



A Review of Municipal Climate Change Adaptation Best Practices

CLIMATE CHANGE PROGRAM
CITY OF CALGARY

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Introduction

Climate change is being experienced in communities across Canada, increasing their vulnerability to hazards such as rising temperatures, more frequent and intense storms, floods, heat waves and wildfires. As Environment and Climate Change Canada and the Federation of Canadian Municipalities note¹ “local government services and infrastructure are increasingly being affected by these events, with each region of the country experiencing impacts differently. All orders of government and sectors of society have a responsibility to become informed and to take appropriate action within their mandates to prepare for and adapt to the impacts of climate change.”

Climate change is changing the context in which development takes place by changing the nature and intensity of climate-related risks. Climate adaptation can be the result of a deliberate policy decision, or as a response to changes in natural or human systems. It can be anticipatory, before climate impacts occur, or reactive to the direct experience of climate change impacts. Current development interventions that fail to address climate change or rely on incremental adaptation at too small a scale, are likely to result in unintended consequences including ‘maladaptation.’

This white paper has been developed to document the state of climate adaptation best practices in municipal planning to inform The City of Calgary Climate Strategy 2022 and Climate Adaptation Action Plan 2022. Along with examples of municipal and institutional best practices, the state of The City of Calgary’s climate adaptation planning and data analysis and tool development has been reviewed and compared. Identifying the most effective and economically feasible paths forward for consideration in planning processes and community engagement requires continued improvement in adaptation planning.

Climate Change Adaptation in the Municipal Context

Climate change adaptation activities help to prepare and protect against current and future impacts of climate change by safeguarding assets and protecting vulnerable populations in the face of increasing extreme weather². The International Panel on Climate Change (IPCC) defined climate adaptation in its Third Assessment Report³ as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.” Addressing climate change requires a consideration of the interdependence of adaptation activities, and the additive effects of actions taken for buildings, infrastructure, services and people on their environment, use, community, and surrounding area.

Municipal governments are on the front line to respond to the impacts of climate change, and in Canada more than 80 per cent of the population lives in urban areas⁴. Cities are complex and integrated social-ecological systems in which humans and their surrounding environment are integrally connected⁵. Municipal climate adaptation planning must be considered in the context of public and private facilities, public and private infrastructure, communities, natural assets, and the surrounding environment. Building on existing land-use planning, regulations, and guidelines is one of the effective approaches to municipal climate adaptation⁶.

There are a variety of strategies for municipal climate change adaptation actions, broadly including:

- **Policy Development** - revising or creating relevant bylaws, regulations and policies.

- **Program Development** - such as developing mechanisms for land-use planning, building standards, maintenance requirements, occupational health and safety systems, rebates and incentives.
- **Information Availability** - providing information about climate risk and vulnerability mapping.
- **Outreach and Engagement** - raising awareness and conducting educational campaigns are important to develop a common understanding and encourage greater individual and community-level preparedness for climate change.
- **Capital Investments** - funding and investments for improved design in Capital infrastructure, lifecycle asset management, and increased priority on building climate-adapted and resilient infrastructure, including natural infrastructure.

Municipalities were selected for the best practice review based on the maturity of their adaptation planning or for their context in terms of population. The review included:

- Vancouver, Canada
- Montreal, Canada
- Edmonton, Canada
- Toronto, Canada
- Halifax, Canada
- Mississauga, Canada
- Boston, United States
- New York, United States
- Portland, United States
- Norway – selected towns
- Denmark, European Union – selected towns

Challenges to Achieving Municipal Climate Adaptation Measures

Challenges to implementing and achieving climate change adaptation measures are considered because they present important context for the best practices noted in subsequent sections. Climate change adaptation must become part of the mainstream and considered as part of existing government policies, institutions and processes^{6,7}. As Armstrong et al. (2021)⁸ note, the climate action movement has plateaued, in part because the current model is not sufficient to drive change as far and as quickly as necessary. The current approach to planning and executing climate adaptation strategies is not centering community values, not changing systems, and not getting communities to their climate targets or to a host of community goals⁸.

Implementation of climate adaptation activities are determined by a number of factors such as the efforts of individuals within the municipal organization, network participation, access to resources, use of external expertise and research projects, and previous experience with extreme weather events (Dannevig et al. 2015)⁹. The number of these factors present in each municipality affected how far in the implementation process they have come.

The following challenges to achieving and measuring climate adaptation goals have been noted¹⁰:

1. Climate adaptation is not an objective or an endpoint, but a process of continual adjustment and there is no clear measure or benchmark that signals that an adaptation measure is successful. Often, evaluation of adaptation relies on proxy measures that relate to the achievement of broader societal and/or environmental aims.
2. Uncertainties are inherent when implementing climate adaptation intervention, and in virtually all monitoring and evaluation processes.
3. Climate adaptation must inherently measure avoided impacts, however in the absence of a climate event occurring, it is onerous to measure how much worse the situation would have been without the intervention.
4. Natural and socio-ecological systems undergo continuous change over time and so the use of a fixed baseline may lose some validity. With this consistent variability, baseline data may not always provide a solid reference point, and therefore climate adaptation is constantly tracking towards a moving target.
5. Climate adaptation spans multiple scales and sectors and requires diverse programming strategies for populations and locations. While climate adaptation is predominantly a local process, progress towards it is often examined at much higher levels, and often at a sector scale. It can be very difficult to compare or aggregate best practices in an effective way because of the eclectic range of sectors, the availability of data, and site-specific context required for adaptation measures.

The most up-to-date and relevant municipal planning information has been included in this white paper, which has scanned across examples in Canada, the United States and the European Union. We have scanned the vast volume of climate change and adaptation literature and initiatives currently available however, this is not an exhaustive report and should be viewed as a snapshot of current best practice status, selected relevant activities, and notable recommendations that have been made.

Assessing Climate Change Best Practices

Climate adaptation best practices can be broadly categorized in three buckets:

- addressing the existing adaptation deficit
- managing incremental changes in climate-related risks
- proactively addressing the longer-term manifestations and impacts of climate change by transforming or replacing existing systems and practices

For this white paper, the organizing structure of the Tracking Adaptation and Measuring Development (TAMD) framework has been used. TAMD is a twin track framework that evaluates adaptation success as a combination of how widely and how well institutions manage climate risks (Track 1) and how successful adaptation interventions are in reducing climate vulnerability and in keeping development on course (Track 2)¹¹. In considering municipal climate adaptation best practices, the most useful information is within how a practice was developed and supported, rather than a list of climate adaptation actions (which are particular to each municipality). In this context, TAMD provides the best practice, and information from municipal sources is arranged to describe examples and processes.

The scope and scale of institutional, people and financial investments in climate change adaptation means that assessment of expected and actual returns needs to be robust¹¹. We need to know how effectively adaptation keeps development on track, and even more importantly, how equitable adaptation costs and benefits are distributed. Climate adaptation requires transformational change that shifts away from business-as-usual approaches. To that end, the TAMD working group¹¹ noted that the criteria likely to be most important in the evaluation of climate adaptation include:

- Feasibility
- Efficacy/effectiveness
- Efficiency
- Acceptability/legitimacy
- Equity
- Sustainability

This white paper has therefore scanned for municipal best practice information that demonstrates these criteria, and provides context for the climate, community and capability conditions in which they are located.

Categories of Climate Adaptation Best Practices

The organization of the best practice information in this white paper follows the generic institutional climate risk management indicators in the TAMD framework^{11,12}, which have been well-organized and tested for the past 10 years worldwide. These indicators are:

1. Climate change integration into planning
2. Institutional coordination for integration
3. Budgeting and finance
4. Institutional knowledge and capacity
5. Use of climate information
6. Adaptation planning under uncertainty

7. Participation
8. Awareness among stakeholders

The ninth indicator from the TAMD framework¹² has not been included for the purposes of this white paper, as it refers to the assessment of vulnerability and resilience for specific communities within a municipality. While this is a critical process, it is specific to each municipality, and the best practices that influence it are covered under the other eight categories contained in this white paper.

1. Climate Change Integration into Planning

The TAMD framework defines “climate change integration into planning” as being the extent to which considerations of climate change (e.g., risks, opportunities) are integrated into organizational planning processes in municipal contexts¹¹. It requires long-term thinking (30+ years)¹⁰ and building capacity to address climate change through the development of climate plans, strategies and mainstreaming mechanisms or systems.

Best practices in this area typically include the following elements¹¹:

- A climate change plan or strategy in a dedicated strategic document, or in principle organizational planning documents
- A formal (legal) requirement for climate adaptation to be integrated into development planning
- Climate-relevant initiatives routinely screened for climate risks
- A formal climate safeguard system to integrate climate risk screening, risk assessment, reduction measures (identification, prioritization, implementation), evaluation and learning

Other Municipalities

Climate strategy documents generally provide information on vulnerability and climate risk assessments, provide climate data analysis to support actions, and address reduction of carbon emissions, preparation for climate change events for the built environment and human health and safety, preserving environmental assets, and addressing waste management issues^{4, 13, 14, 15, 16, 17, 18, 19, 20}. Specific content will differ based on the geography of the city (e.g., coastal, inland, high or low elevation). Online progress dashboards and machine-readable document formats are increasingly available as access tools.

In many cities, development or support of a climate strategy document has been preceded by, or is in alignment with a declaration of climate emergency for the municipal area^{4, 20, 21, 22}. Successive revisions and updates of climate strategies are typically to refine climate mitigation and adaptation actions, to support actions with specific data analysis, and to revise actions where activities have already taken place or need to be changed. Public-facing resilience plans (e.g., heat resilience, flood preparation, urban forest and natural asset protection, open space and recreation plans) develop the strategy into more specific documents that can be used to direct council and public actions, and provide context for specific parts of the planning and development continuum in each city. Integrating existing climate preparedness, public health and equity initiatives are common elements for these plans.

Legal requirements for climate adaptation are generally through council approval of climate resilience strategies and are integrated into planning in different formats. For example, Edmonton’s climate strategy¹⁷ is integrated into development planning through a section of the City Charter. Montreal¹⁵ and Edmonton²³ have updated city bylaws for the construction and conversion of buildings that will require

compliance with the National Energy Code for Buildings. In Vancouver, the British Columbia (BC) government published the BC Climate Leadership Plan²⁴ (2016) which mandates 10-year adaptation plans for public sector operations and supporting more resilient infrastructure. In 2014, the Vancouver City Council adopted amendments to the building bylaw to address the increased risk of flood damage¹⁶. In Toronto, the Climate Change Risk Management Policy commits the city to integrate climate change resilience into decision-making, and coordinates operations and services²⁰.

Climate strategies that have been in place for some time (for example OneNYC in New York in 2015 [based on a 2013 resilience plan]¹³, and the Metro Boston Climate Adaptation Strategy in 2014¹⁴) have a well-developed advisory system with support and oversight from external and internal groups. The City of New York has a Climate Advisory Board (chaired by the Office of Sustainability and with 16 appointees comprising architects, engineers, property owners, representatives from the business sector and public utilities, environmental justice advocates and tenant advocates), as well as the New York City Panel on Climate Change (NPCC), a group comprised of scientists who study climate change and its impacts as well as legal, insurance and risk management experts. The NPCC has been releasing climate risk projections and information since 2009 and works with the New York City Climate Change Adaptation Task Force (city, state, federal and private infrastructure operators and regulators) to assess risk to New York's critical infrastructure.

Montreal has developed a comprehensive system to impose a climate test to prioritize large scale projects (implemented over a three-year period) and has incorporated climate change adaptation measures directly in its budget and financial documents^{15, 25}. Currently, Montreal has allocated 10 per cent of the 10-year capital expenditures budget to climate adaptation¹⁵. The City of Vancouver's climate risk assessments mirror the process recommended in the *Preliminary Strategic Climate Risk Assessment for British Columbia*²⁶ which evaluated the likelihood of 15 climate risk events that could occur in BC, and the health, social, economic and environmental consequences.

The City of Calgary

A Climate Resilience Strategy was developed in 2018 for the City of Calgary, which included specific Climate Mitigation and Climate Adaptation Action Plans in addition to information about climate data and risks for the City, and leadership planning to deliver climate-related planning. The Climate Resilience Plan and Climate Adaptation Plan are currently being updated for 2022 to reflect updated climate data (e.g., downscaled climate model information that has allowed community climate risk indices to be created) and updated actions based on priority programs of work (e.g., for City-owned, public and community infrastructure, natural assets, community climate equity integration, and socioeconomic risks affecting Calgary communities). Funding of some of the climate adaptation action priorities is directed through the Action Plan for the City.

In Calgary, legal requirements for climate change integration into development planning are through the City Charter and Council Approval of the Climate Resilience Strategy. The Charter requires an update of Climate Action Plans every five years, and the Council requires updates to occur one year before each business cycle. To develop a formal climate safeguard system, a Climate Risk and Resilience Overlay on The City's Planning and Development Continuum is currently underway as part of a larger review of the Growth and Development Framework for the City. Understanding the intersection of current City planning processes and inputs is critical to integrating climate risk screening, risk assessment, reduction measures, evaluation, and feedback loops in the Planning and Development Continuum.

2. Institutional Coordination for Integration

The TAMD framework defines “institutional coordination for integration” as being the extent to which climate risk management (CRM) is coordinated across relevant departments with a responsibility to integrate CRM into their activities. It is relevant because the building of capacity to address climate change requires strategies and mainstreaming mechanisms/systems such as the following best practices¹¹:

- Having a coordinating body tasked with climate change planning and actions, with influence and importance to other departments
- Dedicated institutional mechanism for coordination and implementation across sectors
- Dedicated funding or certainty of long-term funding to sustain this mechanism
- Regular contact between the coordinating body and relevant ministries and agencies

The ICLEI–Local Governments for Sustainability (ICLEI) Adaptation Changemakers project²⁷ described these best practices as moving away from pilot projects and towards mainstreaming climate considerations into everyday processes and long-term planning, especially with respect to nature-based solutions and protection of key infrastructure (e.g., roads, water supply and wastewater systems, electrical grids, and telecommunications). Doing so requires that the right technologies and service solutions are supported by, and embedded across, an entire municipal organization.

Other Municipalities

The common theme as to how municipalities manage institutional coordination is the presence of a dedicated climate adaptation team supported by internal stakeholder groups made up of subject matter experts who represent asset and service areas. In New York City, The Mayor’s Office of Climate Resiliency (MOCR) is supported by the NPCC (external experts) and an internal Climate Change Adaptation Task Force²⁸. The MOCR is responsible for science-based analysis, policy and program development for existing resiliency needs and advancing a strategic vision, and leading collaboration across city departments, sectors and community organizations²⁸.

Similarly, in Portland the Bureau of Planning and Sustainability²⁹ and in Montreal the Bureau de la transition écologique et de la résilience (The Office of Ecological Transition and Resilience)²⁵ are home to climate change planning. These Bureaus are responsible for managing climate action plans and coordinating adaptation activities across all city departments. Portland has noted that the barriers to coordinating the implementation of climate actions include challenges with cross-department collaboration and sharing of resources, constantly updated funding sources and/or budget cuts, lack of champions for specific efforts, and shifting priorities as equity is integrated fully into climate work (which may change responsible departments)²⁹. The development of capacity and new skillsets to prioritize and continuously improve equitable outcomes in planning and implementation of climate action is seen as critical for the work of these climate-focused Bureaus^{25, 29}.

The City of Vancouver has an Adaptation Steering Committee of senior managers who provide oversight for implementation of climate adaptation planning and activities³⁰. This group tracks progress of the Resilient Vancouver Strategy and reports to Council annually, with the Sustainability group within the Planning, Urban Design and Sustainability department coordinating and implementing actions with City Corporate functions and departments.

In 2019, the Vancouver City Council approved a budget and capital plan emphasizing resilience as a key objective of the City’s investments and recognizing the need for new tools to support integration of resilience into financial planning and budgeting³⁰. The Finance and Resilience team has worked with 100 Resilient Cities (100RC)³¹ platform partners to review leading practices and lessons learned from municipalities around the world. Further information about budget and funding practices is provided in Section 3.

Joining global networks of cities has provided support for climate adaptation planning, such as 59 towns and cities in Canada who have joined the Compact of Mayors (now the Global Covenant of Mayors for Climate and Energy), an organization of mayors from across the world making voluntary commitments to reducing the impacts of climate change³². Montreal, Toronto and Vancouver all belong to the C40 Cities climate leadership group, which focuses on collaborative and urgent climate action that is clearly aligned with science-backed targets³³. In 2018, The City of Edmonton hosted the inaugural Intergovernmental Panel on Climate Change (IPCC) Cities and Climate Change Science Conference, from which the resulting Edmonton Declaration was a call to the global scientific community to advance its efforts in support of evidence-based climate action in cities, to support ambitious climate resiliency plans³⁴. Over 3,400 municipalities from around North America have endorsed the Edmonton Declaration, with a focus on engaging all levels of government in urgent climate change action planning, and engaging the scientific community and governments to provide better data for decision-making³⁴.

The City of Calgary

The City of Calgary has a Climate Program and dedicated Climate Team (Adaptation, Mitigation and Governance and Strategic Planning) with limited long-term committed funding, aligned with the five-year OneCalgary business plan (2019-2022) process³⁵. Planning and action decisions made by this team are supported by a network of external (Calgary Climate Panel and the Panel’s Climate Adaptation Working Group) and internal (working groups and subject matter expert cohorts) reviews and input.

The City of Calgary received an “A” grade in the 2021 CDP Cities Scoring Methodology, acknowledging the strength of climate adaptation and mitigation plans, and risk and vulnerability assessments carried out as part of City project and planning work³⁶. The A grade for adaptation (defined as cities preparing for and adapting proactively to actual or expected impacts of climate change) is higher than the regional average (B) and global average (D) scores³⁶. A Climate Emergency declared by the City in November 2021 will reinforce the authority and importance of the Climate Program and provide support for the resources needed to strengthen coordination with federal and provincial ministries and agencies.

3. Budgeting and Finance

The TAMD framework defines “budgeting and finance” as the extent to which actions, measures and processes to address climate change are costed, budgeted for, and provided with the necessary financial support. Best practices in this area typically include the following¹¹:

- Funding to pilot measures that address climate change – specifically adaptation and risk management
- Funding to roll out integration of climate adaptation
- Mechanisms to assess costs associated with measures to address climate change (from screening or risk assessment)

- Funding available to cover costs of climate change measures identified during climate screening/risk assessment
- Actions to address change supported by an authoritative financial entity

In addition to these, following the Task Force on Climate-Related Financial Disclosure (TCFD) requirements for annual financial reporting is a best practice because it quantifies climate-related information in financial terms, such as infrastructure investment needs and the costs of inaction, health and other social costs, economic growth potential from clean-economy investments, and integrates climate-related risks and opportunities into operational budgeting and long-term capital planning to allocate resources where needed^{27, 37, 38}. Sorting and reviewing information for the TCFD reporting categories of governance, strategy, risk management, and metrics and targets generally enhances data collection and sharing to improve decision-making^{37, 38}.

In 2020, the Federation of Canadian Municipalities (FCM)³⁹ noted that municipalities in Canada were likely facing a near-term funding gap of \$10-15 billion, and identified the following self-funded and financing tools available for climate adaptation work (noting that some were developed for climate mitigation purposes but can be transferable for adaptation):

- Group purchasing
- Revolving fund
- Local improvement charges
- Retrofit programs
- Time-limited competitive funding from FCM programs
- Green Municipal Fund
- Municipal Asset Management Program

Other Municipalities

Apart from disclosure of some information related to specific activities, such as the initial development of climate strategy documents (in the United States, development of climate adaptation strategy documents has been costed in direct costs and staff time in the range of \$75,000 to \$150,000 in smaller towns^{40,41,42} to \$1.5 - \$2 million in larger cities^{13,14}), information on direct costs and staff allocations for climate adaptation planning and projects can be difficult to parse from municipal budget documents. This can be because climate adaptation work is carried out within larger planning and sustainability teams that do not discretize climate planning work, or costs are embodied in specific climate projects (capital and/or operational budgets) that are not directly disclosed.

In Canada, the cities of Montreal and Vancouver have provided more specific information about budgeting and expenditure for climate adaptation activities, in part because they were two of the first cities in Canada to begin TCFD aligned disclosures in annual financial reporting. The City of Montreal developed a climate plan¹⁵ and called for the city to develop incentives and provide municipal funding for environmentally responsible habits, dedicating 10 per cent of the city's 10-year capital expenditure program to climate change adaptation and to impose a 'climate test' on city decisions. This climate test on contracts, infrastructure projects and bylaws will favour best practices and prioritize projects that optimize efforts to address climate change¹⁵. Some larger projects (>\$10 million) would also qualify for funding from Infrastructure Canada – Climate Lens⁴³.

In the City of Vancouver, 2021 Budget climate change investments include new activities (\$2.5 million) as stated in their TCFD report⁴⁴. In the 2021 Budget and Five-Year Financial Plan, the City of Vancouver also outlined investments for accelerating action on climate change, including existing and ongoing activities (\$44.1 million), new activities (\$2.5 million) and capital investments (\$55 million)⁴⁴. In addition, The City of Vancouver has accessed federal grants to create the Pathways to Disaster Risk Reduction initiative (\$4 million) aimed at transforming regional understanding about the cascading impacts of earthquakes and climate change hazards, and to create cost-benefit analysis tools for risk reduction.

The City of Edmonton has also joined the move to TCFD aligned reporting in annual financial reports as of 2019, and for the years 2019-2022, identified an operating budget for climate resilience initiatives of \$2.5-3 million per year⁴⁵, and \$500,000 for new Climate Change Adaptation Strategy Team staff to develop and maintain a Climate Change Adaptation Plan and to support the calculation and reporting of a climate change resilience corporate measure⁴⁵. The development and maintenance of a Climate Change Adaptation Plan is a mandatory requirement under the City of Edmonton Charter Regulation.

The City of New York has a participatory budget process as part of annual budget planning called myPB that facilitated the allocation of \$210 million to 706 community-designed projects over the last eight years⁴⁶. This has led to the improved delivery of local services, some of which have been climate adaptation projects proposed and led by community members.

The City of Calgary

Public Infrastructure Climate Risk & Resilience Assessment pilot projects (generally high-profile projects) are underway at The City of Calgary, funded through the Climate Program in partnership with the infrastructure-owning business units. In project-specific climate risk assessments, some climate risk mitigation measures are costed but this is not yet a widespread practice. The Climate Adaptation Team has been involved in a national Adaptation Return on Investment Project and internal Resilience Dividend Toolkit Project to provide context for decision-making and prioritization of climate adaptation projects. The City Water Resources team has created a cost-benefit analysis model and associated funding mechanism for climate risk reduction projects specific to river flooding, and the Sustainable Infrastructure team is piloting an Autocase for Buildings tool to assess and optimize the lifecycle financial, social and environmental value. Alignment of these tools and further information related to return on investment for imminent climate adaptation decisions is a focus for 2022.

Budget adjustments for 2022, and the 2023-2026 budget process are currently underway with significant focuses on climate adaptation in response to the declaration of a Climate Emergency approved by City Council in November 2021.

4. Institutional Knowledge and Capacity

The TAMD framework defines “institutional knowledge and capacity” as the extent to which development and adaptation planning is informed by knowledge of climate change in general and specific knowledge relating to methodologies for integrating or mainstreaming climate change into organizational planning, and the extent to which staff are trained in relevant areas¹¹. Best practices in this area include organizational planning involving teams with awareness of climate change and formal training in the issues and overseeing the integration of climate change into organizational planning by staff members with in-depth knowledge of integration processes.

The ICLEI also notes that best practices in this area recognizes resilience and climate-readiness as a strategy for²⁷:

- Attracting business and people to the city
- Focuses on equity, health and biodiversity
- Local solutions for local impacts / locally identified adaptation actions
- A focus on prevention and risk reduction, including a “window of reaction” from a major event being 12-18 months; for midterm planning (1-10 years); and for long-term planning (10+ years)
- The political will, public support and available funds to support action

Other Municipalities

The City of Montreal has centered its climate adaptation activities in the Bureau de la transition écologique et de la résilience (The Office of Ecological Transition and Resilience), which is staffed by engineers and planners within the larger Environmental Planning and Monitoring Division of the Department of Environment¹⁵.

At the City of Vancouver, departments across the city are responsible for implementation of climate adaptation actions⁴⁷. The Risk Management Committee oversees risk governance and the general risk framework, the Adaptation Steering committee (comprised of senior managers) provides oversight to implementation, and the Sustainability group tracks progress in the Adaptation Strategy and reports to Council annually⁴⁷. Similarly, at the City of Toronto, the Resilient City Working Group oversees and tracks climate adaptation activities, and is made up of a multi-sectoral team of 18 city divisions²⁰.

At the City of Edmonton, the Environmental Strategies Section addresses and reports on climate-related risks and opportunities to Council and Committees⁴⁸. An Energy Transition and Climate Resilience Committee (ETCRC) was appointed by Council to advise the Environmental Strategies Section and city departments, as each city department and branch is responsible for identifying and assessing their own climate risks, through a formal Vulnerability and Risk Assessment process.

The City of Portland’s Bureau of Planning and Sustainability is responsible for climate adaptation and mitigation planning and activities. It is noted that a significant proportion of Bureau work is reliant on one-time funding, which is hindering their ability to move projects forward in a timely way, and to thoughtfully resource projects and community partners. The adopted budget for 2020-2021 for Portland notes that stable funding is foundationally critical to long-range planning and sustainability initiatives to provide equitable service and results in the community⁴².

The City of Calgary

At the City of Calgary, institutional knowledge and capacity is largely provided by the Climate Program, made up of component climate adaptation, climate mitigation and climate governance and strategy sub-teams. Climate adaptation team members are trained in multi-disciplinary aspects of adaptation planning ranging from planning and engagement to infrastructure, environmental and natural asset protection. At this time, climate adaptation is still perceived as a primarily environmental issue, but the scope of this focus is being expanded by:

- Recent work on the Planning and Development Continuum (see Section 1)

- More attention on holistic socioeconomic aspects of climate change through the Climate Emergency Declaration by Council in November 2021, and by the Community Climate Risk Index project
- Use of the Public Infrastructure Climate Risk and Resilience Assessment process and prioritization criteria
- Development of a Natural Asset Evaluation for the City

5. Use of Climate Information

The TAMD framework defines “use of climate information” as the extent to which adaptation and adaptation-relevant development interventions are informed by information about climate change (nature, magnitude, rapidity, local manifestations, associated risks), and the extent to which they help to generate new information about climate change¹¹. Best practices for use of climate information include:¹¹

- Use of observational data relating to climate trends
- Climate information readily available and accessible through information-sharing platforms
- Climate information gathered by international organizations is readily accessible and used
- Capacity to interpret and use climate information exists (e.g., scenario planning, risk and vulnerability assessments, frameworks)
- Scientific information is complemented by the use of Indigenous knowledge

In a recent white paper focused on Nordic countries⁴⁹, five reasons were identified for the limited uptake of adaptation research in policy and decision-making:

1. Theoretical concepts and constructs developed and applied in adaptation research do not relate to the decision reality of stakeholders
2. Uncertainty surrounding the potential impacts of climate change makes stakeholders inclined to wait and see rather than act
3. There is a mismatch between the local scale on which many stakeholders operate and the smaller-scale climate information provided by models (for which appropriate down-scaling is required and needs to be applied accurately)
4. There is a mismatch between stakeholders’ primary concern to manage current climate variability and the medium- to long-term perspective of a lot of adaptation research
5. Adaptation research often ignores the fact that adaptation is not the only priority for many stakeholders

Knowledge is different than data in that it includes the analysis and accumulation of facts and observations to provide an understanding about how human communities and the natural environment function in response to climate change. The United Nations University Traditional Knowledge Initiative⁵⁰ noted that this approach is central to Indigenous knowledge, in that Indigenous peoples around the globe have a variety of successful climate adaptation strategies to share. The majority of these are planned adaptive responses that are based on traditional ecological knowledge about modifying existing practices or restructuring relationships with the environment. Examples of Indigenous knowledge and best practices for climate adaptation collected from around the world include⁵⁰:

- The application and modification of traditional ecological knowledge

- Shifting resource bases
- Altering land use and settlement patterns
- Blending of traditional knowledge and modern technologies
- Fire management practices
- Changes in hunting and gathering periods and crop diversifications
- Management of ecosystem services
- Awareness-raising and education, including multi-media and social networks
- Policy, planning and strategy development

The ECCC and FCM Discussion Guide¹ notes that Indigenous knowledge is “inherently built upon and grounded in generations of place-based observations and experiences.” Indigenous knowledge systems connect an extensive knowledge of ways of knowing and beliefs, ecosystems and oral land histories that can inform climate adaptation, both independently and combined with scientific knowledge. The Guide¹ notes that the inclusion of Indigenous knowledge systems should be built into all aspects of the adaptation process, including forms of impact, vulnerability and risk assessments to adaptation planning, implementation and monitoring of strategies.

Other Municipalities

The City of New York has a specialist New York City Panel on Climate Change (NPCC) made up of 20 independent members who synthesize scientific information on climate change and advise City policymakers on local resiliency and adaptation strategies to protect against rising temperatures, increased flooding, and other hazards²⁸. These experts have background in climate science, demography, engineering, geography, vulnerability analysis, global change, architecture and urban planning. They have helped to improve building codes to address future storms and extreme weather as part of the Climate Resiliency Design Guidelines, provided future flood conditions for comprehensive waterfront planning and capital waterfront projects, produced an in-depth assessment of climate equity and community-based adaptation planning methods, and justified upgrades and protections to critical infrastructure²⁸. Their analysis of significant barriers to using climate information were that lack of capacity and funding were the greatest issue, followed by²⁸:

- Lack of expertise
- Lack of information at the right geographic scale
- Lack of information on needed variables
- Financial constraints and narrow approaches to cost benefit analysis
- Lack of shared goals among stakeholders or approaches to consensus building

At the City of Boston, the Greater Boston Panel on Climate change has research advisory groups that update projections as part of a metro Boston regional project¹⁴. The Planning and Development agency releases climate change resilience and preparedness checklists and flood hazard maps by community.

The City of Montreal uses Ouranos, a consortium and consultation forum on regional climatology, to collect meteorological and hydrological observations and make climate projections generated for the region publicly accessible through their website (Version 1.2 of Climate Portraits)⁵¹. The climate information provided by Ouranos is intended to be used to develop scenario planning, and risk and vulnerability assessments and frameworks.

Climate change models used by the IPCC have been combined with a variety of scientific studies to assess potential climate changes for the City of Edmonton, which were identified as changing temperatures, changing precipitation, changing weather extremes, and changing ecosystems¹⁷. Similarly, the City of Halifax has completed a Climate Adaptation Baseline Report in support of the HalifACT Community Energy and Climate Action Plan that has been used to assess potential climate changes for the region⁵².

In the City of Toronto, an Indigenous climate action summary report has been created with local peoples in Tkaronto to review world views, environmental Indigenous traditional knowledge and ideas for development, in a process for ongoing collaborative urban climate action⁵³. The recommendations from this consultation and review process were to⁵³:

- Have more meaningful Indigenous engagement on climate adaptation questions
- Bring climate and the environment out of their silos
- Need and support full cost accounting
- Respect and engage meaningfully with Indigenous knowledge and practices
- Accommodate the urban Indigenous cultural resurgence
- Reflect and relate to the realities on the street
- Support Indigenous relationships with urban land, water and food

At the City of Vancouver, historical climate observations are provided by the Pacific Climate Impacts Consortium (PCIC) at the University of Victoria, British Columbia^{30,54}. Downscaled climate projections for Vancouver are provided online by PCIC, and have been used (with data available in the Climate Impacts Summary⁵⁵) for risk assessments completed by the city. The coastal flood risk assessment program was developed in partnership with the Musqueam First Nation in early work along the Fraser River, and will continue to collaborate with the Musqueam, Squamish and Tsleil-Waututh Nations as coastline areas are addressed³⁰.

The City of Calgary

Down-scaled climate data developed for the City of Calgary by the consultancy GHD and Pacific Climate Impacts Consortium (PCIC) is being aligned in the context of the Climate Adaptation Action Plan and Climate Strategy. Canada-wide and Calgary data have been made available through partnerships, and the City is aligned to national and international research bodies. Most of the data is not yet available in public formats, but this will change rapidly with the completion of The City's Urban Heat Island online tool, the Equity Index tool, Community Climate Risk Index, Natural Asset Valuation Dashboard and downscaled climate projection data.

Alignment with Indigenous knowledge is a gap that is being actively worked on for review and input to 2022 Climate Strategy and Climate Adaptation Plan processes. A review of Indigenous climate adaptation responses is currently underway to provide early guidance for further consultation and advice from Indigenous communities in and around Calgary.

6. Adaptation Planning Under Uncertainty

The TAMD framework defines “adaptation planning under uncertainty” as the extent to which climate change planning explicitly addresses uncertainty related to future changes in climate¹¹. Best practices associated with this area include¹¹:

- Incorporating the use of envelopes of uncertainty (plausible ranges of key climatic parameters over relevant timescales, and climate projections) in planning and wider climate change dialogues
- Scenario planning exercises based on envelopes of uncertainty
- Addressing risks associated with maladaptation in planning
- Guiding planning, design and decision-making by frameworks and methodologies that address uncertainty
- Mechanisms to ensure that planning guidance is updated with new information on climate change as it becomes available

The Prairie Climate Centre⁵⁶ has noted that the uncertainty in how climate change will occur, and its implications for social, economic, ecological and cultural systems, needs to be recognized, embraced and built into decision-making processes. In addition, the perceived cost of implementing transformational approaches can also be a barrier, particularly when there is also uncertainty about the potential benefits that will be achieved. Proposed measures often involve large, upfront investments in actions expected to yield positive benefits years or even decades in the future, and uncertainty in the outcome and possible maladaptations can make decisions difficult.

The complexity of approaches in the adaptation literature has been noted by Dobes⁵⁷, who commented that this is possibly due to the diffuse nature of climatic effects that may occur in very diverse geographical locations. The two most popular policy approaches appear to be risk management and various forms of composite indexes, including Multi-Criteria Analysis⁵⁷. Both approaches can pose risks of maladaptation (i.e., the inefficient utilization of community resources), therefore their growing use in government policy formulation requires a critical review.

Other Municipalities

The City of New York's State of Climate Knowledge Report in 2021²⁸ noted that processes such as decision science, adaptive management, flexible adaptation pathways and scenario planning approaches can help when making decisions under uncertainty. These approaches inherently rely on iterative, flexible planning processes which differs from historically structured and incentivized decision-making. Best practices noted in the Climate Knowledge Report²⁸ to address this tension include:

- New ways to assess which strategies are right for which areas
- Methods for assessing non-monetary values, equity and other social priorities
- Incorporating health and socio-economic impacts into decisions, including valuation of the health costs of climate change
- Including community knowledge on risk experiences as inputs to decisions
- Analysis of which costs and benefits accrue for which stakeholders over what timeframes
- Improved methods for comparing the benefits of natural resource protection to other resiliency measures

The City of New York's Climate Resiliency Guidelines⁵⁸ note that adaptable design may not apply equally to all types of projects or risk reduction. For example, flood mitigation measures may more easily incorporate an adaptable design than the selection of heat-vulnerable materials or below-grade drainage systems. The City of Montreal has included the recognition of great uncertainties for some hazards (e.g., destructive storms) in their Climate Plan¹⁵, as well as providing the constraints and

potential maladaptation risks for measures related to heavy rainfalls, heat islands and heat waves. Extreme heat and flood planning are updated annually through the special response plan coordinated by the Fire Safety Service – Civil Protection Centre. This plan measures episodes for extreme heat and maps neighbourhoods with priority intervention (extreme heat), and monitors for water levels along the St. Lawrence.

The City of Calgary

Data projections developed by The City of Calgary in 2020 were based on 2050 and 2080 timescales, but additional work to incorporate envelopes of uncertainty remains a challenge at this time. Projected climate hazards and climate risk processes are utilized in several formal frameworks and methodologies (e.g., the Climate Strategy, Climate Adaptation Plan, Public Infrastructure Risk and Resilience Assessments, and Community Climate Risk Profiles).

7. Participation

The TAMD Framework defines “participation” as the extent to which climate change planning involves all relevant stakeholders, in terms of both vertical representation (i.e. across different levels of governance) and horizontal representation (i.e. across a diversity of relevant stakeholders at any particular level but particularly the community level)¹¹. Best practices for participation require the inclusion of^{f11,27}:

- All relevant levels of governance (national, provincial, regional and local)
- Those who may be adversely impacted by climate change initiatives
- Those who are most in need of/likely to benefit from climate adaptation initiatives
- Poorest and most marginalized members of society
- Participation of all groups is sustained throughout planning and implementation
- Adaptation Plan actions tied to community participation - making them living documents to be regularly updated

Inclusive climate action starts with an inclusive process where all voices are represented. This underpins the delivery of equitable climate policies and promotes distribution of benefits more fairly across a city population⁴⁶. If there is no inclusive engagement process, then the vulnerability of communities can be worsened by their regular and systematic exclusion from traditional engagement processes related to climate change adaptation (and mitigation) practices. The factors that drive this kind of exclusion may include⁴⁶:

- Communities are not currently recognized within the political system or structures due to a lack of formal legal recognition
- There are cultural barriers e.g., the government cannot communicate in local and Indigenous languages
- There may be technological barriers that may prevent certain groups (e.g., those from limited economic means or older people) from engaging via online tools
- Characteristics of their identity are not protected or not given legal protection e.g., LGBTQI+ or informal or migrant groups

For best practice, inclusiveness is not about the number of stakeholders (quantity), but instead should be more considerate of who needs to be included or is currently excluded⁵⁹. Having overarching

principles that highlight equity as an important tenet is of value in climate strategy and climate adaptation plans. Involving the community in policy development through a co-management or design role will also generate individual and social capital by tackling the shared problem of climate change⁴⁶. This not only builds individual resilience, but also has the potential to build community resilience as individuals can take what they have learned and share it through their formal and informal networks

Other Municipalities

The City of Boston has a compensated Community Advisory Board to guide heat resilience planning that includes open houses, meetings, community ambassador touchpoints, and terms provided in six languages to¹⁴:

- provide a lived-experience perspective and personal knowledge related to the social, economic and cultural impacts of climate change
- Ensure that community priorities are reflected throughout the planning and design process by helping to create an effective, inclusive engagement process and identifying barriers to public feedback
- Help develop and maintain transparency about the planning process within the broader community
- Help honour past work and people's time investments by flagging duplication of efforts from prior and ongoing plans, and by highlighting feedback from prior plans that can inform this new project
- Inform and help refine the planning process in the interest of representing the diverse perspectives of the entire City of Boston community
- Carry forward the knowledge of the planning process beyond the plan document to support achieving community goals during future.

The City of Boston 2019 Climate Action Plan⁶⁰ solicited updates from 60 organizations across Boston including a section titled "Designing for Equity", which included ideas and principles to carry out each step in an equitable way. In addition, *CommunityPlanIt* in Boston engages residents in visioning exercises to inform climate action plans and advance climate change preparedness⁶⁰.

The City of Toronto's *TransformTO* Climate Strategy⁶¹ contains the following guiding principles: advance social equity; improve affordability particularly for vulnerable populations; protect low-income residents; contribute to poverty reduction; enhance and strengthen the local economy; maintain and create good quality local jobs; improve public health; and, create resilient communities and infrastructure. To support these guiding principles, the Environment and Energy Division has created a number of public participation methods including⁶²:

- Participatory emissions budgeting, where participants trade off greenhouse gas emissions reductions with other policy goals
- Story mapping, where community members become data recorders especially where under-reported infrastructure problems are taking place
- Own the strategy, with online platforms and expo events to highlight local people making a difference
- Art interventions and games – workshops and art installations

- Neighbourhood climate action grants for educational workshops, youth engagement, neighbourhood summits and fairs, local research, and art installations

In the City of Portland, the Portland Clean Energy Community Benefits Fund (PCEF) was designed by communities of colour and provides dedicated funding for community-led projects that address climate change and provide social, economic and environmental benefits⁶³. In April 2021, PCEF awarded its first grant recipients for a total of \$8.6 million of investments to benefit communities of colour, low-income people and other historically marginalized groups⁶³.

In the City of Vancouver, best practices from the Sendai Framework for Disaster Risk Reduction 2015-2030⁶⁴ are being implemented, which is a framework adopted by the federal and provincial governments. The first guiding principle of the Resilient Vancouver Strategy³⁰ is that of reconciliation, and this guiding principle is described by a Reconciliation Framework used in all city work. Development of the Resilient Vancouver Strategy³⁰ engaged more than 2,500 individuals from community organizations, interest groups, etc., many of whom represent marginalized members of the community.

The City of Calgary

Climate work in The City of Calgary is aligned with federal and provincial climate risk mandates, and the City participates in provincial stakeholder work. Direct input from community members and external stakeholder on development and updates of the Climate Strategy and Climate Adaptation Plan is undertaken and tools such as the Urban Heat Island, Community Climate Risk Index and Natural Asset Valuation have been communicated to the Calgary Climate Panel and Adaptation Working Group. There is currently a gap in general public and vulnerable community participation, which is being worked on in engagement meetings in December 2021 and early 2022 for the Climate Adaptation Action Plan update.

The City has also developed the Calgary Equity Index⁶⁵ which is a new, geographically-based planning and decision-making tool in an online platform (2022) that provides an initial screening about equity in Calgary. While this tool does not include specific climate risk or vulnerability indicators it will support community-based climate adaptation decision making. The Equity Index is based on the social determinants of health, which are social and economic conditions that influence people’s wellbeing, and is intended to:

- Provide an objective and relative measure of need, in relationship to opportunities or social and economic mobility
- Support decision-making to adjust resourcing and address needs within communities
- Be updated annually to allow for continuous improvement

8. Awareness Among Stakeholders

The TAMD Framework defines “awareness among stakeholders” as the awareness of climate change issues, risks and potential response options, and actions to promote such awareness, in different contexts¹¹. Best practices in this area include¹¹:

- Stakeholders are aware of climate change and implications for society, and aware of potential, ongoing or available climate change response options
- Relevant information reaches key stakeholders in climate-sensitive sectors

- There are mandates to raise awareness of and disseminate information about climate change (risks, impacts, responses etc.), and adequate funding for this work

Other Municipalities

In the City of New York, incorporating climate and environmental information into formal and informal educational opportunities is seen as an avenue for improving climate literacy and motivating action, and equal access to such educational opportunities is a priority. Educational opportunities contribute to more accurate assessments of climate risk at the individual and community scale and therefore have the potential to inform decision making²⁸. The State of Climate Knowledge document also noted strategies to address the gaps in this area of focus, including²⁸:

- Testing the use of multi-media and traditional formats for communicating climate information
- Incorporating climate and climate justice into curriculum at multiple education levels, and conducting research on best practices in implementation of climate curriculum
- Integrating psychology, behavioral economics, and other social science disciplines in the development of communication and outreach materials

In the City of Portland, integration of equity into climate work has been a focus with respect to raising awareness for all stakeholders⁶⁶. This includes increased capacity of city staff to understand and apply an equity lens in their work, building new organizational partnerships that have increased accountability to communities, and expanded policy perspectives such as the recognition that housing stability is a key climate resilience and mitigation strategy. Portland noted that the capacity of community-based organizations to engage in climate and energy work and to advocate in public processes has significantly increased, but more support is needed for community capacity⁶⁶.

In the City of Boston, building awareness among city stakeholders has been a focus for many years, and there are a number of awareness-raising initiatives that have matured in that time⁶⁰. The Climate Ready Boston Leaders program provides tools for volunteers to host community conversations about climate change including flood preparedness and understanding flood insurance, particularly in communities close to coastal flooding zones and that are traditionally disadvantaged in terms of community resources. Urban heat island mapping in Boston has been re-imagined as a community tool to allow the public to map hot spots and cool spots, and contribute to improvement of future versions of the map⁶⁰. In addition, the Heat Resilience Story Comic Builder allows community members to create a character and illustrate what you do to stay cool in a format that can be shared with family and community members. Neighbourhood idea sessions are delivered in a variety of languages, focused on the most heat-prone communities⁶⁰. Finally, the Climate Action Plan is available in six languages as an online Story Map (plain language version) to increase the accessibility of the planning information⁶⁰.

The City of Calgary

Over the past couple years, The City of Calgary has been working on the development of citizen-based climate action information and online webinars to reach community members. The Climate Panel and Adaptation Working Group contain a multi-sector spectrum of engaged community members. A portion of Climate Program Education and Outreach funding is focused on climate risk and adaptation, and further development is planned over the next year. The City has also partnered with the Alberta Council on Environmental Education and EcoSchools Canada to deliver in school programming including adaptation actions schools can take, shared climate hazard, impact and adaptation examples with

students through presentation at Mayor's Environment Expo, and finally, partnered with CPAWS to deliver experiential environmental education through a climate lens.

Conclusion

The goal of all climate adaptation best practices is to help answer the critical questions of¹¹:

- To what extent have adaptation interventions resulted in the integration of climate risk management into development policy and planning, or enhanced existing climate risk management capabilities?
- To what extent have adaptation interventions increased the ability of individuals, communities and institutions to develop and pursue their own adaptation strategies and measures (building adaptive capacity)?
- To what extent have adaptation interventions reduced the vulnerability of individuals and households to hazards associated with climate variability and change?
- To what extent have adaptation interventions increased the resilience of key sectors and natural/managed systems on which human populations depend?
- To what extent have adaptation interventions helped to keep development 'on track' with respect to existing development targets, where climate change and variability act to make the achievement of these targets more difficult?

Far-sighted and context-specific approaches that address changing climate risk contexts, allow for flexible responses to uncertainty and mitigate unintended consequences of governmental interventions, are needed to strategically and successfully implement effective climate adaptation. Acute focus on improving the ability to cope with current climate variability, and on 'climate proofing' to address incremental changes in existing climate-related risks in the near-term does little for improving city or community capacity for climate adaptation.

A recent review of best practices for climate adaptation shows that the level of political and personal engagement has never been higher. Climate adaptation work is entering a period of transition and alternative approaches to track and report progress are emerging. The State of Local Climate Planning study⁸ notes the following examples of communities that are shifting how they track the progress of climate adaptation:

- Moving from a singular focus on greenhouse gas emissions to centering attention on people and equity and evolving reporting beyond top-line greenhouse gas emissions numbers to reporting leading adaptation indicators and activity metrics
- Moving from costly, time-consuming bespoke inventories to utilizing new tools that simplify the process of quantifying key performance indicators
- Moving from responsibility held by disparate, individual local governments to state and federal support for climate services and capacity building programs
- Moving from frameworks originally designed for national and international policy to ones designed to support local processes, regional activation, and opportunities for new governance models to address climate change.

Addressing the timescales associated with climate change impacts requires a combination of short-term actions to address immediate municipal needs, with a long-term focus to address future planning and

protection requirements. The City of Calgary has been working on strategies, plans and tools related to climate adaptation that seek to reduce the level of climate impacts, understanding that risk cannot be eliminated completely and that climate change planning has to explicitly address uncertainty related to future changes in climate. Tools such as the Community Climate Risk Index and Profiles, Natural Asset Valuation, and Planning Continuum Overlay are designed to move beyond the currently dominant view of adaptation as coping with existing climate variability and climate-proofing business-as-usual development against incremental changes in existing risks, to allow adaptation interventions to address different types of climate change-related risks that will operate on different timescales. As shown by the research completed in this white paper, fluent communication between short-term incremental actions and long-term planning shows up in a variety of climate adaptation practices and plans. The City of Calgary seeks to learn from the best practices noted in this white paper to address the over-arching goal of long-term and effective adaptation planning.

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