also affects municipal organization in this region.

Table D3 : Roles and responsibilities and of municipal organizations in the Nord-du-Québec region related to climate change adaptation issues

	Nunavik [A] (north of the 55th parallel)			Eeyou Istchee James Bay Territory[E] (between the 49th and 55th parallel)			
	Northern villages	Naskapi village[B]	Kativik Regional Government (KRG)	Cree villages[C]	Cree Nation Government (CNG)	Municipalities	Eeyou Istchee James Bay Regional Government (EIJBRG)
Municipal levels	Local municipalities	Municipality (Category IB-N lands)	Supralocal (regional municipal body, including 14 northern villages and one Naskapi village), and local municipality (for the unorganized territories)	Municipalities (Category IB lands)		Local municipalities Absence of a supralocal body (there is no RCM)	A municipal body for Category III lands including the towns and villages but excluding the four enclosed municipalities
Regulatory, planning, or policy instruments (optional but strongly recommended)	A territorial master plan, equivalent to a town-planning master plan, a subdivision by-law, and a zoning and construction by-law (the northern village council can decree that the application of the master plan is mandatory)		2020 Kativik Regional Master Plan		Regional Land and Resource Use Plan (RLRUP)	No LUPDP is in force and there is no equivalent	Regional plan for integrated land and resource development (PRDIRT)

APPENDIX D

	Nunavik [A] (north of the 55th parallel)			Eeyou Istchee James Bay Territory[E] (between the 49th and 55th parallel)			
	Northern villages	Naskapi village[B]	Kativik Regional Government (KRG)	Cree villages[C]	Cree Nation Government (CNG)	Municipalities	Eeyou Istchee James Bay Regional Government (EIJBRG)
Areas of jurisdiction	• Urban planning and zoning • Land use planning • Drinking-water supply • Wastewater collection and treatment • Garbage collection • Lighting • Heating and driving force • Roads, traffic, and transportation • Recreation and culture • Public works • Finance	• The environment	• Local administration • Transportation and communications • Development of municipal infrastructure • Drinking water monitoring • Training and labour force use • Land use planning • Airport management and maritime infrastructure maintenance • Civil Protection • Local and regional economic development • Hunting, fishing, and trapping support activities • Wildlife conservation • Development and management of national parks • Public housing • Technical support for northern villages in the realms of financial management, legal affairs, sustainable land use, and public works		• Assist the Cree in the exercise of their rights and the defence of their interests • Monitor general well-being • Regional development • Conduct research and offer technical or professional assistance • Capital works and services • The environment and remediation work • Social and cultural development • Commerce and industry • The CNG can affirm its jurisdiction over all or part of the Category II lands in respect of any field of jurisdiction that the legislation attributes to a local municipality or an RCM	• The same fields of jurisdiction as the municipalities south of the 49th parallel	• Regional development • The same fields of jurisdiction as the municipalities south of the 49th parallel • The EIJBRG can affirm its jurisdiction over all or part of its territory in respect of any field of jurisdiction that the legislation attributes to an RCM • The EIJBRG can affirm its jurisdiction over the Category 1 lands or in enclosed municipalities at their request

APPENDIX D

	Nunavik [A] (north of the 55th parallel)			Eeyou Istchee James Bay Territory[E] (between the 49th and 55th parallel)			
	Northern villages	Naskapi village[B]	Kativik Regional Government (KRG)	Cree villages[C]	Cree Nation Government (CNG)	Municipalities	Eeyou Istchee James Bay Regional Government (EIJBRG)
Legislation, agreements, and key directions[D]	• James Bay and Northern Quebec Agreement • Act respecting Northern villages and the Kativik Regional Govern-ment	• North-eastern Quebec Agreement • The Cree Villages and the Naskapi Village Act	• Québec legislation applies to the KRG insofar as it is applicable and does not derogate from the provisions in the Act respecting Northern villages and the Kativik Regional Government. • Pursuant to several statutes, the KRG is deemed a municipality with the necessary adaptations • James Bay and Northern Quebec Agreement • Act respecting Northern villages and the Kativik Regional Government • Agreement Concerning Block Funding for the Kativik Regional Government (Sivunirmut Agreement)	• The Cree Villages and the Naskapi Village Act • James Bay and Northern Quebec Agreement	• James Bay and Northern Quebec Agreement • Act respecting the Cree Nation Government • Agreement on Governance in the Eeyou Istchee James Bay Territory	• Cities and Towns Act • Act respecting land use planning and development	• Agreement on Governance in the Eeyou Istchee James Bay Territory • Cities and Towns Act • Act establishing the Eeyou Istchee James Bay Regional Government • Act respecting land use planning and development

A. Excluding the Category IA and IB lands of the Cree of Whapmagoostui.

B. The members of the Naskapi community living south of the 55th parallel on Category IA-N lands under federal jurisdiction. However, the Naskapi village (Category 1B-N lands) has no residents and is not urbanized.

C. The members of the Whapmagoostui Cree Village Municipality live on Category 1A lands north of the 55th parallel. The Category 1B lands (Cree village of Whapmagoostui) are also north of the 55th parallel but are not urbanized and have no residents.

D. The ALUPD does not apply north of the 55th parallel, nor on the Category 1 lands south of the 55th parallel.

E. The James Bay Regional Administration is not a municipal body. However, it has jurisdiction to act with respect to regional development for the individuals other than the Cree who reside in the territory of the EIJBRG, including the communities, and that of four municipalities (Chibougamau, Chapais, Lebel-sur-Quévillon, Matagami).

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Knowledge, awareness and mobilization of the stakeholders

KNOW THE STAKEHOLDERS

A knowledge of the stakeholders facilitates the visualization of their relationships and changes in them during the project. The mapping of this network identifies the stakeholders to be included in the project team, those to have intervene as support experts, and those to be informed or consulted.

To foster social acceptability, an array of stakeholders should participate to achieve the comprehensive vision that the municipal body is seeking for its territory.

How to proceed

To know the stakeholders, the process can be broken down into three main steps.

Step 1: Identify the stakeholders in the municipal body's network

The project leader(s) must identify the stakeholders in the municipal body's network.[1] The stakeholders can be government departments, opposition members, support staff, non-governmental agencies, community representatives such as the residents' consultation committee, associations, artists, and participants in leisure activities, NPOs, the local media, beneficiaries' groups, scientists, chambers of commerce, and educational institutions. This step can be carried out by monitoring social, cultural, artistic, legislative, technical, political, economic, scientific, and tourism activities pertaining to the adaptation process, and from varied sources such as scientific articles, the documentation and websites of possible stakeholders, sociodemographic and economic data (Statistics Canada, Institut de la statistique du Québec [ISQ], Institut national de santé publique [INSPQ]), chambers of commerce and industry.

The list of stakeholders identified is not exhaustive in the first step.[2]

Step 2: Collect information on the stakeholders during structured interviews[1 2 3 4]

The project leader(s) must then compile the information on the stakeholders identified previously. Structured interviews, which have three key advantages, are an effective way to do so. First, they afford an opportunity to present to the stakeholders the adaptation project and to take note of the names and contact information of the resource persons from each of the stakeholder organizations identified. Next, they offer a sound way to hone an understanding of the stakeholders' activities and interests in the municipal body's network and to better ascertain the links between them. Lastly, the interviews round out the list of stakeholders to obtain a valid representation of diversity by asking the interviewees to name the collaborators with whom they maintain relationships.

The structured interviews first target each respondent among the stakeholders identified on the list established in step 1. The names of new stakeholders will be added during the initial interviews. The interviews can also be transmitted to them subsequently. After several interviews, the interviewees might name stakeholders who are already on the list. Consequently, when no new name is added, the list of stakeholders in the municipal body's network can be deemed complete. It is important to ensure that all the stakeholders listed and named have been contacted and interviewed to ensure that a maximum number of them adhere to the adaptation project.

A data sheet can be completed at each interview to record the relevant information on each stakeholder in categories determined beforehand, which facilitates the production of the network relationships map. For example, such categories could be "the stakeholder's possible contribution to the project" (Table E1).

APPENDIX E

Table E1 presents an example of a data sheet containing the relevant questions to be posed during the interview (adapted from [1 2]).

Table E1: A sample information questionnaire concerning the stakeholders in the network

	Information to be collected on the stakeholder during the interview	Answers
Description of the stakeholder and categories	Name of the stakeholder (organization)	
	Name of the stakeholder(s) associated with the project	
	Contact information for the stakeholders	
	Scope of the stakeholder's initiatives (local, provincial, national, international)	
	Activity sector of the organization, e.g., public, private, non-profit, community-based, university, and commercial	
	Services that the stakeholder offers, e.g., greening, infrastructure, health, emergency measures, finance, tourism, insurance, business continuity, and regulation	
	The stakeholder's mission (What or who does the stakeholder represent? What viewpoints does the stakeholder defend? What adaptation-related objectives does the stakeholder pursue? What are the stakeholder's concerns?)	
	Adaptation strategies, plans, or measures (adaptation initiatives completed, under way, or impending)	
Description of the stakeholder's relationships	Type and quality of the link with the municipal body	
	Communication role (the stakeholder's ability to connect stakeholders that are otherwise not connected)	
	Names of the stakeholders with whom the stakeholder maintains relations	
	Nature of the relations with these stakeholders	
	Strength of the relations with such stakeholders	
The stakeholders' interest in a possible contribution to the project	Interest in the adaptation project (limited, average, high) Discuss particular facets of the project such as a specific building or a targeted hazard that concern the stakeholder	
	The stakeholder's importance in the project (limited, high, essential)	
	Positioning in relation to the adaptation project (agrees, disagrees)	
	Financial, physical, human, and expertise resources available	
	The stakeholder's constraints in relation to the adaptation project (the project's level of impact on the stakeholder)	
	The stakeholder's power of influence or decision-making power (limited, high, essential)	
	The stakeholder's contributions to the adaptation project (hardly significant, significant, essential)	

Example of the nature of the relationship between the stakeholders:

- collaborative;
- informative and knowledge-centred (type of information exchanged, e.g., scientific or technical, strategic [positions, contacts, activities, and events]);
- administrative and financial, e.g., subsidies, regulations, purchases and sales of goods and services, political requests and representation, and evaluation;
- sharing of jurisdiction;
- sharing of resources.

Characteristics of the strength of the stakeholders' relationship:

- The relationship can be deemed solid if it is established with several individuals from the organization and, to the contrary, weak if it hinges on a single interlocutor;
- The accessibility of one or more interlocutors from the organization affects the strength of the relationship. This implies determining the right person to approach and that the individual can share information.

Step 3: Map the municipal body's network

The project leader can then represent the stakeholders and their relationship in the municipal body's network on a map.[1 5] Several maps can be elaborated depending on the categories that the project leader deems the most relevant. Such categories can focus on interest in the project, positioning with respect to the project, the contributions and constraints associated with each stakeholder in relation to the project, and each stakeholder's power of influence or the scope of the impact that it would sustain without the implementation of adaptation measures.[5] The maps must also indicate the relationships between the stakeholders.[6] They need not be exhaustive but must instead organize along hierarchical lines the information geared to what is to be understood and demonstrated. It is preferable to correlate different maps elaborated according to different categories.

Mind mapping software such as freemind or xmind create such interactive or conceptual mapping, diagrams, and tables.

Step 4: Consider the stakeholders according to their level of involvement

The categories used to elaborate the maps differentiate between the stakeholders and enable the project leader to consider them according to their level of involvement. The stakeholders can be classified according to three levels of involvement:

- A level requiring strong involvement: This stage involves placing the stakeholders to be involved on the project team who must participate in all the steps in the process. For example, a specific category for this level of involvement could focus on the stakeholders most likely to provide expertise and experience relevant to the process, those that the other stakeholders listen most extensively to, or those with decision-making power, since they can represent solid levers for change in light of what they say and do.[2 6]
- A level requiring moderate involvement: This stage involves placing the stakeholders to be sought out at the appropriate times as support experts. Do not overlook the importance of support experts in the project. Indeed, they must be capable of collecting information such as technical data in the field or information on the feelings of the stakeholders with whom they maintain relations and submit them to the project team.
- A level requiring less sustained involvement: This stage involves placing the stakeholders to be consulted and/or informed. More often than not, this involves the general population but can also involve other regional or local stakeholders that have not been selected because they are not extensively involved and have thus not been asked to join the project team. It is possible to implement public consultations. Such consultations can identify the public's concerns at different times and throughout the process. They can target the most vulnerable individuals such as young children, seniors, and individuals with reduced mobility, to ensure the equity of potential adaptation measures. The website of the Ministère des Affaires municipales et de l'Habitation (MAMH) provides a detailed, simplified operational guide to help municipal bodies implement a public consultation.[7]

RAISE AWARENESS AMONG THE STAKEHOLDERS

Heightening awareness among the stakeholders consists mainly in informing them to obtain their adherence to the project and, more generally, to foster social acceptability.[8] It aims to steer collective habits in a direction conducive to adaptation[4] since individuals who are aware are more inclined to constructively further a project.[8] Awareness-raising among the stakeholders must be targeted since, depending on the level of involvement attributed to the individuals concerned, the message and the means of transmitting it are different.

How to proceed

Before they are approached concerning the adaptation project, the stakeholders have neither the same knowledge concerning climate change, adaptation to climate change and the adaptation process that the municipal body has undertaken, nor the same approaches and concerns faced with them. Furthermore, the desired level of involvement of the stakeholders can affect their level of knowledge before the adaptation process is launched. To properly satisfy these different levels of awareness-raising among the stakeholders, several communications and training strategies can be implemented.

A general message can be transmitted by:

- the mass media (television and radio, websites, and the social and print media).

A more targeted message, for example concerning the understanding of climate hazards that affect the municipal body's territory or the measures that it has already implemented can be disseminated by means of:

- brochures and newsletters;
- emails;
- public meetings or training to support the stakeholders.[8]

Solid evidence demonstrates the importance of establishing a link between the climate hazards and common values, to focus the messages on familiar risks, and use experience gained from extreme weather events to underpin joint debate.[9]

Depending on the stakeholders targeted, awareness-raising can have different objectives:

Awareness-raising among municipal services stakeholders should target the importance of tackling the problem and promoting adaptation in addition to explaining the impending changes.[8] This awareness-raising seeks to obtain the commitment of the municipal body's policy makers and staff.

Awareness-raising in the general population should emphasize climate change impacts at the local level and with respect to their everyday lives to make clear that acting collectively is necessary and useful. It should also promote concrete gestures that the public can make to contribute to adaptation to climate change. In this way, it will be possible to prevent climate change denial in the population.[9]

Examples of messages to be transmitted in the context of awareness-raising [8]:

- climate change is already apparent in the frequency and intensity of extreme events and seasonal and annual changes;
- the relationship between climate change and the anticipated impacts;
- the anticipated future impacts could be more significant if measures are not implemented;
- tackling climate change must include both GHG emission reductions and adaptation to the impacts;
- all the stakeholders must make combating climate change a priority;
- it is not too late to act;
- by acting now, we are preparing our children's and our grandchildren's future.

What is more, it is advantageous to communicate certain noteworthy elements such as:

- the impacts of climate change in the everyday lives of the stakeholders;
- how such changes can affect the community or the target audience and impending damage;
- the potential opportunities and benefits stemming from adaptation;
- concrete examples of the municipal body's existing effective adaptation measures inspired by similar communities.

MOBILIZE THE STAKEHOLDERS

The mobilization of the stakeholders avoids opposition to the adaptation project and thus affords the municipal body the possibility of carrying it out more effectively.[2 3] Climate change impacts can spark negative emotions that lead some individuals to deny the problem.[10]

How to proceed

While it is necessary to include an array of stakeholders to ensure that all the sectors of the municipal body are represented, their agreement to participate does not guarantee their mobilization to carry out the project.[1 11] A lack of active participation by the stakeholders can significantly hinder the project's success. Mobilization should be sought throughout the process to sustain and bolster the general level of involvement.[8] To involve the stakeholders and ensure their ongoing mobilization throughout the adaptation project, here are some steps to follow.

Step 1: Identify the types of behaviour with respect to the project

The individuals mobilized are present at meetings and participate actively in discussions by making arguments or asking questions that facilitate progress. Certain counterproductive behaviour can arise during the project, which could affect other stakeholders and even curtail medium-term, and indeed short-term, mobilization. It is, therefore, important to react promptly when this happens. Throughout the project, the objective is to alter counterproductive behaviour to ultimately ensure that 50% and 80% of the individuals are actively, positively involved.[2]

More significant mobilization efforts may be necessary to limit certain behaviour that might impede the project's progress, such as individuals who:

- are not interested in the project, i.e., partisans of a wait-and-see policy who are awaiting results before acting;
- who have a negative perception of the project, i.e., passive- inactive (-) individuals;
- seem openly opposed the project, i.e., opponents;
- display oppositional behaviour but do not say so openly, i.e., passive-active (+) individuals who can act indirectly to belittle the project among other stakeholders.

To assess the stakeholders' level of mobilization, it is possible to have them respond at key moments during the project to a short, five question questionnaire.

Table E2 presents examples of questions to ascertain the stakeholders' level of mobilization (adapted from [2]).

Table E2 : Sample questionnaire to ascertain the stakeholders' level of mobilization

Question	Answer
What is your perception of the adaptation project?	Very important, important, not topical, pointless
The adaptation project's benefits will be:	Very useful, useful, imperceptible, pointless
The adaptation project's objectives are:	Very clear, hardly operational, hardly clear, contrary to my values
The adaptation process' organization is:	Very good, correct, poor, dangerous
Will you advise your colleagues to do everything possible for the project?	Yes; yes with reservations; no, I will not ask anything; no, I will advise against the project

Step 2: Anticipate and discuss the topics that might demotivate the stakeholders

Table E3 presents examples of topics that it is important to anticipate and that must be discussed with the stakeholders (adapted from [2]).

Table E3: Example of topics to anticipate and discuss with the stakeholders

	Anticipate	Discuss
In organizational modes of operation	Changes in the municipal body's modes of operation that either the adaptation process or the implementation of adaptation measures or follow-up to them might engender.	With all the stakeholders concerned by such changes before the project starts to prepare them for the changes and avoid presenting them with a fait accompli.
	The organizational practices during the adaptation process that might annoy the participants or the employees. For example, meetings that last longer than anticipated, held late in the evening, or at which participants have the impression that their presence serves no purpose.	With all the stakeholders to ensure that the practices are satisfactory.
	The sharing of working documents such as reports on meetings and information provided by experts to ensure that they are neither overly numerous nor too long to read to avoid a work overload for the stakeholders, and in formats that are always accessible, i.e., not only printed documents but also links to file-sharing platforms.	With all the stakeholders the number of documents to read, their length, and the file-sharing platforms.
During the adaptation process	As soon as possible, provide the information prior to the initiation of the project by evaluating the person-time for stakeholders' representatives but also for the project manager(s).	Changes in the schedule. Do not hesitate to hire new resource persons in the event of the risk of a work overload.
	As soon as possible, estimate prior to the initiation of the project the total cost of the adaptation process and of each of its steps, from the mapping of the stakeholders to the adjustment of the measures implemented.	For example, at what point delays in the schedule might engender cost overruns.
At meetings of the project team, with the support experts, or during the public consultation	Differences of opinion and language. Certain divergences of opinion might arise and create tension since the stakeholders participating in the discussion have different interests or sustain varying impacts depending on the climate hazards examined.	With all the stakeholders, weigh the pros and cons of each viewpoint. Avoid presenting a viewpoint as the best one without taking the time to listen to all the stakeholders participating in the discussion and debating all the viewpoints, failing which the stakeholders might demobilize.

Table E4 presents avenues for discussion according to oppositional discourse (adapted from [2]).

Table E4: Example of oppositional discourse and potential responses

Oppositional discourse	Potential responses
"We don't have time."	Count and indicate the necessary duration of each activity such as meetings, reading documents, and collecting information.
"We don't know who to contact."	Produce an information document that specifies the resources available and distribute it to all the stakeholders.
"No one is helping us."	Provide information on the staff assigned to adaptation activities and the physical resources available.
"It's irrelevant."	Develop a list of selling points for the adaptation project that mentions the attendant benefits for the municipal body, the population and the stakeholders, the government's obligations, the costs stemming from each climate hazard, the number of people affected, the technological constraints, and initiatives undertaken elsewhere.
"We keep reinventing the wheel."	Establish clear objectives for the project and propose indicators such as the objectives attained, or the deliverables provided to show that the project is advancing on time.
"The arguments are not solid."	Ask the stakeholders who make these remarks to justify them and propose more robust solutions that differ from yours, based on scientific facts. Back up the arguments with scientific facts to show the soundness of the methodology and refute this type of discourse.
"You don't know what is happening on the ground."	Integrate into the project team individuals who are thoroughly familiar with what is happening on the ground and enjoy strong legitimacy.
"You're going to wreck everything."	Present the advantages of the solution to be implemented in relation to what exists or is already known. Also present the elements that will endure after the solution is implemented.
"Your project isn't adapted."	Present the changes that must be made according to various scales of the local general adaptation framework.
"You're overlooking social inequalities, which is unfair."	Present the changes contemplated by integrating socioeconomic data and the viewpoints of all the stakeholders involved in the implementation of the adaptation measures when reflecting on them.[12]

Step 3: Establish communications measures

Depending on the stakeholders' level of mobilization, various communications measures will be necessary. Informative or formative communications measures could target passive individuals. Opponents of the project could be subject to targeted support depending on what puts them off. Their contribution can be harnessed by having them participate in meetings, appointments, and interviews throughout the project to obtain their support.[13] Occasionally giving weight to their opinions by appointing them to committees with decision-making power can make them more receptive to the project.[5] For example, it could be prudent to include them on the project team or as external experts.[2]

Note: Knowing, raising awareness among, and mobilizing the stakeholders can take varying amounts of time depending on the human resources available and the number of stakeholders to be involved in the adaptation process. Such initiatives are not only important during the initial phases of the adaptation process but should be pursued throughout it.

Example of the mobilization of stakeholders according to the principle of participatory democracy[14]

The municipality of Compton is essentially agricultural. The Coaticook River, which is subject to frequent and occasionally serious open-water flooding such as in 2011, 2015, and 2019, crosses the municipality. A study was conducted in 2019 to adapt a 20 km section of the river. It sought the mobilization of all the stakeholders. To this end, committees were established on the principle of local inclusive, participatory democracy, which sustained the stakeholders' mobilization since they experienced their participation as a significant contribution to decision-making.

The project team established several committees that ensured that the adaptation solutions proposed considered local concerns and issues while facilitating discussions between the residents of the region under study and the experts.

The first committee established was the technical committee. It comprised the project team and additional expertise from the Conseil de gouvernance de l'eau des bassins versants de la rivière Saint-François (COGESAF) at the Université de Sherbrooke and other experts from Ouranos and the ROBVQ, and its role was to coordinate the project.

The second committee established was the local monitoring committee. It comprised local professionals from the MRC de Coaticook, the municipality of Compton, the Union des producteurs agricoles (UPA) de l'Estrie, project offices, Rés-Alliance, and local agricultural producers. Its role was to validate the approach and ensure the proper integration of local concerns. The local monitoring committee sustained, supported, advised, and guided the technical committee and ensured continuity between the project team and the situation on the ground. The local monitoring committee held five meetings during the process.

The prioritization advisory assembly was the third committee established. It represents the community directly affected by the climate hazards in Compton and comprised 11 agricultural producers. In theory, the prioritization advisory assembly must equally represent uses and major socioeconomic groups in the territory of intervention, e.g., in the territory of the drainage basin. It could comprise elected officials or urban planners while at the municipal level farmers and residents could sit on the committee. However, in the portion of the territory under study here, the agricultural producers were the most extensively affected. The committee's role was to map the impacts observed in the territory and major social concerns, assess the solutions, and validate them. For example, at the first workshop that relied on data provided by the technical committee, the prioritization advisory assembly listed preliminary adaptation solution scenarios that the participants found acceptable and noteworthy. They proposed scenarios that the technical committee had not contemplated. Since the integration of the concerns of the participants in the prioritization advisory assembly is essential, the technical committee went back to the drawing board to produce new solutions in addition to the previous ones. At the second workshop, the technical committee presented to findings on risks and residual issues. The discussions focused on the preferred solutions and determined the obstacles to adaptation.

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For additional information on the participative workshops, read File 5: Co-Construire le Changement, in Autissier, D., Moutot, J., & Johnson, K. (2022). La boîte à outils de la conduite du changement et de la transformation.

Examples of systems and components to be studied

It should be emphasized that Table F1 is not exhaustive. The approach is adjustable, flexible, and open-ended. Accordingly, this list can change as the adaptation process progresses and items can be added, moved, or removed. Moreover, certain components can be found in different systems, hence the importance of thinking the matter through upstream and properly categorizing the systems and components. The items marked with asterisks are deemed essential for a municipal body to study.

Table F1: Examples of systems and components to be studied

System	Examples of components
Infrastructure	
Road network*	• Travel lanes • Bridges, culverts, and tunnels
Rail network	• Railway sidings • Railroad lines
Port facilities	• Port terminals • Wharves and marinas
Port facilities	• Airports (airport terminal buildings) • Heliports
Energy and telecommunications	• Electrical generation, transmission, and distribution infrastructure • Control dams • Telecommunications infrastructure
Disaster-resilient infrastructure*	• Flood defences such as embankment levees, protective walls, concrete blocks, sheet piling, masonry, or riprap • Coastal erosion and flooding protective structures such as beach nourishment, green infrastructure, and riprap
Drinking water system	• Drinking water distribution networks • Water intakes • Drinking water treatment plants • Pumping stations • Drinking water reservoirs • Wells
Wastewater and stormwater collection and treatment network	• Pre-treatment facilities • Wastewater treatment and purification plants • Pumping stations • Sewer systems • Overflow structures • Stormwater management structures such as retention ponds and infiltration basins, vegetated swales, and filter marshes
Municipal buildings* Cultural and heritage buildings	• Foundations • Building envelopes • Roofs • Plumbing • Heating, ventilation, and air conditioning (HVAC) • Equipment
Residential buildings*	• Principal residences
Sport, recreation, and tourism infrastructure	• Urban parks • Sports and leisure activity spaces and facilities such as swimming pools and water displays, sports grounds, skating rinks, and bicycle paths • Regional parks
Population and local economy	
Population*	• Residents • Municipal workers such as police officers and firefighters • Non-residents such as tourists
Businesses and socioeconomic activities	• Agriculture • Forestry • Fisheries • Businesses or employers important for the territory
Natural environment	
Biodiversity Wetlands and water bodies Protected areas	• Fauna and flora • Watercourses and lakes • Peat bogs and marshes • Groundwater • Forests and woodlands

<table>
<tr><th>System</th><th>Examples of components</th></tr>
<tr><td colspan="2">Municipal services</td></tr>
<tr><td>Public works*</td><td rowspan="4">• Snow removal and disposal
• Residual materials collection and management
• Maintenance of green spaces
• Fire and disaster management
• Municipal budget
• Skating rink maintenance</td></tr>
<tr><td>Public safety*</td></tr>
<tr><td>Finance</td></tr>
<tr><td>Recreation</td></tr>
</table>

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A simplified example of a climate impact chain

A climate impact chain is a general representation encompassing climate impacts, human activities, and natural resources.[1] It is a series of direct or indirect impacts that spreads in risk-prone systems. A climate impact chain analysis assesses whether the impacts stemming from one or more climate hazards affecting a component in a given system, in turn, impact other components in the same or other systems. In other words, this analysis must ascertain whether the impacts on a system affect the same system or other systems. Impact chains can be constructed fairly simply and refined through a better understanding of the relationships between the systems.[2]

Table G1 presents the analysis of a simplified climate impact chain for two climate hazards related to changes in the precipitation pattern.[2] [3] The terms "primary," "secondary," and "tertiary" can also be used to describe the impacts. The terms are not intended to imply a level of gravity or priority but instead to describe the sequence of events that generates the impacts. [4] Indeed, as the example in Table G1 illustrates, the potential consequences of indirect impacts can be significant. The pink cells indicate the major problems directly related to the climate hazard on water supply and distribution, i.e., a direct or primary impact. This results in indirect consequences, indicated in yellow (secondary) and orange (tertiary). For example, the indirect impact of the saturation of urban sewer and drainage conduits is the loss of crops for a farmer.

Table G1: Example of a climate impact chain stemming from the modification of the precipitation pattern

Climate hazard: drought			
Impacts on supply			
Reduced water reserves →	Reduced field irrigation →	Crop loss →	Higher food costs
Impacts on water distribution			
Reduced water levels and flows →	Longer low-water periods →	Water supply problems →	Tension over stockwater and conflicts of use

Climate hazard: torrential rain				
Impacts on supply				
Saturation of urban sewer and drainage conduits →	Runoff →	Contamination of farmland →	Crop loss →	Higher food costs

Climate hazard: torrential rain			
Impacts on water distribution			
Saturation of urban sewer and drainage conduits →	Runoff →	Contamination of drinking water sources →	Higher drinking water production and wastewater treatment costs

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Vulnerability analysis

The vulnerability analysis seeks to determine a system's propensity or predisposition to sustain damage from a climate hazard. It must only be produced for the components of the systems whose exposure to climate hazards have been established. It is proposed on an optional basis in this guide as an exercise to better identify upstream the elements that must be selected in the context of the risk analysis. If this exercise is not carried out, vulnerability must be considered during the risk analysis to examine the potential consequences.

Vulnerability is assessed in light of the sensitivity and adaptive capacity of the elements exposed (Figure H1). Sensitivity and adaptive capacity are essential elements to be considered before or during the risk analysis.

In this sub-step, sheet 3 of workbook 1 can be completed.

Figure H1: The components of vulnerability

Determine the sensitivity level

The objective is to attribute a sensitivity value to each system or component. To this end, it is useful to analyze how the system has been affected historically by the climate hazards contemplated. To determine the sensitivity level, it is necessary to grasp which intrinsic characteristics of the component make it reactive to one or more climate hazards. In other words, the characteristics of the component that might contribute to aggravating the consequences must be identified.

Here are some examples of characteristics for an "infrastructure" system:[1]

- the design;
- the construction materials;
- the architectural quality;
- the heritage value;
- the level of obsolescence;
- all the other factors that the project team identified.

Here are some examples of characteristics for a "vulnerable population" system:[2]

- age;
- general health status, e.g., chronic diseases, comorbidity factors, handicaps, and mental health status;
- income and social status, e.g., socially and economically disadvantaged individuals, the unemployed, and single-parent families;
- level of mobility, e.g., level of access to transportation, and the disabled;
- educational level;
- living environment, e.g., salubrity of the living space or dwelling unit.

Determine the level of adaptive capacity

The objective is to assign an adaptive capacity value to each of the components. The level of adaptive capacity is determined by the component's current capacity to react to a climate hazard. The question is to understand whether the component possesses the means to limit the consequences of a weather-related event, e.g., financial and human means, and the existence of adaptation or emergency management measures.

The characteristics to be considered with respect to an "infrastructure" system:[1]

- previous adaptations;
- previous experience during similar events;
- staff training;
- other factors that the project team identified.

The characteristics to be considered with respect to a "vulnerable population" system include:[2]

- financial resources;
- human resources;
- the social networks.

Fill out the vulnerability matrix

The outcome of the vulnerability analysis is a matrix (Table H1) indicating the intersection between sensitivity and adaptive capacity. For example, for an exposed component, the intersection of a moderate adaptive capacity (2) and high sensitivity (3) gives a vulnerability value of 6 (2 x 3 = 6).

The matrix presented here is an example that can be modified according to the context by adding sensitivity and adaptive capacity levels.

Table H1: Example of a vulnerability matrix*

		Sensitivity		
		1 - Low	2 - Moderate	3 - High
Adaptive capacity	1 - High	1	2	3
	2 - Moderate	2	4	6
	3 - Low	3	6	9

Vulnerability	Value
Low	1 to 2
Moderate	3 to 5
High	6 to 9

*When the exposure value is 1, i.e., when the sub-system or the component is deemed to be exposed to the climate hazard.

It is worth noting that this analysis should be conducted for each of the climate hazards and systems or components selected during the preceding sub-step.

Interpret the vulnerability analysis

The vulnerability analysis values help the project team to prioritize the systems and components that should be subject to a risk analysis. Table H2 illustrates an example of prioritization. For example, the municipal body might decide with respect to the rest of the process to not select the systems and components that display low vulnerability, or a different initiative could be associated with different components in the same system.

Table H2: Example of a decision according to the vulnerability analysis

Vulnerability	Action
Low	The components are not selected for the following steps in the process
Moderate	The components will not be subject to a risk analysis, but a surveillance system should be established
High	The components will be subject to a risk analysis

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Examples of structural and non-structural adaptation measures that facilitate adaptation to different climate risks

The structural and non-structural measures indicated below are usually part of current practices since they are relevant independently of climate change. While increased climate change-related risks can engender the need to implement new measures, in most cases they instead make it necessary to intensify or adjust existing measures.

Table I1: Examples of structural and non-structural adaptation measures that facilitate adaptation to climate risks

Examples of risks exacerbated by climate change	Examples of structural measures	Examples of non-structural measures
Risks linked to heavier and/or more frequent rainfall: • water damage to the road network, sewer systems, buildings, infrastructure, and property[1 2 3 4 5] • saturation of water management infrastructure, e.g., sewer backups and overflow[1 3 6 7] • increased costs related to wastewater treatment and the production of drinking water[3 4] • health problems related to increased mould[1 4 7] • vector-borne diseases[7] • psychological distress[5 7] • difficulties encountered in moving about by individuals and emergency services because of flooding[3]	• the conservation and restoration of natural environments that foster rain-related risk management[1 2 3 5] • the creation, restoration, and conservation of green and blue belts and ecological corridors[1 5 6] • the increased surface area of the urban canopy[5 6 8] • revegetation and tree planting in public spaces[5 6 9] • the maintenance and extension of natural settings in urban environments[5] • bioretention areas in urban environments[6 8] • permeable cellular paving in parking lots[10] • permeable street and parking lot surfaces[8] • the revegetation of building roofs and walls that prioritizes diversified indigenous species adapted to their environment[1 5 6 9] • water-resistant building construction materials[11] • waterproofing building foundations[11] • vertical housing construction[11]	• criteria and standards that promote the protection of wetlands[3] • flooding-related risk management plans, e.g., prevention, preparation, intervention, and restoration[7] • training programs for emergency service responders to prepare them to manage post-traumatic stress disorder[3] • awareness-raising and training programs for municipal and business employees and the public concerning climate change-related questions[3] • urban planning by-laws that better control development in risk-prone zones[3] • flood-related alert, management, and risk analysis systems[3]

APPENDIX I

Examples of risks exacerbated by climate change	Examples of structural measures	Examples of non-structural measures
Risks linked to an increase in the frequency or the intensity of rising water levels, floods, and coastal erosion and flooding: • land loss on shores and coasts[5 6 7] • reduced land values in riparian and coastal environments[5] • polluted watercourses[3] • reduced ecological services provided by coastal ecosystems[5] • damage to the road network and related structures[4 5 7] • damage to houses or immovables[4 5 7] • increased psychological distress[7] • reduced public safety[7]	• conservation and restoration of natural riparian and coastal environments[3 5 6 9] • beach nourishment[5 6 9] • rigid protective structures such as dikes on beaches and banks[5 9]	• urban planning by-laws that better control development in risk-prone zones[3]
Risks associated with high summertime temperatures and more frequent, intense heatwaves: • damage to transportation networks stemming from the thermal expansion of materials such as asphalt, concrete, rails, and bridges[1 2 4 7] • the deterioration of infrastructure[1 4 7] • interruptions and breakdowns in drinking water distribution networks[1 4 5] • foul odours emanating from residual materials[7] • physical discomfort[4] • health problems related to air pollution[4 7 9 12] • certain vector-borne diseases[4 7 12] • heatstroke and dehydration[4 12] • higher mortality and hospitalization rates[7 12] • reduced ecological services provided by vegetation[5] • the proliferation of certain invasive alien species[4]	• the revegetation of public spaces[5 6 8] • the conservation and restoration of urban forests and residual woodlands[1 3 5] • permeable cellular paving in parking lots[10] • reduced parking lot surfaces[8] • increased albedo of infrastructure[9] • the revegetation of building roofs and walls that prioritizes diversified indigenous species adapted to their environment[5 6] • reflective or pigmented materials for external building cladding and roofs (white roofs)[9] • sun-shading devices for building windows[10] • air conditioning technologies and ventilation systems for buildings[10]	• emergency measures plans[3] • urban planning by-laws that better control development in risk-prone zones[3] • extreme heat response plans[7] • programs to protect existing urban ecosystems[7] • awareness-raising and training programs for municipal and business employees and the public concerning climate change-related questions[3] • intense heat warning systems[3]
Risks linked to more frequent or intense extreme events: • damage to infrastructure, e.g., transportation networks, power systems, and buildings[1 2 4 5 7] • reduced insurance coverage and/or higher insurance premiums[1 7] • psychological distress[4 7] • risk of injury[4] • higher mortality and hospitalization rates[4]	• the conservation and restoration of natural environments[3 5]	• emergency measures plans[3] • training programs for emergency service responders to prepare them to manage post-traumatic stress disorder[3] • awareness-raising and training programs for municipal and business employees and the public concerning climate change-related questions[3] • alert and communications systems that target vulnerable populations[3]
Risks linked to more frequent or intense storms: • service disturbances and interruptions associated with the infrastructure affected, e.g., power outages, air transport, and supply chain[3 4] • difficulties in moving about encountered by the public and emergency services[3 5 7] • increased road accidents[4 7]	• renewable energy sources in buildings[10] • lightning rods on infrastructure[12] • windbreaks along highways[13]	

Examples of risks exacerbated by climate change	Examples of structural measures	Examples of non-structural measures
Risks linked to more frequent or intense forest fires: • damage to infrastructure[1] • damage to plants[5] • reduced ecological services provided by ecosystems[5] • altered water quality in watercourses and water bodies and drinking water sources[3]	• forest management to limit fire hazards[5] • fire-resistant building construction, cladding, and roofing materials[5]	

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Examples of adaptation measure prioritization analysis methods

This appendix compares three so-called prioritization methods that could be used to facilitate decision-making on the choice of adaptation measures:

1) the multi-criteria analysis;

2) the scenario analysis;

3) the cost-benefit analysis.

The three analytical methods have been emphasized in this appendix since each one presents a different way of identifying the most promising adaptation measures. They can be used in correlation in certain projects when human and financial resources allow.

WARNING:

The objective of this appendix is to make known three prioritization analysis methods and compare them according to their context of use, advantages, and drawbacks to ascertain which one is the most compatible with existing needs and the available resources. The appendix does not present the methodology in detail. It is, therefore, necessary to rely on the right experts to successfully carry them out.

Generally speaking, the three analytical methods have the advantage of:

- facilitating decision-making;
- providing reliable economic and social information;
- revealing the related advantages of the measures, such as a more inclusive living environment;
- heightening awareness that it is worth investing in adaptation as soon as possible;
- optimizing and capitalizing on what has already been accomplished, i.e., to refine and add to the practices already implemented;
- comparing the projected efficacy of the measures in a future climate over different time horizons;
- considering an array of dimensions pertaining to the context surrounding the implementation of the measures and the relevant criteria given the situation of each municipal body;
- integrating uncertainty as an evaluation criterion.

The following difficulties are associated with the three methods:

- The implementation of the analyses takes a long time and engenders costs that must be integrated into the adaptation process' budget and schedule;
- It is difficult to evaluate the long-term benefits;
- It is difficult to evaluate the measure's efficacy and life cycle.

APPENDIX J

Table J1: Comparison of three methods to select the adaptation measures

	Prioritization tool		
	Multi-criteria analysis	Cost-benefit analysis	Scenario analysis
General description	The adaptation measures are selected according to several sociopolitical, environmental and economic and/or financial evaluation criteria that are noted for each measure	The choice of the adaptation measures hinges on the premise that the benefits and co-benefits of the measure exceed the cost of implementation, maintenance, and inaction	The adaptation measures are selected in light of their soundness and the "critical thresholds," which, when exceeded, trigger an array of graduated responses
Context of use	When several criteria can be used to choose the measures	When the financial dimension is the main criterion governing the choice of measures	When climate change is the main criterion governing the choice of measures
Advantages	• Comparison of multiple quantitative and qualitative criteria • Relevance of the criteria according to each municipality's situation through reliance on a participatory process	• Concrete comparison of costs and benefits by means of a common monetary unit • Quantification of inaction and the profitability of the measures	• Reliance on thresholds for given climate parameters • The possibility of greater tolerance to risks • The possibility of modifying the measures along the way
Drawbacks	• The choice of the criteria can be complex • The need for experts • The difficulty of fairly noting all the dimensions of a project and all the criteria contemplated	• The need for economic experts • The difficulty of monetizing certain environmental and social benefits such as collective well-being related to the measures • The choice of the capitalization rate can represent a question of equity between current and future generations depending on whether it is low or high	• The need for scenario analysis experts • The difficulty of establishing with certainty the critical thresholds of the measures because of uncertainty associated with the projections • The difficulty of choosing the most appropriate measure in the long term because of growing uncertainty at each step in the process

References:[1] [2] [3] [4] [5] [6] [7] [8]

The multi-criteria analysis

The multi-criteria analysis is more appropriate if decision-making must rely on dimensions such as the value of ecosystems that it is hard or impossible to quantify.

The dimensions that the analysis must consider are divided into quantitative evaluation criteria (e.g construction costs) and qualitative evaluation criteria (e.g. embellishment).[9] [10] The project team must agree on the evaluation criteria to be considered, which must respond to the adaptation objectives. The criteria must be adaptable to all the measures to be compared. A rating scale, defined by the project team and identical for all the criteria, must be established to rate how the measure satisfies the criterion. This could be a scale of 0 to 4 or a "smiley face" displaying three emotions (Table J2). For each measure, the scores obtained for each evaluation criterion are added or averaged. The total indicates the project team's satisfaction with respect to each measure and it is thus possible to organize them along hierarchical lines.

To facilitate the comparison, it is a good idea to present in a table all the measures to be compared in rows and the criteria in columns.

Table J2: Hypothetical example of a qualitative multi-criteria analysis of three adaptation measures that limit the impact of flooding

Measures	Criteria					
	Efficacy	Feasibility	Flexibility	Co-benefit	Adherence	Overall satisfaction
1 - Adapt soil use rules to the future climate						
2 - Elaborate a communications strategy for extreme weather events						
3 – Pile construction						

Example of a multi-criteria analysis based on a comparison of three measures

Table J2 presents a hypothetical example of a qualitative multi-criteria analysis. The rows represent the measures contemplated and the columns represent the evaluation criteria. For the "Efficacy" criterion, measure 1 obtains a green smiley face while the other two measures obtain a yellow smiley face. Measure 1 is therefore considered more effective to achieve an objective than the other two. The right-hand column represents the project team's overall satisfaction. Given that measure 1 obtained the highest overall satisfaction indicated by the green smiley face, it should be prioritized, followed by measure 2, then measure 3.

It bears noting that the criteria listed here serve as examples. Several other criteria could be used, e.g., the level of risk reduction, whether the measure can be adjusted, cost, job creation, synergy with the mitigation, implementation time, and the duration of the impact.

The scenario analysis

The scenario analysis is more appropriate if decision-making is carried out in the long term since uncertainty increases over time. It can also be used to establish how to properly link the rollout of the implementation of the measures by comparing their advantages, drawbacks, and critical thresholds. Accordingly, the scenario analysis falls within the scope of a flexible adaptation strategy.[11]

The adaptation measures contemplated are compared with different climate and socioeconomic, political and technological scenarios, and their social acceptability, which change over time.[12 13 14] For each measure, changes in the scenarios lead to the attainment of a "critical threshold," i.e., the turning point at which the measure no longer properly fulfills its purpose.[12] When the threshold is exceeded, an array of responses is triggered, which must be examined in the context of a succession or a sequence of possible measures according to the criticality of the climate hazards concerned. In other words, when the critical threshold is reached, a new measure is planned to replace the preceding measure in order to maintain the system's resilience. The objective of relying on critical thresholds is to shift readily from one measure to the other by considering the soundness of different measures according to different time horizons or in relation to the dominant uncertainty.[13] The outcomes of this analysis lend themselves to the schematization on a temporal scale of changes in the critical thresholds of the measures.[12] Hence, the scenario analysis facilitates adjustable decision-making that is not final.[11 12 13]

Example of a scenario analysis based on the comparison of four measures

Figure J1 is a schematization of the scenario analysis for the "reduced rainfall" climate hazard projected over short-, medium-, and long-term time horizons. The performance of the adaptation measures and that of the status quo (current measure; measure 0) are compared. The figure shows that measure 3 works best, with reduced rainfall for the three time horizons. As for the current measure, it is effective up to a 15% rainfall reduction. Beyond the 15% reduction, measure 2 or measure 4 could be implemented. Measure 4 would also continue to function for reduced rainfall above 30%. As for measure 1, if it were selected based on a 5% reduction it would function up to a critical threshold of -20%, beyond which measure 2, measure 3, or measure 4 would have to be implemented. Hence, based on these findings, the measures to be implemented can be prioritized according to the time and appearance of the threshold set.

However, although the analysis facilitates the selection of measures based on certain climate factors, decision-making should nevertheless consider other factors such as the cost of implementing the measure. If it is, therefore, possible to prioritize the introduction of a measure before attaining the critical threshold for a different reason such as the need to restore ageing infrastructure. For this reason, measures 1 and 3 could be introduced before the critical threshold of the current measure (measure 0) is attained.

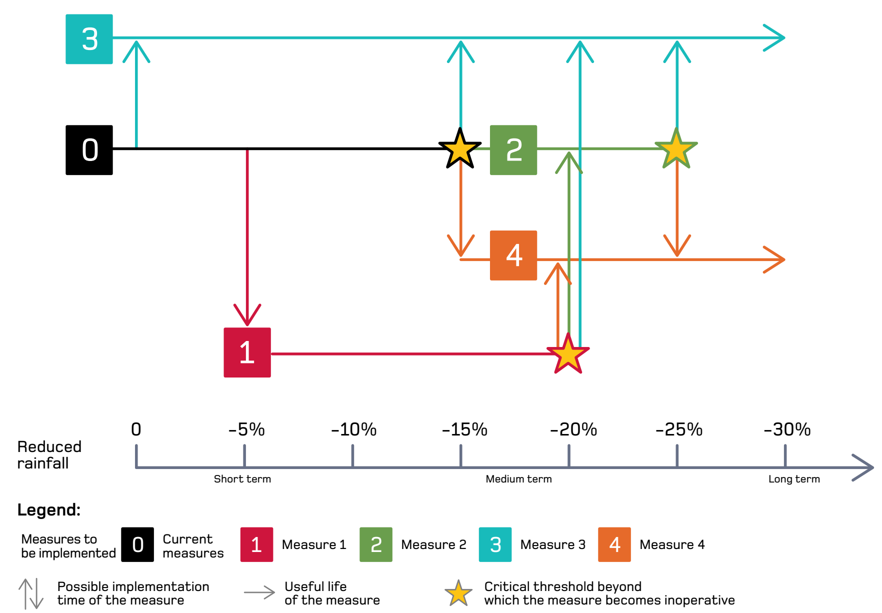

Figure J1: Diagram of a scenario analysis that incorporates the four adaptation measures proposed to adapt to a greater reduction in future rainfall over a long-term trajectory

The scenario analysis can also bolster the decision-makers' adaptive capacity by spreading investments over several adaptation measures that can be modified over time. As such, the municipal bodies could prioritize this analysis to enhance their risk tolerance.

The cost-benefit analysis

The cost-benefit analysis (CBA) is more appropriate if decision-making seeks to prioritize the evaluation of the cost of the investment to reduce the economic weight of a climate impact and the assessment of returns on the investment concerning different adaptation measures, i.e., the economic benefit of an adaptation measure.[15] This analysis usually hinges on the overall comparison of the costs and benefits of different measures expressed as avoided costs.[16] It might be decided to select the measure that avoids the highest costs. The avoided costs are the amount of damage that the measure avoids in relation to the cost of inaction, which serves as a reference point.[15] Evaluating inaction entails estimating the future costs if current practices are unchanged, in other words, the absence of measures. It is expressed in a uniform, usually monetary unit of measurement such as the Canadian dollar that integrates changes in the value of the currency over time, e.g., inflation, by means of a discount rate. Hence, the monetary value attributed to a measure can be compared to another measure and compared over time.

Example of a cost-benefit analysis based on a comparison of three measures[17]

Figure J2 compares three adaptation measures pertaining to agricultural practices in respect of the "major flooding" climate hazard and the avoided costs stemming from their implementation. The vertical axis indicates the amounts of the net asset value (NAV) of the measure in millions of dollars ($M). The horizontal axis shows five measures represented by five pictograms. The legend below indicates the main costs and co-benefits.

The first, red frame includes the essentially grey measures that represent shoreline stabilization by means of rigid concrete structures. These measures are less advantageous than inaction since the NAVs are negative, i.e., between –$4.5 million and –$32 million. These measures entail implementation costs alone but neither co-benefits nor avoided costs.

The second, pale green frame indicates the measure, i.e., the introduction of sustainable agricultural practices, which has proved to be advantageous for the environment but avoids limited costs related to flooding. Furthermore, this measure has a rollout cost, which means that its value is equivalent to that of inaction (the small circle representing the NAV appears directly on the $0 black line).

The third, dark green frame presents two measures, i.e., the conservation of a widened riparian strip and the authorization to engage in agriculture in the flood-prone area. Since flood- and erosion-related damage is located in this strip, it is easier to tolerate much less frequent damage that occurs outside the strip. The opportunity cost of changing use is hardly significant, and the co-benefits related to ecosystem services are significant. This is the most advantageous measure in relation to inaction (the two circles are located above the $0 black line). These scenarios imply a net reduction in the land area cultivated.

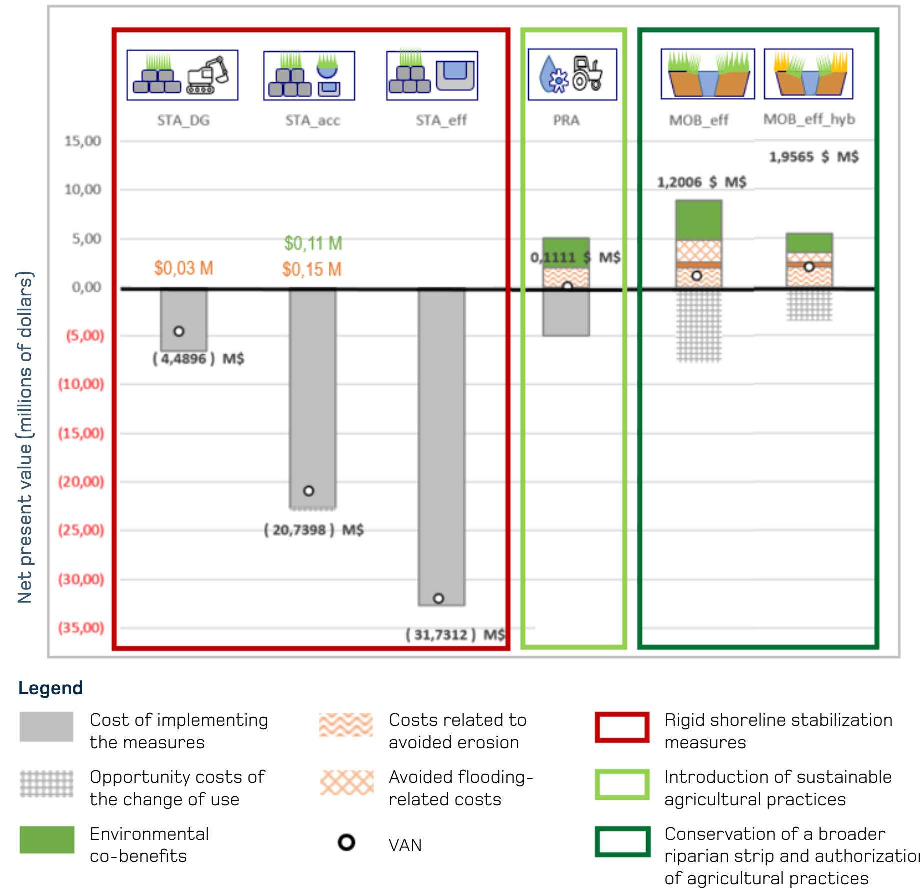

Figure J2: A comparison of the costs and advantages of three types of adaptation measures (Inspired by [17])

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Checklist

Checklist of significant elements to be included in an adaptation plan made public [A]

Objectives, scope, and structuring	
The adaptation plan presents the objectives of the adaptation process.	☐
The adaptation plan presents the scope of the adaptation process: • Geographic boundary: the territory of the municipal body • Temporal limit: ☐ current (1991-2020) ☐ medium term: 2050 (2041-2070) ☐ long term: 2080 (2071-2100)	☐
The adaptation plan presents the structuring of the adaptation process: ☐ Overview of the municipal body and its territory ☐ Identification of the systems analyzed (the essential systems are identified below) ☐ Identification of the climate hazards analyzed (the essential hazards are identified below)	☐
Climate risk assessment	
A description of the following systems in the RCM and each of its municipalities is presented, where applicable: • Infrastructure ☐ Road network ☐ Loss protection infrastructure ☐ Municipal buildings ☐ Residential buildings • Population and local economy ☐ Populations • Municipal services ☐ Public works ☐ Public safety	☐
The following climate hazards are presented, where applicable: ☐ Heatwaves ☐ Heavy/frequent rainfall (liquid) ☐ Coastal erosion and flooding ☐ Fluvial flooding (open water) ☐ Pluvial floods ☐ Forest fires ☐ Landslides ☐ Permafrost thaw ☐ Ice	☐

Climate risk assessment (cont.)	
The reference period to characterize the current and past climate is presented. The period 1991-2020 is preferred if the data are available.	☐
The findings of the risk assessment are presented according to: ☐ a minimum of two time horizons, i.e., the medium term (2041-2070) and the long term (2071-2100) ☐ a minimum of two GHG emissions scenarios, i.e., an intermediate emissions scenario and a high emissions scenario (SSP2-4.5 and SSP3-7.0 or RCP 4.5 and RCP 8.5) ☐ the completed risk matrices	☐
The risks relevant to each municipal body have been evaluated and prioritized according to the risk value and are presented ☐ for the RCM at the regional level ☐ for each of the municipalities at their level	☐
Climate risk treatment	
The links between the risks identified and the measures proposed are clearly highlighted.	☐
The adaptation measures are presented.	☐
Monitoring indicators respecting the measures are presented.	☐
Planning the implementation, monitoring, and assessment of the measures is presented.	☐
Presentation of measures	
• Each measure presented includes: ☐ An order of magnitude of the costs, when possible ☐ The approximate implementation schedule ☐ The municipalities concerned by each of the measures in the case of an RCM plan ☐ The municipal bodies responsible for the implementation ☐ The desired adaptation outcome	☐
Production, monitoring, and revision of the adaptation plan	
The adaptation plan presents the process planned to monitor and disseminate the findings, e.g., the frequency of data collection and the means of dissemination.	☐
Other	
The adaptation plan presents a summary of the consultations conducted among the stakeholders.	☐
The adaptation plan illustrates by means of mapping a summary of the results of the risk assessment and risk treatment. This summary presents the socioeconomic characteristics of the territory, the climate hazards that affect the territory, changes in them over time under the impact of climate change, and the priority intervention zones.	☐

[A] The elements in the checklist are neither exclusive nor exhaustive. Other elements may be deemed important for inclusion in a municipal body's adaptation plan. The elements presented here are also relevant for a more detailed adaptation plan in which certain more technical elements would be reserved for the internal use of the municipal body or its partners.