



REIMAGINING PUBLIC SPACES

Technology-Based Solutions for Resilience

A Practitioner's Toolkit
February 2023



ACKNOWLEDGEMENT OF INDIGENOUS LANDS AND TREATIES ACROSS CANADA

Evergreen and Future Cities Canada respectfully acknowledge that the sacred lands upon which we operate, and the built communities and cities across the country, are the traditional territories, homelands and nunangat of the respective First Nations, Métis Nations and Inuit who are the long-time stewards of these lands. We acknowledge that these are occupied lands and subject to inherent rights, covenants, treaties, and self-government agreements to peaceably share and care for the lands and resources across Turtle Island. These regions are still home to diverse Indigenous peoples and we are grateful to have the opportunity to live and work on these lands.

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PREFACE

Communities across Canada are rich in public spaces of all kinds and sizes. These spaces are essential social and environmental infrastructure that can become a powerful lever towards building innovative, smart, and more sustainable communities for all. At their best, these physical spaces, part of the civic commons, foster greater livability, vibrancy, belonging and engagement. Positive outcomes range from stronger connection, wellbeing and community, to improved climate resilience, safety, inclusion and diversity. However, it can be challenging for communities to understand how to better tap into the potential of these spaces in ways that work for them.

Public Space

Areas or places that are open and accessible to all people, including streets, public squares, parks, beaches and civic spaces. Successful public spaces are designed with all residents in mind and allow people to interact with these spaces in different ways. Great spaces enhance livable cities by supporting a sense of connection, individual and social wellbeing, and community expression, identity and diversity.

WHY THIS TOOLKIT

Communities across Canada are facing increasingly challenging impacts as a result of climate change. From extreme weather events to long term shifts in the environment, community leaders are seeking solutions to tackle these challenges, and to help their communities become more climate resilient. The public spaces in a community are powerful assets in these efforts as Katherine Peinhardt from Project for Public Spaces notes: “Public spaces are where we experience global environmental challenges at the human scale. By thinking about challenges like climate change as they pertain to places and people, we can use public spaces as tools for both lessening our collective contributions to climate change, and dealing with its imminent effects.”¹ The design and use of these spaces, especially parks and open spaces, can be leveraged to include important solutions for climate change impacts. Through strategic and innovative approaches to public space, communities improve their climate resilience, and build more sustainable places that are healthier and safer for everyone.

There are a number of ways that public spaces may be used in tackling climate change impacts, including managing water (e.g., floods, drought), providing relief from extreme conditions (e.g., heatwaves), reducing emissions and supporting the emergency needs of residents, to name a few. However, understanding risks, along with where and how to best invest can be challenging for communities. Additionally, finding ways to be more proactive and informed over time can prove difficult. This is where technology and data can be used. In our 21st century world, technology-based solutions have emerged that can help in advancing climate resilience for public spaces in communities. Some can help in better understanding key risks for informed decision-making, planning and investment and others can help to lessen and respond to the impacts of climate change. Technology and data are a key part, often a starting point, of a holistic climate resilience approach for communities, which can greatly support deployment of other solutions such as infrastructure, climate conscious public space design, communication, policy, and social strategies. In this rapidly-evolving digital world, communities may not be fully aware of the options they might consider.

The **Technology-Based Solutions for Resilience** toolkit is designed to support you and your team in charting a pathway towards greater resilience through your public space(s), leveraging technology to help you understand your local risks and respond to them. It can help you to better plan and invest where you need it, using innovative tools, to keep your community safer and healthier for the future, and more resilient to “weather the storms”. The toolkit includes easy-to-understand tools for you to work through and take action on as you work towards more resilient public spaces where all will feel welcome. These tools cover three main themes:

- 1 **Planning for Climate Resilience**
- 2 **Understanding Your Risks**
- 3 **Action for Mitigation and Adaptation**

Climate Change is measurable changes in weather patterns over a long time (decades), and may be due to natural or human causes. Changes occur in the composition of the atmosphere, when greenhouse gases build up and get trapped.

Extreme Weather Events is a rare (by location or season) meteorological event, that is outside the normal range for a location. Examples include flooding, heat waves and intense storms.

Climate Resilient describes the capacity to respond to resist, respond to, adapt to or cope with climate change impacts.

¹ Katherine Peinhardt, “Public Spaces in an Era of Climate Change”, *Project for Public Spaces*, Apr. 22, 2018, <https://www.pps.org/article/public-spaces-in-an-era-of-climate-change>.

HOW TO USE THIS TOOLKIT

This toolkit is best used as you consider your overall resilience planning for your community. It can be helpful in building alignment and a shared understanding of priority areas and technology options. Using the toolkit in conjunction with other strategies and processes around resilience for your community will help to ensure more successful approaches overall.

You are encouraged to work through this collaboratively with your team and key stakeholders, ensuring a range of perspectives across key municipal departments.

This resource is intended for leaders in communities in Canada of all sizes who are looking for strategies and solutions to make their community more resilient in the face of increasingly severe risks due to climate change. These include municipal staff, elected officials and leaders at other organizations who are tackling climate-related challenges such as public health, emergency response, parks and environment, urban planning, connected technologies or data. It is meant to be an introduction and resource for your resiliency journey, rather than a comprehensive or technical guide.

We know that each community is unique, with its own strengths, assets and challenges. Communities and their leaders are invited to use the tools as they wish (they complement each other), to explore a range of options and craft their own resilient public space approach. **Use what works for you and feel free to adapt or expand along the way.** You are encouraged to explore the range of options and get creative in your unique approach to move your project forward.

Creating more resilient public spaces in your community, where it is needed most, is critical to ensuring the health, safety and future of your community.

Let's explore how technology can be leveraged towards creating more resilient public spaces.

PLANNING FOR CLIMATE RESILIENCE

Tool 1: Climate Resilience Planning Canvas



As you move towards more resilient public spaces in your community, it is important to set a strong foundation by following some key steps. Before diving into solutions, build a clear picture of where you are at and where you need and want to go, understanding current and future risks. With this deep understanding in mind, you can then make data-driven and informed decisions for your public space(s), exploring and implementing strategic

actions for the future. As with any complex planning process, you will want to ensure that you engage with a diverse group of people at key moments, and continuously monitor and improve. With climate change impacting many intersecting elements in your community, cross-sectoral involvement becomes even more important.

ABOUT THIS TOOL

With both worksheets and checklists, the **Climate Resilience Planning Canvas** is designed to help you consider the key components of a robust process towards greater climate resilience in your public spaces. Providing an introduction to these key steps, particular focus is given to elements especially important to a climate resilience process, whether focused on one single project (e.g., a park) or your whole municipality or region. These steps may also be integrated into broader planning in your community (e.g., strategic or community plan). While the canvas follows a linear process,

know that working towards climate resilience can and should be an iterative and collaborative process. You are also encouraged to explore the more detailed resources and toolkits listed in the [Resources](#) section of this toolkit. Ultimately, the canvas can help you achieve a more focused, sustainable and successful approach for more resilient public spaces, investing your limited resources for greatest impact.



TIPS

- ✓ Consider forming a task force for your initiative, and identify local champions who can help amplify and accelerate forward movement.
- ✓ Remember to consider both current and future risks, prioritizing for the short and long-term.
- ✓ Work regionally to pool resources and monitoring, especially if you are a smaller community. Remember that climate change impacts don't end at your project or community borders. Andreas Boehm from Kelowna notes that: "It's not going to work unless we're talking to everybody up and down the valley - a drought or a flood does not just happen in one city, it happens across the region".
- ✓ Keep climate equity at the centre of your planning process, especially considering the more vulnerable who may experience the negative impacts of climate change the most.
- ✓ Get leadership on board as champions for accessibility; engage local political leaders to advocate.
- ✓ Keep these key principles in mind throughout: collaborative, proactive, integrative, flexible, practical².



²L. Bizikova, T. Neale and I. Burton, *Canadian communities' guidebook for adaptation to climate change. Including an approach to generate mitigation co-benefits in the context of sustainable development*. First Edition, 2008, 15, https://data.fcm.ca/documents/tools/PCP/canadian_communities_guidebook_for_adaptation_to_climate_change_EN.pdf.

An Interagency FireSmart Committee in Kamloops³

With concerns growing around wildfires near Kamloops in the interior of British Columbia, the city created a multi-stakeholder team to coordinate their response, the Interagency FireSmart Committee. The team included representatives from fire rescue, parks, forestry, the region, development and engineering, and subject matter experts were also engaged. By working together, they were able to develop a “Community Wildfire Protection Plan” with recommendations to reduce risk to life and environmental and property losses due to wildfire in the area. The team continues to monitor and evaluate progress.

Acting on Climate Together in Halifax⁴

After declaring a climate emergency in 2019, the Halifax Regional Council, Nova Scotia, initiated a robust climate strategy process, engaging 250 stakeholders and the public across sectors and the region. After 16 months, the resulting HaliFACT 2050 plan charted an ambitious course to act on climate change, through reducing emissions and helping communities in the region adapt. They assessed the risks and projected changes in their region for 50 years in the future, which ranged from higher temperatures, increased precipitation and more severe storms. The plan includes the concept of a carbon budget, a limited “bank account” of how much CO2 can be spent. A range of actions from short to long-term are already being implemented, including a number of risk analysis actions in public space, to inform future plans.

³ I.C.L.E.I. Canada, *Changing Climate, Changing Communities: A Guide and Workbook for Municipal Climate Adaptation*, 21, Accessed Nov. 17, 2022, <https://icleicanada.org/project/changing-climate-changing-communities-guide-and-workbook-for-municipal-climate-adaptation/>.

⁴ Halifax Regional Council, *HalifACT-Acting on Climate Together: A Climate Action Plan for Halifax*, 2020, https://www.halifax.ca/sites/default/files/documents/about-the-city/energy-environment/HRM_HaliFACT_vNew%20Logo_.pdf.

TOOL 1: CLIMATE RESILIENCE PLANNING CANVAS

Planning for Resilience

A step-by-step process for taking action to leverage public space for climate resilience. Follow these general, and iterative steps, and work through the canvas that follows to think through your own local approach to these steps. Dig deeper on key areas in Tools 2 & 3 as indicated.

1. Launch Your Climate Resilience Project⁵

Get your initiative off the ground, by engaging the right people.

Launch Checklist

Start with a public space project in mind or with an overall view on your public spaces and their role in your climate resilience approach

Determine the scope and scale of your project – will you focus on a particular sector or department, a specific project or location, or will you be working on resilience for your entire community or region?

Build a team to guide the process with diverse expertise and perspectives, drawing on stakeholders and experts, and appointing a leader

Be sure to engage your stakeholders in meaningful ways, and provide training around climate change topics as relevant

Appoint a chief resilience or sustainability officer

Establish political support. For example, get a resolution from council towards your climate resilience work

⁵Largely adapted from: *I.C.L.E.I. Canada, Changing Climate, Changing Communities*; *Bizikova, Neale and Burton, Canadian communities' guidebook*; Municipal Climate Change Action Centre (MCCAC), *Climate Resilience Express: A Community Climate Adaptation Planning Guide*, https://mccac.ca/app/uploads/CRE_Planning-Guide_Final.pdf

TOOL 1: CLIMATE RESILIENCE PLANNING CANVAS

Planning for Resilience

Identify Stakeholders & Potential Partners

Climate change impacts affect virtually all parts of our communities. Who needs to be involved in your process? You may have more than one contact for each category, depending on your community.

Type of Stakeholder	Contact Name	Contact Information
INTERNAL (PUBLIC SERVICE) STAKEHOLDERS		
Emergency Services (e.g., Fire, Police)		
Infrastructure & Roads		
Planning Department		
Public Health		
Public Works (Water, Sewage, Waste)		
Parks, Recreation & Forestry		
Planning & Zoning		
Environment, Conservation & Protected Areas		
Economic Development, Culture & Tourism		
Indigenous Affairs		
Elected Officials		
Other (indicate)		

TOOL 1: CLIMATE RESILIENCE PLANNING CANVAS

Planning for Resilience

Identify Stakeholders & Potential Partners

Climate change impacts affect virtually all parts of our communities. Who needs to be involved in your process? You may have more than one contact for each category, depending on your community.

Type of Stakeholder	Contact Name	Contact Information
EXTERNAL STAKEHOLDERS & PARTNERS		
Nearby Communities in your Region		
First Nations and Indigenous communities and groups		
Regional or provincial/territorial governments		
Local Advocacy Groups and Residents		
Subject-matter experts		
Local universities, institutions		
Regional and provincial conservation authorities and parks		
Other (indicate)		

TOOL 1: CLIMATE RESILIENCE PLANNING CANVAS

Planning for Resilience

2. Understand your Risks

You likely already have a sense of your key areas of risk – use the space below to jot down your initial thoughts on the most likely ways that climate change is impacting your community now or could in the future. Consider how well-prepared your community would be for extreme weather events.

This is just the start - it is important to understand these in detail, so you can make informed decisions. Use [Tool 2](#) to dig deeply into your risks, considering technology enabled tools to gather and make sense of your data.

1
2
3
4
5

Risk is the likelihood of an event occurring combined with the negative consequences and impact.

3. Plan for Action

Once you understand your risks, and critical impacts, you are ready to plan for taking action to make your community's public spaces more resilient in the face of a changing climate.

Action Plan Tips

In addition to your risk assessment, dig into how prepared your community already is to respond to and adapt to potential risks, and build from there

Engage stakeholders collaboratively in developing the plan

Talk to other communities to learn about what they have done

Right-size the process – take enough time to create a solid plan that is well-informed, but don't get paralyzed in planning

Be specific about the details – why, when, where, who and how

Put your plan in writing and share widely

Establish criteria to select action items for the short-, medium- and long-term.

Formalize your plan with approval from key stakeholders (e.g., council, municipal staff & community)

TOOL 1: CLIMATE RESILIENCE PLANNING CANVAS

Planning for Resilience

Resilient Public Space Action Plan Overview		
GOALS		
Using a data-driven approach, use the critical risk areas identified in Step 2 to formulate clear goals. Remember that they should be SMART – specific, measurable, achievable, relevant and time-bound. Keep them short and sweet.		
	Critical Risk Addressed	Goal Statement
[SAMPLE GOALS]	<i>Urban heat island effect</i>	<i>Reduce the negative health impacts on vulnerable populations during extreme heat events</i>
KEY ACTIONS		
Working collaboratively with your team and stakeholders, identify key actions to help to achieve your goals. You will likely have multiple actions that will address each of your goals. See Tool 3 to explore innovative tech-based solutions that can help you move forward.		
Goal Addressed	Action Item (consider existing and new actions)	(timeline, lead, cost)
[SAMPLE]	<i>Increase tree cover by 25% in vulnerable areas</i>	<i>Within 5 years; Parks & Forestry; budget line for next fiscal.</i>

4. Take Action

Now that you have your actions for a resilient public space identified, it is time to put it into effect. Review the advice below and explore more action options in Tool 3.

Advice for Action

Provide training for staff, leaders and stakeholders to build understanding and support for the action plan (e.g., training about the plan and intended outcomes, new policies, legislation and guidelines and new technologies or approaches for public projects).

Continue to engage diverse stakeholders throughout the implementation period and communicate progress widely.

Engage skilled partners and contractors to lead and implement your action plan.

Use pilots or “quick-win” actions to test ideas and build momentum.

Establish criteria to select action items for the short-, medium- and long-term. For example, develop criteria around cost and benefit, feasibility and potential co-benefits.

5. Monitor & Review

Establish a baseline at the start and determine indicators and metrics for monitoring progress as you go.

Evaluate both the progress towards intended outcomes as well as the process itself.

Adopt a learner’s mindset and continue to improve your resilience strategies.

Continue to monitor climate change hazards and risks

Review and update your action plan over time.

Communicate and celebrate progress! Use your public spaces as key communication sites and platforms for education.

UNDERSTANDING YOUR RISKS

Tool 2: Risk Assessment Inventory



In order to decide where and how to take action, it is important for communities to have a solid understanding of their risks, both acute (e.g., extreme events) and more long-term changes. This will enable them to make informed decisions, with a data-driven approach⁶. Data can be either qualitative or quantitative, and can come from a range of sources. It is especially important to include knowledge from those in your community, such as the traditional knowledge of Indigenous groups and local knowledge from your community, like those who have worked or lived there a long time. Their memories and history help to paint a rich picture of what is changing.

Start with what is already known and build from there, drawing on valuable sources and leveraging technology to dig deeper in information and interpretation. This can then inform your targeted approach to risk reduction, “identifying, prioritizing and adapting government investments in infrastructure, operations & services to address climate change risks and promote resiliency”⁷. Assessing risk can happen at a regional, municipal, neighbourhood or even project level, and can focus on one or more operational areas (e.g., parks or health).

Technology-based solutions are helping advance the understanding of climate change risks for communities. An article in the Lancet highlights that using big data and spatial information platforms, and drawing on a range of information, can “develop a decision support system to help prioritise and select strategies across environmental, economic, and social facets[...]. Developing this capability is crucial for the city planning agencies to create robust climate-informed policy making in the future.”⁸

The **Risk Assessment Inventory** is designed to help you clearly understand risk and your risk areas, through a structured process that is built from best practices in the sector. Then, it presents a range of innovative technology-based approaches to support your risk assessment, many of which are inter-connected. By using this tool to better understand your risks, and how technology can be used to help you do so, this will ultimately help you to make better informed decisions, prioritizing investment in your public spaces where it will have the greatest impact on reducing the negative impacts of climate change, and even taking advantage of the new opportunities these changes may bring (e.g., longer summer season).

⁶ Alessandra Battisti, “Mapping Public Space: Activating Outdoor Climate Control” In Activating Public Space: An Approach for Climate Change Mitigation, 19, edited by Alessandra Battisti and Daniele Santucci, 19-33, 2020, <https://mediatum.ub.tum.de/doc/1543270/1543270.pdf>.

⁷ Irene Pichola, Mahesh Kelkar and Mateusz Bratek, “Building climate-resilient cities – Exploring the five lenses of climate action”, Deloitte, Aug. 26, 2021, <https://www2.deloitte.com/xe/en/insights/industry/public-sector/climate-resilient-cities.html>.

⁸ BrendaBLin, et al., “Integrating solutions to adapt cities for climate change”, (The Lancet, Vol 5, July, 2021, pe479-e486A0), <https://www.thelancet.com/action/showPdf?pii=S2542-5196%2821%2900135-2>.

UNDERSTANDING YOUR RISKS

Tool 2: Risk Assessment Inventory



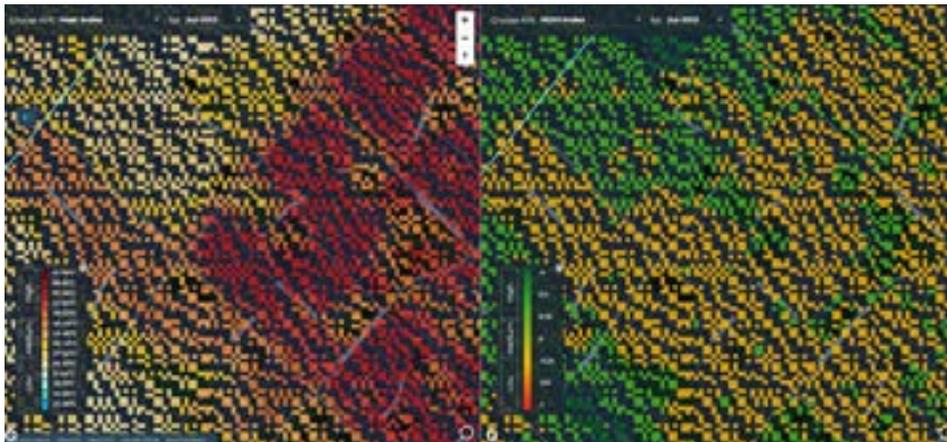
TIPS

- ✓ Be sure to frame and scope your assessment before beginning, with a plan on how you will use the results. Consider geographic area, scale, focus areas, sector(s) and/or departments.
- ✓ Think about risk for the immediate and long-term future. Consider using the risk assessment on different timescales such as one for the next 3-5 years and another for 30 years from now.
- ✓ Prioritize addressing impacts on more vulnerable populations, such as older adults, small children, people with chronic illness, people with disabilities, newcomers, and people in equity deserving areas or with low-income.
- ✓ Think of the natural environment as a key stakeholder and consider the impacts on it as well.
- ✓ Conduct your risk assessment in a collaborative way that engages stakeholders, considering both top-down and bottom-up approaches.
- ✓ Plan how you engage residents and other groups in the process. See Evergreen's [Toolkit on Public Engagement](#) for more insights on engaging community members in your project.
- ✓ Engage an experienced consultant and subject matter experts to support the risk assessment.
- ✓ The larger or more complex your project or community, the more detailed you will want to go into your risk assessment, using more granular quantitative information.
- ✓ Remember that risks don't occur in silos and are often interdependent, operating in a complex system. It is important to consider your climate risk situation as a whole.



Assessing Risk in Sault Ste Marie⁹

The Climate Risk Institute worked with the City of Sault Ste. Marie, Ontario, to conduct risk assessment workshops, engaging a range of staff from diverse departments. Data about climate change for the municipality, past, current and projected, were explored, along with resulting impacts. Participants ranked the likelihood of different risks, as well as the consequence (degree of impact), across people, economic and financial, environment and department categories. This data-driven approach (qualitative and quantitative) resulted in a ranking of various impacts, surfacing high priority risk areas. This risk assessment provides a strong foundation for municipal departments to develop future climate-responsive plans while conducting more detailed assessments for health and emergency management.



ABOVE: A comparison view within the application of heat analysis (left) and the Normalized Difference Vegetation Index (extent of vegetation and vegetation health) in Peel Region.

Artificial Intelligence for Detailed Understanding in Calgary

In Calgary, Alberta, an innovative initiative launched in 2020 is currently underway, tapping into the power of data, technology, machine learning and Artificial Intelligence. The *AI for the Resilient City* project is “a climate solution tool for municipal and government stakeholders to take action on extreme weather events like extreme heat – to understand which parts of their municipalities, communities, and neighbourhoods are being most affected – and have the resources and data visualization tools to narrow down to a resolution at the street level on those community members most affected – and how they can help them”, describes Joshua Welch, the team’s Program Officer. In partnership with Evergreen and funders, this project has created a multi-variable, integrated view of the city, through diverse data sources, with strong visualization and analytic capabilities, both in real-time and with scenario projections for the future that users can create. This allows municipal climate adaptation teams and decision-makers to focus on areas of greatest risk. Building on the success of the pilot in Calgary, the second phase pilots, using only open-source data, are now rolling out in new communities, including Peel Region, Ontario, and three municipalities. New communities may be added in the future.

Machine Learning is a form of artificial intelligence where computers use data and algorithms to “learn” over time, improving the performance of tasks over time and mimicking how humans learn.

⁹ Climate Risk Institute. *Climate Change Risk Assessment-City of Sault Ste. Marie*. 2020, https://saultstemarie.ca/Cityweb/media/Community-Services/GHG/Final-Report-Climate-Change-Risk-Assessment_SSM.pdf.

Data Sources

Where can you find data, to clarify and validate your risks, at an appropriate scale (e.g., regional, municipal, local geography, neighbourhood)? Consider data that is historic, current and future-focused. Here are a few common (and free!) sources to get you started:

- **Atlas of Canada:** Combining climate science, mapping and storytelling around climate change in Canada. <https://climateatlas.ca/>
- **Canada Climate Change Data Portal:** Easy and intuitive access to the latest climate data in Canada for all users. <http://canadaccdp.ca/>
- **Climate Data for a Resilient Canada:** High-resolution climate data to help decision makers build a more resilient Canada. <https://climateatlas.ca/>



Key Risk Assessment Terms

Hazard is a natural event or process that may cause harmful impacts to humans or the natural world. There are a range of climate hazards communities in Canada face, as listed in the matrix below, and they are often interconnected. Ask: What hazards are your community facing? What is the duration, intensity, frequency, seasonality and geographic range for each one?

Impact is the effects of existing or forecasted changes in climate (hazards) on built, natural, and human systems. Impact can occur on social (e.g., health, displacement, work and emergency needs), economic (e.g., loss, insurance, restricted movement and demand for goods), physical (e.g., on public spaces and infrastructure), and ecological systems (e.g., changes in species distribution, habitat change and survival rates), which are inter-connected¹⁰. Ask: What are the ways these hazards might impact your community? Are there particular areas or people that are most vulnerable, due to geography, built environment and/or social factors? How significant or severe would the consequence of each impact be for your community?

Likelihood refers to the probability of an event or hazard occurring. Ask: How probable is it that each of these impacts will occur?

Risk Rating is a final assessment of how high the risk for each potential hazard and impact would be for your community, multiplying the likelihood by the severity of impact rating. The higher the risk rating, the more critical it will be for your community to take action in this area. Ask: What impacts have the highest risk rating?

¹⁰ I.C.L.E.I. Canada, *Changing Climate, Changing Communities*, 15; CCME, *Good Practices in Climate Change Risk Assessment: A Summary*, 2021, <https://ccme.ca/en/res/riskassessmentssummarysecured.pdf>; MCCAC, *Climate Resilience Express*.

Risk Assessment Matrix

Use this matrix to think through all aspects of potential risk for your project area, to determine level of risk and priority areas. The matrix can be deployed on different scales – from a single public space project to thinking through your entire municipality or region. Use the best data you have to make your assessment. The more complex your project, the more detailed and robust your data should be. Consider one risk assessment that focusses on the more immediate future e.g., the next 10-15 years) and also other(s) that look to a longer-term future (e.g., 20-50 years). Note that utilizing technology to support your risk assessment (as outlined in the next section) may complement or even replace aspects of this matrix.

IDENTIFY AND DESCRIBE PRIORITY HAZARDS	
Potential Hazards	Impact Details
Which of these acute and slow-onset hazards (often inter-connected) are threatening your community? Collect data to verify.	Describe each hazard and the ways it could impact (ecological, social, physical, economic) your community (who, where, when). What may happen as a result of each hazard?
<p>Extreme Heat (e.g., prolonged heat waves, heat domes and heat island effect)</p> <p>Flooding (e.g., river, shoreline, spring, urban, stormwater; short/long-term)</p> <p>Drought (e.g., seasonal, desertification)</p> <p>Wildfires (e.g., grass, forest, in town or beyond)</p> <p>More intense storms (e.g., ice, hail, snow, rain, freezing rain, wind, thunderstorm, tornado)</p> <p>More intense storms (e.g., ice, hail, snow, rain, freezing rain, wind, thunderstorm, tornado)</p> <p>Poor Air/Water Quality (e.g., from wildfires, pollen, contamination)</p> <p>Landslides (e.g., caused by extreme precipitation, earthquakes)</p> <p>Changes in water levels (e.g., sea level rise, fluctuating lake levels)</p> <p>Toxins (e.g., increased toxicity from pollutants)</p> <p>Ecosystem shifts (e.g., changing seasons, species & range changes, more vectors (e.g., Lyme)</p>	
Other (describe)	

DETERMINING RISK RATING FOR CRITICAL HAZARDS

Critical Hazards	Likelihood	Severity of Impact	Risk Rating
List the most critical hazards and each of the related impacts for your community as identified above.	1=rare 2=unlikely 3=possible 4=likely 5=very likely	1=insignificant 2=minor 3=moderate 4=major 5=extreme	likelihood x consequence <6 low 6-11 medium 11-19 high >19 extreme
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Technology Tools for Data Gathering and Understanding

A suite of technology-based tools has emerged in recent years that can help you to grasp your risks more clearly, anticipate future challenges and achieve a higher level of specificity, localization and quality in your climate risk data. Using these can also help provide a more holistic and systemic approach for assessment, interpretation and projections to better understand potential future challenges. All of this can lead to better decision-making around how best to leverage your public space(s) for greater climate resilience. These tools use big data at different scales and from different sources, and can aggregate and analyze it quickly, for descriptive, predictive and sometimes even prescriptive (diagnostic) applications. They use high-speed internet and deploy new machine-learning, algorithms and artificial intelligence. In some cases, their function can also be used in future action, as part of ongoing adaptation and mitigation strategies.

Review the highlighted tools below and choose any that might support your risk assessment process.

TECHNOLOGY TOOLS FOR CLIMATE RISK ASSESSMENT ¹¹	
Technology Tool	Example
<p>Socio-economic data Data such as census data that provides information about more socially vulnerable people and areas, as they have experienced disproportionately negative impacts from climate change hazards.</p>	<p>Windsor, Ontario is conducting a study using census data, to better assess if and how vulnerable communities may be more negatively impacted by flooding than others, to inform future actions.</p>
<p>Environmental sensors Simple electronic sensors, connected to the internet, are used to monitor the status of a range of climate risk factors in real time, to support assessments as well as ongoing monitoring and emergency preparedness.</p>	<p>Sensors can be used to monitor air quality (e.g. pilot in Atlantic and Western Canada), tides, water levels (e.g. real-time shallow aquifer monitoring in Nova Scotia), gases, weather conditions, ice (e.g. pilots in the Arctic), sound and more. Sensors can be mounted on land, in water or even on drones and other monitoring devices.</p>
<p>Mobile technology Cell phones (usually smart phones), apps and cell and internet connectivity that they use for climate risk assessment.</p>	<p>The County of Peterborough, Ontario deployed a mobile app to support data collection on road assets and conditions by staff, to assess impact of increased spring and fall freeze-thaw cycles on their extensive road system.</p>
<p>Drones & aerial/satellite imagery Unmanned Aerial Vehicles (UAVs) called drones are used to collect photographic, video and other data remotely, as well as environmental samples. Drones can also operate under water. piloted aircrafts as well as satellites to gather climate change information remotely, and the data can then be processed using photogrammetry, analytics and algorithms to contribute to climate risk assessments, monitoring and projections.</p>	<p>Drones and satellites are being used to assess a range of factors such as tree cover, tree health, shoreline erosion, watershed monitoring. Victoria, British Columbia, for example, used drone-based imagery to develop a pre-disaster 3-D map of their downtown. Some satellite and aerial imagery is available through Natural Resources Canada.</p>

¹¹ Sources include: Sotirios A. Argyroudis et al. "Digital technologies can enhance climate resilience of critical infrastructure." *Climate Risk Management* 35(2022): 100387; Natural Resources Canada, "Canada in a Changing Climate: Advancing our Knowledge for Action" (website), <https://changingclimate.ca/>; UNFCCC (Climate Change Secretariat), Technologies for adaptation to climate change, 2006, https://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf.

TECHNOLOGY TOOLS FOR CLIMATE RISK ASSESSMENT¹¹

Technology Tool	Example
<p>GIS (Geographic Information System) Mapping Combining data from numerous sources to present them as multi-dimensional digital maps.</p>	<p>Thompson, Manitoba is using GIS for wildfire mitigation, to better plan for fire fighting and prevention resourcing.</p>
<p>Digital Dashboard The concept of bringing streams of different climate data into one centralized virtual site so all stakeholders have a centralized view of real-time information in the area.</p>	<p>In Kelowna, British Columbia, the city has a digital dashboard that shows real-time data on snow packs, lake levels and other factors in this flood-prone area. This can be used not only in planning but also in adaptation actions.</p>
<p>Integrated Assessment Models (IAM) Combining different types of knowledge and data, to better understand how natural and human factors combine and interact, in order to better understand climate risk and the cost/benefit of possible action options, in numeric terms.</p>	<p>In Calgary, Alberta, they are deepening their understanding of the urban heat island effect, by integrated data around urban infrastructure, population, temperature and more at a neighbourhood scale. This is helping them to identify “hot spots” to inform their priorities and to create community risk profiles for every neighbourhood.</p>
<p>Digital Twins, Climate Modeling & Scenarios Various digital technologies are emerging to help craft models of climate in communities that can be manipulated to understand current and future scenarios, based on varying climate and action inputs. Data visualization, interpretation and simulation can be involved. They draw on historic and real-time data (see examples above), and deploy algorithms, AI and machine-learning for analytic, predictive and prescriptive applications at different time scales. At the most detailed scale for example, a digital twin is a virtual replica of physical assets, processes and systems in a community.</p>	<p>A new project is underway across Canada to create high-precision 3D maps of 100 Canadian cities, to support net-zero efforts, with the cities of Windsor and Thunder Bay, Ontario at the forefront. AI-based mapping will include key public space elements such as roads, sports facilities, waterways, green spaces and sidewalks. This is envisioned to become the foundation of a digital twin for these cities to support data-driven decision-making towards more sustainable, safe and smart communities.</p>
<p>Climate Data Visualization Using visual tools to convert climate data into easy-to-understand visualizations like maps, graphs and more.</p>	<p>The Climate data viewer offered by the Government of Canada allows you to visualize climate data in the country based on a selection of datasets and variables. CBC News recently used data analysis to visualize who lives in the hottest urban areas in 17 Canadian cities, powerfully illustrating how people with low income and immigrants are the most vulnerable.</p>

ACTION FOR MITIGATION AND ADAPTATION

Tool 3: Technology for Resilience Action Guide



Once key priority areas have been identified and clarified ([Tool 2](#)) and you have begun mapping out your goals for climate resilience in your public space project, it is time to consider actions. These actions can focus on [mitigation](#) and/or [adaptation](#). “Mitigation will help avoid the unmanageable. Adaptation is essential to manage the unavoidable.”¹² Following the canvas in [Tool 1](#), you want to choose actions that will align with your goals, and strive towards an overall reduction in risk, harm and impact due to climate change.

When considering action, it is important to prioritize your options against criteria, while also considering what policies and programs you already have in place and how well they are working. These might include considering how well they help to achieve your resilience goals and address priority risks, how feasible they are, whether they have any positive or negative co-benefits and how well your stakeholders will accept them. Co-benefits might include improved livability or enhanced economic development. For actions of adaptation, they may focus on prevention, anticipation, responding, or accommodating.

Resilience actions can take many forms and can range from nature-based solutions and infrastructure investment, to social and political solutions. Your suite of actions may involve government, private sector and residents each doing their part. A few of these are highlighted here.

Climate Mitigation is any action or response intended to reduce or prevent greenhouse gas emissions, or to enhance sinks that capture or store carbon, usually towards long term benefits.

Climate Adaptation in a climate change context means any measures taken with the intent of reducing the negative effects of climate change on built, natural and social systems, to cope with the consequences, or to take advantage of the positive effects.



¹² MCCAC, *Climate Resilience Express*, 2.

SOCIAL, REGULATORY AND NATURE-BASED OPTIONS FOR ACTION

Communities across Canada are adapting and creating public spaces that support their goals towards greater resilience. Here are some examples:

Social, Regulatory & Political Actions

- Creating cooling/warming centres for extreme weather events, offering misting stations or extended pool hours, especially important for the [most vulnerable](#)
- Changing policies (e.g., low impact development standards, land use, financial policies), plans and bylaws to support climate resilient public space development and management
- Focussing on awareness and education about risks (e.g., heat, flood, fire) to encourage desired behaviour
- Incentivizing sustainable behaviour
- Updating emergency response and evacuation planning and guidelines
- Resourcing your action plan
- Improving lower-emission transportation through public transit, bike lanes, etc. ([see Evergreen's Toolkit on mobility in public spaces](#))
- Implementing "Smart growth" approaches

Nature-Based Actions

- Nature-Based Actions
- Planting more trees and native plants to add cooling, manage water, improve air quality, etc.
- Shading including seating – cool pavement
- Designing parks and open spaces to support diversion and/or retention of precipitation and water flow and acting as "sponges" and flows for water, diverting away from vulnerable areas. [Climate-ready schools](#) and [schoolground greening](#) can be a unique opportunity for resilience action.
- Adding more permeable surfaces for flood mitigation, and de-paving where possible
- Proactive fire prevention through prescribed burns and fuel thinning
- Adding water features and green space for enhanced cooling
- Choosing plant species that will be resilient for future climate realities
- Preserving and expanding open spaces, wetlands, wooded areas, grasslands and other critical green spaces

Technology can be a powerful tool that can be leveraged, in combination with other actions, to help adapt to and sometimes mitigate the impacts of climate change. Building on the assessment technologies profiled in [Tool 2](#), there are host of tech-based applications emerging to help accelerate, focus and deepen climate resilience action.

This **Technology for Resilience Action Guide** provides a brief overview of emerging technological solutions that communities might consider using as part of their approach to more resilient public spaces. It also highlights key success factors to keep in mind for deploying technology in your journey towards greater resilience. By working through these elements, your community can be better prepared to understand and implement technological solutions in your public spaces to build climate resilience.

TIPS

- ✓ While your actions may be geared towards tackling climate change risks, they may also come with connected co-benefits for your community. For example, these actions may reduce inequalities, improve biodiversity and increase livability.
- ✓ When considering actions, be cognizant of potential negative consequences that may result and counteract the intended impact. For example, using a mobile public alert system might further exacerbate impacts on vulnerable populations who may have limited digital literacy or access.
- ✓ Strive for an integrated approach towards your goals, where different actions can complement and enhance one another towards greater positive impact.
- ✓ Be sure to think about actions that would support both acute issues and also more long-term risks.
- ✓ Prioritize actions for the short, medium and long-term, for both acute and slow-onset hazards. Use a structured ranking that might include social, economic and environmental sustainability, effectiveness, benefit and co-benefit & cost and ability to implement.
- ✓ Establish a baseline for measuring progress and change against the intended outcomes of each action.

Digital Dashboard to Anticipate Risk in Kelowna

In flood-prone Kelowna, British Columbia, in the Okanagan Valley, the municipality created a [digital dashboard](#) to monitor water levels affecting their community. Beginning in 2016, the initial dashboard provided real-time information, and has expanded to the region. Tapping into data from City sensors and partner sensors to monitor watersheds, Kelowna is now going further, tapping into machine learning to do more predictive analytics and modelling to inform future planning and response. They are also deploying drones to monitor difficult to access areas, creek obstructions and more to get a high level of detail on any issue areas. Working collaboratively with technology vendors has helped build internal capabilities to really leverage tech to better handle both flooding and droughts for the future. For communities looking to do similar projects, Andreas Boehm leading this initiative with the community shared that some things to keep in mind include starting with pilots, being clear with vendors on required outcomes, and thinking collaboratively, regionally and cross departmentally.

A Heat-Health Portal in Southern Quebec

In southern Quebec, they have implemented an [interactive portal](#) that includes heat-health data layers, land surface temperatures and automated alerts. Layers include important information such as cooling centres, vegetation maps, and socio-economic deprivation, and access to air conditioning that users can select. A vulnerability tool at the census dissemination area level is also available and can be parameterized by the user.¹³

¹³ Province of Quebec, "Interactive Map", accessed Dec. 10, 2022, <https://www.donneesquebec.ca/recherche/dataset/ilots-de-chaleur-fraicheur-urbains-et-temperature-de-surface/resource/82a3e8be-45d2-407e-8803-fcc994830fcc>.

Technology Options for Resilience¹⁴

There are a number of technology applications, sometimes inter-related, that can be considered to deploy as part of your action plan towards a more resilient community. Mitigation, with its focus on reducing greenhouse gas emissions, largely focuses on the sustainable energy and transportation sectors, will not be included here, but are explored in other toolkits in this suite. The examples below are more focused on adaptation efforts instead, and are intended to inspire and catalyze creative thinking for your action plan. Explore these options, along with your team, and choose what will help you to reach your resilience goals.



Remote Monitoring

Real-time data is central to many technology-based adaptation and mitigation strategies. While some data may be readily available, for example weather data or historic data, some may not. Remote monitoring through environmental sensors (e.g., water gauges, air quality sensors, etc.), drones (e.g., photos, videos, sampling) and more, will provide the accurate, real-time data for your community, leveraging internet and cell phone technologies to consolidate. Low-powered options can help in areas with poorer bandwidth. Consider where your data gaps are and explore options to better understand key indicators related to your risk areas, and then ensure the data collected through remote monitoring can be accessed for other technology applications.

Early Warning Systems

Tap into monitoring data to anticipate rising risk levels, especially in advance of extreme weather events. Early warning signs can help to trigger emergency measures, response and public alerts. Robust digital systems with advanced analytics can help provide a clearer picture of real-time risk, and help to assess response scenarios quickly using machine learning and AI. For example, air quality sensors can show pollution levels at specific locations, providing detailed information around how a wildfire might progress through a community. In Eastern Ontario, a quarter of communities has implemented a real-time syndromic surveillance system (ACES), using GIS, that has time and space capabilities, to better monitor changes and trends in endemic health hazards, including extreme heat and air quality.¹⁵

¹⁴ Key sources used: SmartCity Press, “How Smart Cities Enable Extreme Weather Resilience”, May 12, 2022, <https://smartcity.press/extreme-weather-resilience/>; Smart Cities Dive, “No city is immune to extreme weather, July 25, 2022, <https://www.smartcitiesdive.com/spons/no-city-is-immune-to-extreme-weather/627424/>.

¹⁵ Paul Kovacs et al., *Cities Adapt to Extreme Weather: Celebrating Local Leadership*, ICLR, 2018, 75-77, <https://www.iclr.org/wp-content/uploads/2018/12/cities-adapt-to-extreme-weather-update-website.pdf>.

Emergency Response

When emergencies arise as a result of climate change hazards, communities can tap into technology to help responders understand more details about risk areas, get to where they need to be quickly, and respond to changes efficiently. [GPS tracking systems](#) can provide a real-time view of road conditions, as well as the location of emergency response vehicles like snowplows. Smart technologies can help optimize routes, and smart grids can alert utilities about local outages. Perth County, Ontario has implemented a municipal 511 system using real-time data, that provides accurate, real-time information to emergency responders.¹⁶

Public Alerts

As increased risk levels are identified through early warning systems, public alerts can be triggered, based on pre-determined thresholds. Communities across Canada issue alerts for air quality, extreme heat and cold, water quality, wildfires, humidity and more, notifying them of risk and how they can, and should, respond. In Gatineau for instance, they use technology to assess when to issue heat-alerts, based on historic and real-time data for their specific region. A toolkit for [Air Quality in Schools](#) suggests sharing real-time air quality information through technology channels. Timely and accurate data about local weather is essential for this made-in-place solution.¹⁷

Mobile Technology

Using mobile technology and smart phones can be an important part of a community's climate adaptation actions. Mobile apps and chatbots can support public alerts and information sharing, to help minimize risk. For example, a community might deploy a climate risk app or automated messaging to provide timely messaging around emerging risk levels such as heat or flooding, along with clear information on how to respond. Data about conditions, using user photos and narrative can better paint a picture of impact by location, tapping into location data on phones. Keeping telecommunications functioning during an emergency is critical for emergency responders and residents and communities are encouraged to diversify and expand internet access with a mix of satellite, cellular and hard lines.

Digital Dashboards

By consolidating and integrating data from diverse sources and departments into a comprehensive picture of current and anticipated risks in a community, all stakeholders can have a consistent and clearer picture of current, emerging and future risks. Digital dashboards, sometimes connected to early warning systems, can provide real-time, simplified and visual information to support critical decision-making. Mapping application like GIS can also help to analyze environmental and socio-economic data to better understand potential impacts and vulnerabilities.

Autonomous Tech

Technologies that operate through machine learning or AI are just starting to emerge as part of the climate adaptation approach for public spaces. Autonomous tech applications can be used to support any kind of adaptation action in a public space. For example, autonomous tech can take data from sensors that might include wind, sun or water conditions to automatically adjust watering levels, to save, recycle or upcycle water as needed. For example, an [ambitious project in the Netherlands](#) is using autonomous tech to manage water flows in public spaces designed to absorb them.

¹⁶ Kovacs et al., *Cities Adapt to Extreme Weather*, 88-92.

¹⁷ Sophie Guilbault et al., *Cities Adapt to Extreme Heat: Celebrating Local Leadership*, ICLR, 2016, 20-23, <https://www.iclr.org/wp-content/uploads/PDFS/cities-adapt-to-extreme-heat.pdf>.

Technology Success Factors

As you embark on deploying technology solutions in your climate resilience initiative, reflect on these key factors with the team to ensure a successful and impactful experience.

Have you aligned your tech-based solution to your resilience goals?

Is your internet reliability and speed robust enough to support the technological solution?

Do you have capability internally to implement the solution? Do you have a way to build it? Will you need to engage external help?

Do key stakeholders and decision-makers support this action?

Have you talked to others to learn from their experiences?

Are you considering working regionally?

Have you considered any barriers to implementation that may require a social or governmental intervention?

Are you developing protocols and guidelines for the usage of this kind of technology?

Have you considered the timeline and total implementation costs (including capital and operational)?

Do you have a strong implementation (tech) partner?

Do you know who in your community will be the lead agency?

Do you know how you will foster open and frequent communication and collaboration across departments and stakeholders?

Do you have a way to ensure cybersecurity for the data?

How can you build capacity, capability and institutional knowledge through the project?

You have now concluded the tools shared through the Technology-Based Solutions for Resilience Toolkit. Well-done. Your community has now taken some important steps towards leveraging technology as part of your efforts towards greater climate resilience. You have worked on a plan, responding to the risks your community faces, that you can now understand more clearly. You have also explored technology options to both help you understand your risks and take action to address them. We hope that this toolkit has helped you in taking action towards your resilience goals – and we are excited to hear where this takes you as we all strive towards a better future.



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UNFCCC (Climate Change Secretariat), *Technologies for adaptation to climate change*, 2006, https://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf.

Additional climate change resources can be found here:

Government of Canada, website, “Climate-related resources for local governments”, <https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/local-government-resources.html>.



Climate Adaptation in a climate change context means any measures taken with the intent of reducing the negative effects of climate change on built, natural and social systems, to cope with the consequences, or to take advantage of the positive effects.

Climate the weather of a place, averaged over a period of time, often in 30 years, and includes both the 'normal' and extreme weather for a particular place.

Climate Change is measurable changes in weather patterns over a long time (decades), and may be due to natural or human causes. Changes occur in the composition of the atmosphere, when greenhouse gases build up and get trapped.

Climate Mitigation is any action or response intended to reduce or prevent greenhouse gas emissions, or to enhance sinks that capture or store carbon, usually towards long term benefits.

Digital twin is a virtual replica of physical assets, processes and systems in a community.

Extreme Weather Event is a rare (by location or season) meteorological event, that is outside the normal range for a location. Examples include flooding, heat waves and intense storms.

Hazard is a natural event or process that may cause harmful impact to humans or the natural world.

Impact the effects of existing or forecasted changes in climate (hazards) on built, natural, and human systems.

Likelihood refers to the probability of an event or hazard occurring.

Machine learning is a form of artificial intelligence where computers use data and algorithms to "learn" over time, improving the performance of tasks over time and mimicking how humans learn.

Resilience is capacity of individuals, communities, and institutions to design and implement solutions that allow them to adapt, grow and innovate in the face of future disruption and systemic change.

Climate Resilience describes the capacity to respond to resist, respond to, adapt to or cope with climate change impacts.

Risk is the likelihood of an event occurring combined with the negative consequences and impact.

¹⁸ Definitions adapted from these sources: <https://icleicanada.org/wp-content/uploads/2019/07/Guide.pdf> (p. 9); <https://ccme.ca/en/res/riskassessmentguidancesecured.pdf> p. i-ii; p. A14.

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