

Building Healthy, Equitable & Climate Resilient Communities

10 Municipal Case Studies

Presented by:



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About CANUE (canue.ca):

CANUE develops and delivers environmental exposure data to support health research across the country. CANUE also develops web-based tools, including HealthyPlan.City, that enable users to map, analyze and report on the distribution of environmental exposures and environmental inequities in cities across Canada.

About CHASE (chasecanada.org):

The Canadian Health Association for Sustainability and Equity (CHASE) is a Canadian non-profit organization, directed and run by public health professionals, that promotes the public policies that mitigate climate change and/or increase climate resilience.

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I Introduction

This report presents ten municipal case studies of climate adaptation measures being implemented across Canada and the United States. Developed with funding from the Local Leadership for Climate Adaptation initiative from the Federation of Canadian Municipalities, this report is intended to support municipal staff, public health practitioners, planners, and community partners by documenting practical examples of actions that can help build healthier, more equitable, and climate-resilient communities.



Role of Municipalities

Municipalities play a critical role in the protection of their residents from climate-related events. They can establish education and communications plans, mobilize the community, and develop emergency plans that can be implemented before and during extreme events. They can also develop policies, programs and plans that change the built environment; initiatives that make their communities more resilient to climate-related events. Municipalities also have a key role to play in the reduction of greenhouse gases and the development of sustainable communities. Many of the actions needed to mitigate climate change will produce immediate health co-benefits by reducing air pollution, increasing levels of physical activity, and improving social cohesion and mental health¹.

The goal of this report is to share innovative climate adaptation measures being implemented by municipalities, particularly those that have been employed with an equity lens. The case study vignettes herein aim to inform, encourage and support municipal staff across Canada to develop and build upon these examples in their own communities.

Focus on Extreme Heat and Flooding

The case study vignettes contained in this report highlight climate adaptation measures focused on extreme heat and flooding, since they are among the most important climate-related threats experienced in Canadian cities. Most of the cases discuss climate adaptation measures directed at changes in the built environment to increase the community's resilience to extreme heat and flooding. These types of measures can be supported by HealthyPlan.City, a geospatial tool developed by CANUE that brings together environmental and socio-demographic data to help municipalities identify areas within cities that may benefit most from climate adaptation interventions. This includes areas where climate-related exposures, such as high heat or flood risk, overlap with social vulnerabilities.

Climate Adaptation Measures Included

The case study vignettes included in this report address different types of interventions that can be employed at a municipal level to address extreme heat and/or flooding. They include:

- A coastline restoration design project in Vancouver informed by Indigenous knowledge;
- An equity-based urban tree canopy strategy in Winnipeg;
- A heat alert and response program in Hamilton that is built upon engagement of susceptible populations and community mobilization;
- An equity-based green streets program in Toronto that addresses storm water;
- An equity-oriented heat resiliency strategy being implemented in Montreal;
- A sponge parks program in Montreal that reduces flooding;
- A green schools program in Chicago that reduces flooding and extreme heat while improving school grounds in racialized and underserved neighbourhoods;
- A cool roof pilot project in Boston directed at public housing and non-municipal community facilities that serve susceptible populations;
- A small-scale rain garden project for private property promoted by Peterborough.
- A fruit tree pilot project offered in a park in a neighbourhood with a high concentration of immigrants in Fredericton, New Brunswick.

Peer-to-Peer Mentoring Approach

Each case study vignette is based on an interview with one or more municipal staff members and/or a staff person from a non-profit organization that is collaborating with the municipality. The content of the case-study vignettes is also informed by a review of related reports.

A peer-to-peer mentoring approach was taken with the vignettes so staff were asked to:

- Describe the climate adaptation measure being implemented, its primary goal, and any co-benefits associated with it;
- Identify the role of their organization and the other organizations involved in the development and implementation of the measure;
- Explain if, how and when the community was engaged in the process;
- Indicate if and how health and/or social inequities were being addressed; and
- Discuss the challenges faced and the lessons learned from their experience in the process.

Staff interviewed were given the opportunity to review the vignettes before they were finalized.

Case Study Vignettes

Each of the vignettes included in this report has been posted as blogs on the CANUE and CHASE websites in both French and English in 2025/26. The case study vignettes document valuable insights from municipal staff and non-profit partners. They describe the processes, collaborations, and challenges encountered during the development and implementation of climate adaptation measures. They discuss how and where an equity lens has been applied to a particular intervention. And they identify how geospatial tools have been used to inform and support these processes.

II Climate Change, Health and Health Equity

Climate Change is Harming Health in Canada

Canada is no longer immune to the harmful impacts of climate change². It is already having a significant impact on the lives of people across the country. Hotter temperatures and longer droughts are intensifying wildfires that are now exposing millions of people to high levels of toxic air pollution³ and giving rise to \$0.5-6.4 billion in health-related costs each year⁴.

Heat waves, that have already become hotter, longer and more frequent, are exposing millions to harmful levels of heat and resulting in deadly consequences for many⁵. Hurricanes, heavy rainfall, and ice storms, that have also become more frequent and intense, are causing injuries, deaths and dislocation, while also damaging infrastructure and buildings⁶. Extreme weather events are increasing the risk of food-borne illnesses as they disrupt food supply cold chains that are used to keep foods refrigerated or frozen during storage and distribution⁷. Intense rainfall, rising sea levels, melting permafrost, rapid snowmelts and long droughts are increasing the risk of contaminated or depleted water supplies⁸.

Melting permafrost, that covers 40% of Canada's land mass, is threatening the integrity of infrastructure, and disrupting transportation routes and access to food in northern regions^{9/10}. Climate change is also shifting the range and transmission of infectious agents. It has already increased the spread of some infectious diseases such as Lyme disease and West Nile Virus¹¹. Global food security is already being affected by climate change as is the food security of Indigenous communities that rely heavily on traditional food sources¹².

Climate change is also harming the mental health of people across Canada. Studies have documented post-traumatic stress disorders among those who have experienced extreme weather events, anxiety and grief among many people who are generally concerned about climate change, and a sense of loss and grief among those who feel their homes, communities, and way of life have been disrupted by climate change¹³.



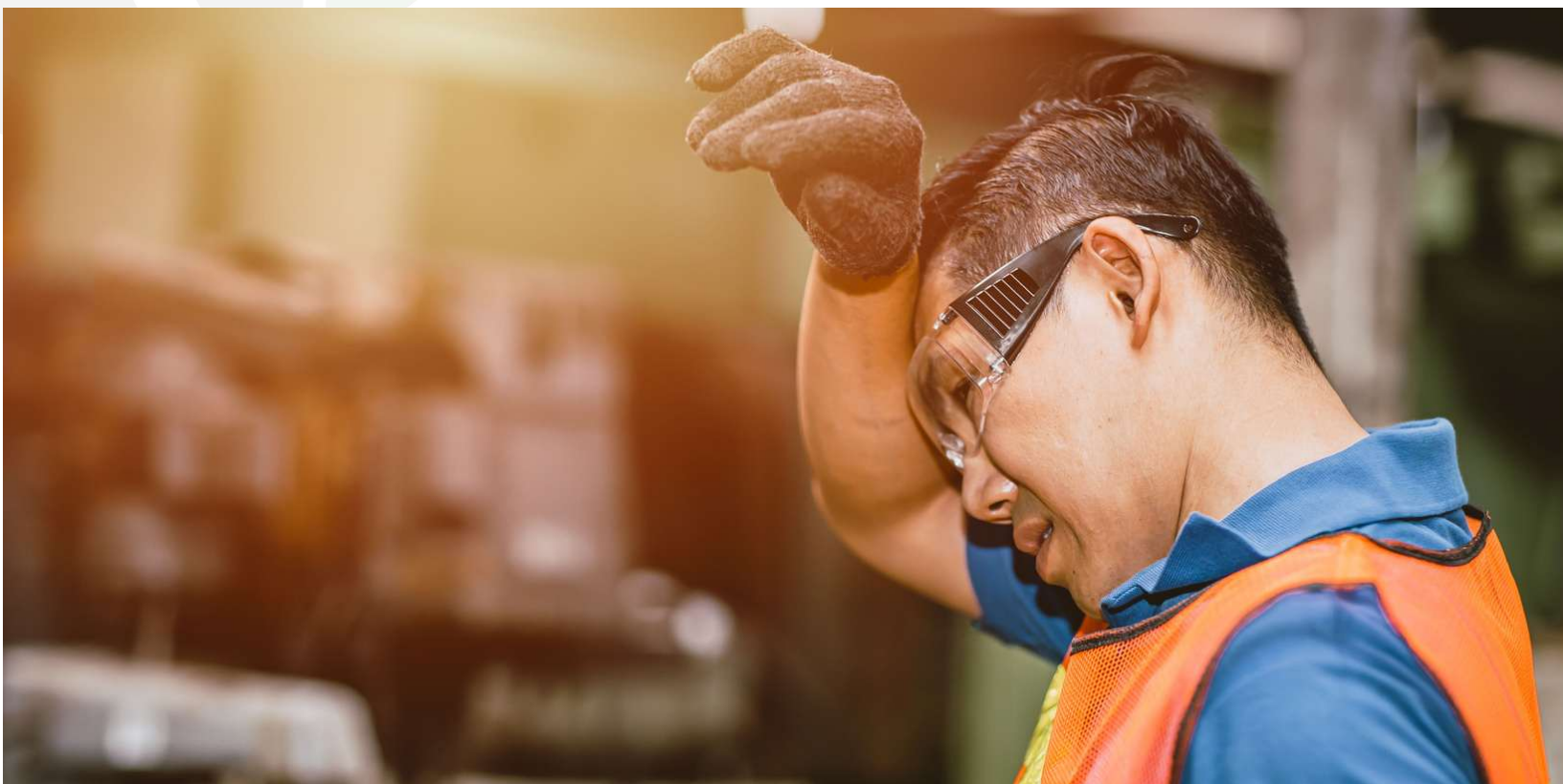
Climate Change Amplifies Health Inequities

While climate change presents health risks for everyone, it presents greater risks for some populations. Young children, older people, and people with pre-existing health conditions are physiologically more sensitive to environmental stressors such as extreme heat and wildfire smoke, and therefore more susceptible to the impacts of climate risks¹⁴.

Other populations are more susceptible to harm from climate-related impacts because of social and material circumstances that put them at greater risk of developing acute and chronic illnesses and of dying prematurely. Factors such as income level, quality of housing, immigration status, gender, ethnicity, and access to health care, can have a significant and compounding impact on the health of people. These factors, which are often referred to as the social and environmental determinants of health, are influenced by individual and systemic biases in society such as racism, sexism, and colonialism¹⁵.

Susceptible populations can include newcomers to the country, visible minorities, Indigenous people, people living on low incomes, and unhoused populations. They are at greater risk of harm from climate-related impacts because: their health has already been compromised by the other stressors in their lives; they can experience greater exposure to climate-related impacts such as extreme heat and flooding; and they are less likely to have the resources needed to protect themselves or recover from climate-related exposures. In these ways, climate change can amplify the already-existing health inequities experienced by susceptible populations¹⁶.

Health equity exists when everyone has a fair opportunity to attain their optimal health or well-being. A health equity approach to public policy involves the removal of barriers related to social, economic, and/or environmental conditions that shape health outcomes. In the field of climate adaptation and climate resiliency, a health equity approach requires the prioritization of those populations, and the neighbourhoods in which they live, for actions that mitigate the impacts of climate change and increase climate resiliency¹⁷.



III Extreme Heat and Flooding

1. Extreme Heat – Health, Health Equity and Adaptation

Defining Extreme Heat Events

Extreme heat events, often referred to as heat waves, involve prolonged periods of unusually high temperatures compared to historical temperature averages for a given location. These events can last from several days to several weeks¹⁸. There are no universal criteria for extreme heat events because heat-related health impacts depend in part on the temperatures to which populations are accustomed. Environment and Climate Change Canada has identified 25 different regions across Canada and developed heat warning criteria for each region in collaboration with the provincial and territorial governments¹⁹.

Heat Health Risks

Extreme heat can cause dehydration, hyperthermia, heat exhaustion, and heatstroke, which can be a life-threatening condition. It can also aggravate pre-existing chronic conditions such as respiratory, cardiovascular, cerebrovascular, renal and neurological diseases, diabetes, and mental health disorders, which can lead to fatal results. Death rates tend to increase as the duration and intensity of the extreme heat event increases. Heat-related mortality is also affected by humidity, night-time temperatures, behaviour, and adaptive measures²⁰. Extreme heat has also been associated with adverse reproductive outcomes such as miscarriages and increases in aggressive behaviour, non-violent and violent crimes²¹.

Heat Health Impacts in Canada

Extreme heat events have substantially increased ambulance calls and death rates in communities across Canada. For example, ambulance calls increased by 12% during extreme heat events in Toronto in 2005, 2006 and 2010²², and by 11-23% in different regions of Quebec in 2018²³. One review of death rates in 26 Canadian cities found that extreme heat events can increase death rates by an average of 2-13%²⁴. A study that examined 815 heat-related deaths that occurred in British Columbia between 1986 and 2010 found that death rates increased by 4% to 19% the day after an extreme heat event and by 2% to 19% within a week of that event²⁵.

Exposure to Extreme Heat is Increasing

Many communities in Canada have experienced a high number of extremely hot days for decades. Between 1976 and 2005, the average annual number of very hot days was 25 in Kamloops, 10.9 in Saskatoon, 11 in Winnipeg, 12.2 in Toronto, and 8.2 in Montréal. With human-induced climate change, extreme heat events are increasing in frequency, intensity and duration. In 2025, for example, heat warnings were issued for 29 days for Toronto²⁶. Over the next two decades, it is predicted that communities across the country will experience a doubling in the annual number of very hot days because of climate change²⁷.



Populations Susceptible to Heat

As discussed earlier, some populations are more vulnerable to harm from extreme heat. Pregnant women, very young children, older people, those with chronic diseases, those who use certain prescribed and non-prescribed drugs, and those who engage in intense physical activity are at greater risk of harm from extreme heat for physiological reasons. Other populations are more susceptible to harm from extreme heat because their social and material circumstances increase their health risks. These susceptible populations may also experience greater exposure to extreme heat because they do not have the information, financial resources, physical ability and/or agency needed to protect themselves from it. Susceptible populations can include people who are unhoused, those who live on low incomes, people who are socially isolated or have mobility challenges, outdoor workers and migrant workers ²⁸.



Urban Heat Islands Increase Health Risks

Urban heat islands are communities, or areas within communities, that experience higher air temperatures because they have less vegetation, more heat-absorbing surfaces such as pavement, and more impervious surfaces such as concrete. Many large urban centres in North America are generally 1-3°C warmer than the rural areas surrounding them. The higher air temperatures in urban centres, particularly at night, can magnify the health risks for urban dwellers ²⁹.

Urban heat islands have been associated with an increase in heat-related health impacts. For example, in Toronto, one study found that, during extreme heat events, the number of emergency calls was 18 times higher from neighbourhoods with few trees than from neighbourhoods with a tree canopy greater than 70% ³⁰. In Montreal, death rates from respiratory diseases were 1.4 to 14 times greater in urban heat islands that were 6-8°C hotter with higher levels of ground-level ozone, than the cooler areas within the city ³¹.

Low-Income Populations at Greater Risk

Those living on low incomes are more likely to live in houses that are poorly insulated, poorly ventilated, and lack air conditioning. A number of studies have also found that low-income populations are also more likely to live in neighbourhoods that lack trees and vegetation and have higher temperatures ³². For example, a 2020 study of Toronto, Montreal and Vancouver found that neighbourhoods with less material deprivation were more likely to be highly walkable, have lower levels of air pollution, and have higher levels of greenness, while highly deprived neighbourhoods were more likely to be less walkable, have higher levels of air pollution, and have lower levels of greenness. The authors concluded that inequitable access to greenness can amplify the negative impacts of extreme heat among materially deprived populations ³³.

Higher Death Rates for Susceptible Populations

The heat dome that settled over British Columbia in June 2021 gave rise to 619 premature deaths across the province; 98% of which occurred indoors³⁴. Researchers who studied that event estimated that indoor temperatures reached 30 to 40°C that week with little relief at night because outdoor temperatures remained high and so few homes had air conditioning³⁵.

Deaths in the community increased by 440% during the heat dome with much higher death rates among older people (i.e., 65-74 years in age) and those who live on low incomes. The death rate among materially and socially deprived populations (28.1%) was several times greater than that of materially and socially privileged populations (6.1%). Death rates were also higher in homes without air conditioners, in neighbourhoods with less greenery and higher building densities, and in neighbourhoods located further from the water and closer to major roads³⁶.

The Canadian Climate Institute has estimated that the heat dome cost the healthcare system \$12 million directly and produced \$5.5 billion in health-related costs³⁷.

Assessing Heat and Health Vulnerability

The vulnerability of a community to heat-related illnesses and deaths depends upon a variety of factors:

- the regional climate and nature of the built environment;
- the health status of the population;
- the social and material conditions of populations within the community;
- the community's knowledge of heat health risks and the protective measures that can be taken;
- the strength of social networks and support; and
- the actions implemented by the community to protect those susceptible populations from harm³⁸.

While health-related data, expert opinions, and community engagement are essential elements in the assessment of a community's heat and health vulnerability, geospatial tools can help to identify the neighbourhoods in a community that experience the highest temperatures, have a high concentration of one or more susceptible populations, and/or amenities that support the adaptive capacity of the community³⁹.

The 2021 BC heat dome cost the healthcare system \$12 million directly and produced \$5.5 billion in health-related costs.

Improving Heat Resiliency

Municipal, provincial and territorial governments can improve heat resiliency in their communities by:

- Establishing and implementing Heat Alert and Response Systems as recommended by Health Canada with a particular focus on the needs of susceptible populations;
- Educating residents about the ways they can reduce indoor temperatures with passive design changes such as roof and wall insulation, window awnings, and cool roofs with reflective surfaces, and by mechanical means such as air conditioners and heat pumps;
- Establishing retrofit programs to increase heat resilience and cooling in low-income housing and low-income households;
- Expanding vegetation on municipal properties, along transportation routes, and in parks, with priority given to urban heat islands that are home to a concentration of susceptible populations;
- Developing policies and plans that:
 - encourage the integration of natural ventilation and water features into urban design at a local and regional scale;
 - reduce heat absorbing surfaces such as pavement;
 - promote reflective surfaces such as cool roofs; and
 - encourage the greening of buildings, private property, and the public realm;
- Reducing the production of waste heat from buildings and vehicles by promoting energy efficiency, the use of renewable energies and electrical technologies, and active modes of transportation ^{40 41}.

2. Flooding – Health, Health Equity and Adaptation

High Cost of Floods in Canada

Flooding is the most common and most expensive extreme weather-related event experienced in Canada. Many of Canada's largest cities are located in high-risk flood zones. Estimates suggest that floods affecting homes are costing \$2.9 billion per year. This figure does not include the cost of damaged infrastructure such as roads, bridges and water mains. Nearly 90% of these home-related costs are associated with 10% of the highest risk homes ⁴².

Without interventions, flood damage costs in Canada are expected to increase five-fold over the next few decades in response to several factors. First of all, the flooding hazard is expected to increase significantly as all types of flooding increase in frequency and severity in response to global warming. Secondly, exposure to flooding is expected to increase across Canada as development of buildings, assets and infrastructure increases in high-risk flood zones continues. And last of all because demographics, governance systems, and colonial attitudes have left some susceptible populations in Canada, particularly those in Indigenous communities, without the policies or resources needed to mitigate harm from floods ⁴³.



Changing Flood Patterns

Records indicate that the annual average precipitation across Canada increased by 20% between 1948 and 2012 with a greater increase in the North. It is expected that both extreme precipitation and annual average precipitation will increase in the coming years as a result of climate change ⁴⁴.

Experience indicates that short-term heavy precipitation (i.e., 24 hours or less) can produce floods that damage local infrastructure, while long-term heavy precipitation (i.e., lasting for several days) can cause flooding that damages infrastructure over a large region. With precipitation patterns changing in Canada, it is expected that rainfall-related flooding will increase, while snowfall-related flooding will decrease. Urban areas are expected to see an increase in overflows and flash floods while the eastern, western and northern coasts in Canada are expected to see rising sea levels and an increase in storm surges ⁴⁵.

Types of Flooding

There are several different types of floods. Fluvial flooding occurs when river, creek, or stream levels rise above their banks so that water flows onto land. Pluvial flooding occurs when heavy rainfall exceeds the capacity of ground absorption and/or storm water drainage. Coastal flooding occurs when sea levels rise beyond land levels or overcome coastal defences. Flooding can be caused by heavy rainfall, rapid snowmelt, ice jams, or in coastal areas, rising sea levels and storm surges ⁴⁶.



Health Risks from Flooding in Canada

Floods can affect the health and lives of people in direct and indirect ways. Floods can result directly in injuries and deaths from drowning, hypothermia and electrocution, both during the flood and during the recovery and clean-up period. Flooding can also be associated with power outages that can lead to food-borne illnesses, hypothermia, and carbon monoxide poisoning. But flood-related injuries and deaths account for a small fraction of the health impacts associated with floods. Many more people are impacted by the indirect health risks ⁴⁷.

Floods can contaminate drinking and surface water with biological or chemical agents that result in water-borne diseases or poisoning. Stagnant pools of water created from floods can give rise to water-borne and vector-borne diseases as well as other infectious diseases. Flooded buildings can become breeding grounds for fungal agents, molds and bacteria that can give rise to allergies, asthma and respiratory illnesses. In addition, the trauma, dislocation, financial losses and uncertainty resulting from floods can have a negative impact on mental health, creating post-traumatic stress disorders, anxiety, depression and suicidal ideation ⁴⁸.

Populations at Greater Risk from Flooding

Adolescents, young adults in their 20s, and people over 60, appear to be at greater risk for injuries and death from flooding events than the general population. In addition, people with pre-existing health conditions such as cardiovascular disease, people with mental health issues, those who require medication to maintain their health, and those with mobility challenges are at greater risk of harm during flooding events than the general population ⁴⁹.

People who do not have insurance experience more mental duress during and after flooding events, and these people are much more likely to live on lower incomes than the general population. People living in low-income remote or rural communities can experience greater risks from coastal flooding because their communities do not have the resources needed to prepare for, or recover from, such events. In addition, many Indigenous communities are at greater risk of water-borne diseases from heavy precipitation because they do not have the funding needed to provide safe drinking water to their residents under the best of conditions ⁵⁰.

Studies conducted in other countries have found that “socially vulnerable communities are disproportionately exposed to flooding and are more significantly affected by its impacts”. When it comes to flooding, susceptible populations are those with circumstances that limit their capacity to prepare for, respond to, and recover from a flood hazard event ⁵¹.

Assessing Flood Risks

When assessing the impacts of flooding on a community, it is important that three interacting variables are included: the flood hazard, the exposure of people and assets, and the vulnerability of people and assets to flood impacts ⁵².

Climate Resilience Against Flooding

To build community resilience against the growing risks and costs associated with flooding, there are actions that municipal and provincial/territorial governments can take.

They can:

- ensure that flood forecasting and warning systems are in place along with flood management plans;
- provide residents with information about simple actions they can take to reduce the risks of basement flooding;
- collaborate with community partners to promote flood resilience measures to residents;
- incorporate flood resilience measures into the management of, and financial planning for, government assets;
- provide up-to-date flood-risk maps through a free online portal;
- establish funding programs to support flood resilience retrofits for residents;
- adopt best practices for flood resilience in policies and plans that guide and regulate land use and transportation planning ⁵³;
- invest in flood protection infrastructure, such as floodwalls and nature-based solutions, that can minimize the risks associated with flooding ⁵⁴;
- restrict new developments from high-risk flood zones;
- support relocation of existing residents and communities from high-risk flood zones; and
- develop insurance schemes or programs that cover susceptible individuals and communities that cannot afford flood insurance ^{55 56 57}.



IV Using Geospatial Tools to Assess Climate Vulnerability



Municipal Context

Each municipality experiences distinct geographical conditions, climate projections, and socio-economic inequities that require localized solutions to climate adaptation. As the level of government that is closest to communities, municipalities are uniquely positioned to implement climate adaptation strategies that integrate local context and community needs to build climate resilience. Climate adaptation plans are most effective when municipalities engage with their communities to identify health risks, community priorities, and the interventions that best respond to their local needs. Locally relevant data can support this process by helping municipalities make evidence-informed decisions about where adaptation measures are most needed and where they can have the greatest impact.

Geospatial Analysis

A spatialized approach to climate adaptation planning allows municipalities to identify and prioritize areas in their communities that are at highest risk of harm from climate-related impacts. Geospatial tools that include environmental data related to extreme heat (e.g., average summer temperature) and flooding (e.g., flood susceptibility) can be used to identify the neighbourhoods that present the greatest risk of exposure. When geospatial tools include socio-economic and demographic data, they can identify the neighbourhoods that have a high concentration of people who are susceptible to harm from extreme heat or flooding due to physiological factors (e.g., older adults and children) or social and material circumstances (e.g., low-income older adults, newly arrived immigrants, and individuals living alone). Geospatial tools that include built environment data can also identify the neighbourhoods that have characteristics or amenities that support the adaptive capacity of the community (e.g., tree canopy cover, large natural spaces, and parks) ⁵⁸.

HealthyPlan.City Tool

With funding provided by the Public Health Agency of Canada, CANUE developed HealthyPlan.City, a geospatial tool that can be used by urban planners, public health professionals, community organizations, and policy-makers to fold socio-economic and demographic factors into climate adaptation assessments.

HealthyPlan.City is a free web-based mapping platform that visualizes spatial data for more than 125 Canadian cities. The tool allows users to examine built environment indicators, susceptible populations, and environmental exposures at the neighbourhood scale. It also identifies “equity priority areas” where a higher proportion of susceptible populations are exposed to unfavorable environmental conditions within the municipalities ⁵⁹.

V Case Study Vignettes



Case Study 1: Hamilton's Equity-Based Heat Response Plan

Heat in Hamilton

The City of Hamilton has developed an equity-based Community Heat Response Strategy to offer greater protection to those people in its community who are at greatest risk of harm from extreme heat. With human-fueled climate change, extreme heat is becoming a greater health concern for communities across Canada. In Hamilton, which wraps around the western tip of Lake Ontario, the mean number of days over 30 degree C is on track to increase from 16.2 between 1976-2005 to 37.2 between 2021 and 2050.

Multi-Sectoral Collaboration

Hamilton's Community Heat Response Strategy is only one component of the city's overall Climate Change Action Plan. This strategy is being led by Public Health Services, which is part of the Healthy and Safe Communities department within the City. The strategy is being developed and implemented in collaboration with several other divisions and departments within the City including Housing Services, City Housing, Parks and Cemeteries, the City's transit authority, Recreation, and the Hamilton Public Library.

"One of the strengths of our strategy is that it has been developed with expertise and resources from so many departments" explained Shelly Rogers, Project Manager, Air Quality and Climate Change with Public Health Services. "Opportunities that we may not have considered have been brought to the table by other departments along with the resources to implement them."



A few elements in Hamilton's strategy go beyond those commonly included in a Heat Alert and Response System (HARS) such as the expansion of the tree canopy and the installation of shade structures and misting stations in parks. It also includes several innovative elements that are directed specifically at the health needs of at-risk populations:

- **Wellness Check-ins:** Wellness check-ins are provided by the City's paramedics for older adults and those with pre-existing health conditions who have enrolled for the Mobile Integrated Health Program.
- **Cool Kits:** City staff and community organizations distribute "Cool Kits" to high-risk populations. For housed people, Cool Kits include ice packs, reusable water bottles, cooling neckties, fridge magnets with health tips, thermometers, and information on the health impacts of extreme heat. The Cool Kits for unhoused people include hats, sunglasses, sunscreen, reusable water bottles, and a list of cool spaces and locations to refill water bottles across the city.
- **Cooling Support:** In 2024, the City launched a pilot program to help low-income individuals with medical conditions that are aggravated by heat to stay cool at home. Eligible residents could receive a one-time \$350 subsidy per household to buy an energy-efficient air conditioner to cool one area of their homes.

Originally, the program was only available to people receiving Social Assistance but the pilot has expanded eligibility to include anyone living below the Low Income Measure. This program is budgeted to continue in 2025 with up to 50 eligible households being supported each year on a first-come, first-served basis. This expanded support is in addition to the existing air conditioner program offered for Social Assistance recipients.

- **Adequate Temperature Bylaw:** At the request of City Council, City staff are developing an Adequate Temperature By-Law that may provide maximum temperatures for residential rental units within the city.
- **Transportation to Cool Spaces:** In 2024, 2000 bus tickets were allocated to at-risk populations to help them reach cool spaces during extreme heat events. These tickets were distributed by City staff and community partners to unhoused and low-income populations in Cool Kits and through recreational centres across the city.

Community Engagement

The strategy has been informed and supported by a broad group of individuals and organizations from the community that represent or serve different at-risk populations within the city. These community partners include groups such as ACORN that advocate on behalf of tenants, the Accessibility Committee for Persons with Disabilities, The Seniors Advisory Committee, Environment Hamilton, the YWCA, the Hamilton Community Legal Clinic, and the Hamilton and District Apartment Association.

Community partners have been included in virtual meetings facilitated by Public Health Services along with staff from other departments. This group of people, which is called the Extreme Heat Working Group, includes over 40 people. These meetings have been used to provide updates from City staff, solicit advice from community members, and coordinate actions across City departments and community groups.

“

“Community engagement has been crucial to the development and implementation of the strategy,” noted Rogers. “Community members have offered fresh ideas and practical advice that is based on their lived experience or that of the people they serve. The community groups have also brought resources and support to the table. For example, they helped us distribute Cool Kits and health information to the at-risk populations that we are trying to reach.”

”

Identified Susceptible Populations with Geospatial Tools

Hamilton staff worked with the interactive mapping tool developed by Université Laval to identify the areas in the city that are home to high-risk populations. They used socio-economic data related to factors such as age, income, and the type of dwelling, and environmental data such as surface temperature and vegetation in this mapping exercise. The mapping tool identified Wards 2, 3, and 4, that border heavy industry on the south shore of Lake Ontario, as the neighbourhoods with the populations at greatest risk from extreme heat.

“We have used the geospatial tool to: identify the neighbourhoods that should be prioritized for Cool Kits and educational resources; create maps that identify the location of cool spaces for at-risk populations; and evaluate our programs to see if they are reaching the neighbourhoods with the greatest need,” explained Rogers.

Challenges and Lessons Learned

“The toughest part of this process has been scoping it,” said Rogers. “There is so much that can and should be done to protect high-risk populations from extreme heat. But we knew if the scope was too broad, it would be easy to lose focus. So we have tried to identify actions that could make a big difference in peoples’ lives within the next 5 years.”

“Working across city departments has been extremely valuable,” offered Rogers. “The process has helped us to cultivate relationships with staff in other departments and to understand what the other departments do and how we can support one another.”

“We have also learned so much from the community engagement process” Rogers noted. “Once we began the process, people from the community were asking to be involved. They have been excited to have a voice on something that is so important to them and their community.”

Funding

There was no external funding for this work. All of the funding came from the operational budgets of various departments across the City as well as the Climate Change Reserve.

Case Study 2: Winnipeg's Equity-Based Urban Forest Strategy



Background

The City of Winnipeg has developed its first Urban Forest Strategy. This is a 20-year strategy that aims to increase tree canopy coverage, diversity of the canopy, and equitable distribution of the canopy across Winnipeg.

Located in central Canada, the average number of days over 30°C in Winnipeg is projected to increase from 14.3 between 1976-2005 to 30.5 between 2021-2050, making heat adaptation measures crucial to the city's future. Increasing tree canopy coverage is recognized as an effective heat adaptation strategy for urban environments. Trees can decrease air and surface temperatures, reduce the risk of morbidity and mortality due to extreme heat, and reduce ultraviolet radiation exposure.

Urban Forest Strategy

Winnipeg's Urban Forest Strategy aims to address several needs: to expand the tree canopy to increase the city's resilience to the changing climate; to replace the Elm and Ash trees that are being lost to Dutch Elm Disease and an invasive pest called the Emerald Ash Borer; and to ensure that tree canopy is more equitably distributed, particularly in high-needs neighbourhoods that are characterized by higher rates of poverty and lower incomes.

"The tree canopy we see in Winnipeg today will not be the same canopy we will have in the coming decades," explained Martha Barwinsky, City Forester at the City of Winnipeg. "Our trees are vulnerable to pests, disease, construction and natural mortality. That is why our strategy is not just about planting more trees. It is about diversifying the trees in our community and building a resilient urban forest that can thrive in the future."

The Urban Forest Strategy was finalized and approved by Winnipeg City Council in 2023 along with a budget for its implementation. The strategy commits the City to expanding the tree canopy cover from 17% in 2018 to 24% by 2065. The City has already increased tree planting from a historic 300 trees per year to 6500 trees per year.

Assessing the Urban Forest

"The strategy took about four years to develop but really was about 20 years in the making. The first step in the process was to assess the current state of the forest," explained Barwinsky.



Within that 20 year period, the City of Winnipeg collected field data on the trees in parks and on boulevards and potential planting sites throughout the city. The City's Public Tree Inventory database was developed and now includes over 300,000 trees that are managed by the Urban Forestry Branch in the Parks and Open Space Division within the Public Works Department. This inventory does not include trees in natural areas or on private property.

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“With this snapshot, we could picture the trees we had, what we were losing, where the gaps were, and what we needed to manage,” Barwinsky noted. “One of our goals was to determine where canopy can go, considering all aspects of feasibility including infrastructure, soil conditions, and the community’s need for trees.”

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Identifying High Priority Neighbourhoods

Winnipeg's Urban Forest Strategy identifies the need to maximize tree canopy to protect people from extreme heat, particularly for populations that live on low incomes:

“Maximizing tree canopy is critical, especially in areas with vulnerable populations who are more susceptible to heat related illnesses. Trees in the urban environment decrease the risk for heatstroke and are associated with a decrease in morbidity and mortality from the effects of heat due to their role in decreasing air and surface temperatures, as well as reducing exposure to ultraviolet radiation.”

“Poverty can be a significant barrier to health, wellbeing, and social equity. People living in poverty may have few means to access private amenities that can reduce vulnerability to heat, such as shady back yards and in-home or in-care air conditioning ... For some people, public trees and forests provide a main opportunity to keep their homes cooler, provide shade as they walk to school or work, or to experience nature.”

Areas with higher levels of poverty in Winnipeg were identified in a 2020 report prepared for the City entitled, *Defining Higher Needs Neighbourhoods*. It was based on 2016 Census data. The higher poverty areas were compared against the City's public tree inventory, temperature data from a hot July day, and canopy data derived from satellite images of the city. The results revealed that high poverty neighbourhoods had significantly fewer trees per hectare and per person, lower canopy cover, lower tree diversity, and higher average air temperatures, than low poverty neighbourhoods.

These inequities will be addressed with a number of policies. For example, the Small-scale and Low-Rise Residential Development Guidelines for Mature Communities, promote the retention of mature trees, particularly for front yards and boulevards, by requiring an arborist report to guide tree preservation and protection during the development process. They dictate the quantity and size (at maturity) of new trees required with each development and the minimum percentage of lot areas and setbacks that must be reserved for soft landscaping.

Community Engagement

“We started to develop the strategy in 2019 and held two rounds of community engagement. We worked closely with advocacy groups in urban forestry and held online

stakeholder workshops with community-based organizations,” said Barwinsky. “Our first engagement was centred around the question, ‘What should Winnipeg’s urban forest look like?’”

“One of the strongest messages we heard was the pressing need to plant more trees and increase canopy cover,” offered Barwinsky. “Many residents also stressed the importance of tree protection through stronger bylaws, especially as they have observed canopy loss due to development and densification.”

“In the future, when we are not limited by the conditions imposed by a pandemic, we want to do more to establish relationships with diverse and low-income populations that were under-represented in our community engagement process,” said Barwinsky. “We also want to work with Indigenous communities to incorporate their knowledge and perspectives into tree species selection.”

Multi-Sectoral Collaboration

The Urban Forestry Branch, that led the development of the Urban Forest Strategy, collaborates with divisions across the City including Water Services, Wastewater, Solid Waste, Engineering, Transportation, Street Maintenance, Planning, Zoning and Development, Urban Design, Transit, and Community Services, on the planting and maintenance of trees in parks and on boulevards.

“The strategy touches just about every division in the City of Winnipeg,” explained Barwinsky. “We have embedded ourselves into the work of each department, which has helped advance understanding of tree needs, soil volume requirements, and tree protection measures.”

The Urban Forestry Branch also provides expert advice for the care of trees outside their direct responsibility.

“We are often asked for advice on the planting and maintenance of trees around transit properties and water treatment plants for example,” explained Barwinsky. “Bringing forestry expertise into every part of the City’s operations helps ensure that trees are adequately protected and, if that’s not feasible, trees are replaced and new trees are planted.”

Challenges and Lessons Learned

The City faces several challenges in its quest to expand the tree canopy.

“Winnipeg is in a prairie ecological region,” Barwinsky notes. “This is an eco-region that supports grasslands. So, it may appear that we have an abundance of space to plant more trees, but there is also value in protecting and preserving the grassland areas and their ecology.”

“Older neighbourhoods in high poverty areas and with low tree species diversity are at high risk of losing their canopy to species-specific invasive pests, like Dutch Elm Disease, and much of these neighbourhoods have many obstacles like overhead hydro lines and narrow boulevards that limit where we can plant trees,” explained Barwinsky.

“That is why collaboration across departments is central to an urban forest’s success. By

coordinating across departments, we can try to develop solutions that make space for trees while meeting other infrastructure needs.”

But Barwinsky identifies that the biggest challenge—one that is universal to cities across the country—is growing tree canopy cover across the city when the city also needs to develop many new homes, including new affordable housing.

“It is a challenge to grow the tree canopy in a city when we are trying to densify neighbourhoods, create more walkable neighbourhoods with more or wider sidewalks, and build more cycling infrastructure,” explains Barwinsky. “Infill development and trees are competing for the same space within a city. There is a lot of infrastructure below and above ground that needs to be considered when looking for space for tree planting and for long term maintenance of trees.”

Barwinsky notes that the City of Winnipeg is conducting research on the best way to meet their tree canopy targets, recognizing that there may be a need for different targets for different neighbourhoods and types of land use.

While trees provide many benefits, Barwinsky notes that not all residents want a tree planted on their property.

“Trees can be a big responsibility, especially when the leaves fall and residents want to clean them up and when the trees need to be pruned,” said Barwinsky. “Our role is to help residents see the bigger picture— to recognize that trees provide shade, cool air, and reduce extreme heat risks for the whole neighbourhood. Once people understand the connection between trees and heat adaptation, hopefully they start to view them as essential infrastructure.”

“We inform residents if they are receiving a tree on their boulevard by providing door hangers with details about the tree planting process,” explained Barwinsky. “We explain how the City maintains and waters trees to establish them, and we also provide contact information if they want to learn more. This kind of transparency and education helps set each tree up for success.”

“Some neighbourhoods maintain frequent contact with the City directly, while others may communicate through their city councillor,” noted Barwinsky. “Connecting to the community helps us understand what is working for a community and where future outreach may be needed.”

Funding

The majority of funding for tree planting will come from the budget that the City has allocated to the implementation of the Urban Forest Strategy. The Federal Government’s 2 Billion Trees initiative is currently providing funding for a 5-year Home Grown program to augment the City’s tree planting, and through which community groups can apply for a grant to plant trees on public property in their neighbourhoods.

Other grants and tree planting initiatives help support tree planting in the city— on property belonging to schools and institutions, for example— through Tree Canada’s multiple programs and Manitoba Hydro’s Forest Enhancement Program. Trees Winnipeg, a local non-profit organization, supports tree planting projects on school properties, and hosts their ReLeaf Program whereby private property owners can purchase trees at a subsidized cost to plant on their properties.

Case Study 3: Montreal's Nature-Based & Equity-Oriented Response to Heat



Montreal's Climate Change Plan

Adopted in December 2020, Montreal's Climate Change Plan 2020-2030 was developed with a commitment to making the city greener, fairer, more resilient, and carbon neutral. The plan was designed to meet the city's new climate target "to reduce its greenhouse gas (GHG) emissions by 55% by 2030" and to enable the Montreal community to reinforce the city's climate resilience. The 52 measures in the Climate Plan will set Montreal on the path to being a resilient, inclusive and carbon-neutral city.

This plan is consistent with the Montreal Strategic Plan, Montreal 2030, which is guided by four key goals:

- accelerating the ecological transition;
- reinforcing solidarity, equity and inclusion;
- amplifying democracy and participation; and
- stimulating innovation and creativity.

Nature-Based Goals and Indicators for Climate Resilience

In order to increase resilience to climate hazards such as heat waves, heavy rain, and destructive storms, the climate plan commits the city to "increasing protected natural areas and the resilience of urban forests, reducing heat islands, restoring the riverbanks and favouring the development of healthy and dynamic urban agriculture".

The plan includes eight indicators that are to be monitored and reported on annually. Four of those are dedicated to the city's climate adaptation:

- The number of trees planted by the city and its partners with priority given to vulnerable areas to heat waves with the goal of planting 500,000 trees by 2030;
- The area of land to be protected as a natural area or natural environments that contribute to biodiversity with the goal of increasing that area to 10%;
- The status of climate hazards with the goal to decrease overall vulnerability; and
- The area of heat islands with the goal to decrease that area.

All of these indicators are pertinent to extreme heat and the heat resilience of the City of Montreal, although some have goals related to biodiversity, flooding and other climate-related events.

Nature-Based Interventions: Increasing the Ratio of Greenspace

"The climate plan identifies several nature-based solutions that can increase the heat resiliency of the city," said Claudia Atomei, Planning Consultant with the Adaptation, Resilience and Biodiversity Division in the Office of Ecological Transition and Resilience with the City of Montreal. "First, Action 17.1 aims to develop the necessary means to curb the use of impermeable artificial surfaces such as pavement and concrete, particularly through

urban planning and regulations. Montreal's Land Use and Mobility Plan aims to increase the ratio of greenspace from 38% at present to 40% by 2050. This will help reduce temperatures while increasing the absorption of water from rain and snow."

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"This may not sound like an ambitious target, but it is when you consider how much development will happen across the city over the next 25 years and the fact that Montreal is situated on an island with hard boundaries for growth," noted Rachel Mallet, Research Geomatic Analyst on Climate Change Adaptation, in the Adaptation, Resilience and Biodiversity Division with the City of Montreal.

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"This action will require mapping the physical properties of surface materials across the Agglomeration of Montreal for their reflectivity and heat storage capacity," Mallet noted. "We want to map these surfaces so we can evaluate the vulnerability of different neighbourhoods to heat waves and monitor our progress over time."

"Second, Action 17.2 in the climate plan aims to increase green spaces in vulnerable and priority areas in the city by promoting the removal of pavement and concrete on streets and lots surrounding schools, low-rent housing, and seniors' residences," said Mallet.

Nature-Based Interventions: Increasing Tree Canopy within Vulnerable Areas

A third action in the climate plan, Action 20, requires the City and its partners to plant, maintain and protect 500,000 trees in neighbourhoods vulnerable to heat waves between 2020 and 2030. It aims to reduce indoor and outdoor air temperatures to protect people, while also decreasing energy costs, air pollution, noise levels, and the risk of flooding.

The trees are to be planted on public and private property. The City has set aside funds in its Ten-Year Capital Expenditures Program to reach 50% of this target and expects the private sector and senior levels of government to provide the rest.

The trees are to be selected for their climate resilience and with an eye to encouraging biodiversity. Policies are to be developed to prioritize the planting of trees in the neighbourhoods that are most vulnerable to heat waves. The city is supporting the boroughs by identifying potential planting sites, including sites that need to be de-paved, which are very often located in urban heat islands.



Nature-Based Intervention: Other Actions that Increase Heat Resiliency

The climate plan includes several other actions that are directed at increasing biodiversity or flood resiliency that will also improve the city's heat resiliency:

- Action 19 commits the City to increase the proportion of protected natural areas and areas that contribute to biodiversity from 6.1% to 10%. To achieve this goal, the City is creating new parks and green corridors that connect natural spaces. The primary goal of this action is to support wildlife movement and the dispersion of plants but it will also cool neighbourhoods.
- Action 19.2 aims to optimize the ecological contribution of municipal green spaces in ways that support biodiversity such as reducing mowing frequency.
- Action 21 commits the city to restoring the public riverbanks in the large parks network and will add green and blue spaces in the city that can help reduce air temperatures.

"We are working to naturalize the city's greenspaces," said Atomei. "We are promoting the replacement of tightly trimmed green grass with indigenous mature plants that have deeper roots, absorb more water, and support a more diverse mix of insects, birds, and mammals. This type of vegetation also has a greater cooling effect on air temperatures, especially during night-time."

"Montreal is also committed to becoming a 'Sponge City' that has parks, streets, and boulevards that use vegetation and containment systems to absorb and capture rainfall and snow melt," offered Atomei. "While these surfaces and structures are designed to manage stormwater, reduce flooding, and improve water quality, they will also help cool air temperatures."



Assessing Climate-Related Risks and Tracking Progress

The climate plan commits the city to develop a decision-making tool to analyze the land across the Montreal Urban Agglomeration for its vulnerability to climate-related impacts. This analysis, which has been integrated into the 2050 Land Use and Mobility Plan, helps to identify the areas most vulnerable to extreme events. It is also used to monitor progress using the indicators identified above.

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“I have been tasked with the job of developing tools that can be used to identify vulnerable neighbourhoods that should be prioritized for action to protect people at greatest risk of harm from climate-related events,” explained Mallet. “The index for greening, for example, is based on data related to urban heat islands, the tree canopy index, areas vulnerable to heat for health reasons such as age, neighbourhoods that are vulnerable to harm for socioeconomic reasons, and living environments where people live or congregate. The Large Parks, Mont Royal, and Sports Department use it, among other things, to adjust their program for creating and enlarging designated areas for planting trees.”

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Assessing the Efficacy of Climate Resiliency Measures

The vulnerability index is also used to assess the urban planning policies and interventions that can be used to protect people from extreme events such as heat.

“Our Division is assessing various climate resiliency interventions for their efficacy under different circumstances,” said Mallet. “For extreme heat, this includes the gathering of existing data and the collection of data that is missing such as surface and air temperatures in local areas, to analyse how well various resiliency measures reduce surface and air temperatures, decrease the area of urban heat islands, or reduce the exposure of residents.”

“When it comes to heat, these assessments will likely be directed at interventions that have been employed in the boroughs such as white roof by-laws and green laneways, as well as those that have been employed by other jurisdictions,” added Mallet. “This will be particularly important for priority neighbourhoods where tree planting is not feasible because of space constraints.”

Montreal Governance Structure

The City of Montreal and 15 reconstituted cities are part of the Montreal Urban Agglomeration which provides common services such as water treatment, waste management, and policing for the whole region. The City of Montreal, which is composed of 19 boroughs, has a population of approximately 1.7 million people. The central office in Montreal provides data, policy support, and funding to the boroughs, but the boroughs can and do develop and implement programs and policies independent of the central office.

Case Study 4: Cool Roofs in Underserved Neighbourhoods in Boston



Opportunity Knocks

In 2022, the City of Boston implemented a Cool Roofs Pilot Project to cool underserved neighbourhoods that experience higher temperatures in the summer months.

“The Cool Roofs Pilot Project was somewhat experimental,” offered Zoe Davis, Senior Climate Resilience Project Manager, with the Office of Climate Resilience at the City of Boston. “It was a huge period of opportunity. We had just completed Boston’s Heat Plan. Mayor Wu had recently taken office and was eager to address climate change and inequities in the city. Additionally, there were many funding opportunities for climate-related projects through the Inflation Reduction Act and American Rescue Plan Act provided by the federal administration.”

“The City had 250 gallons of reflective paint left over from another project and the Heat Plan identified cool roofs as an action that could reduce temperatures in some of our underserved neighbourhoods so we moved forward with a cool roofs pilot project,” said Davis.

Boston’s Equity-Based Heat Plan

In 2022, Boston had just completed a comprehensive heat plan, Heat Resilience Solutions for Boston, that included geospatial analyses, community engagement, the identification of a broad range of strategies, and simulation modelling.

The heat plan was designed as an equity-centered framework that would reduce the risks and effects of extreme heat, with particular attention to populations in the city that “can experience greater extreme heat exposure and risk, including communities of color, immigrant communities, communities where English is spoken as a second language, older adults, individuals with chronic health conditions, and youth.” While it will apply to the whole city, it aims to prioritize overburdened neighbourhoods that are disproportionately impacted by extreme heat.

The heat plan was also developed around the premise that “a better, more resilient Boston can create cooler communities and also support broader benefits for justice, equity, and basic improvements to everyday life.”

Identifying Priority Neighbourhoods

Heat data was combined with socio-economic data from several sources for 2015-2019 to identify critical hot spots across Boston where high temperatures coincide with historic disinvestment and “environmental justice communities with minority, low- to no-income, and English-isolation characteristics.” Five neighbourhoods or “focus areas” were prioritized for action with this process – Chinatown, Dorchester, East Boston, Mattapan and Roxbury. With Chinatown, for example, which is the hottest of the five prioritized neighbourhoods, the city-wide heat analysis found that day-time and night-time median temperatures (40.6°C and 31.1°C respectively) are 3°C hotter than the city’s median day-time and night-time temperatures (37.5°C and 27.7°C respectively).

The urban form analysis found that Chinatown has less green space, wider streets with fewer street trees, and higher population and building densities than other neighbourhoods in Boston. Tree canopy and parkland make up only 8% and 3% respectively of the land cover in Chinatown compared with 27% and 23% respectively for the city as a whole. This is a significant difference and helps to explain the temperature difference between Chinatown and the City as a whole.

The socio-economic analysis found that Chinatown is also home to a greater proportion of people who are susceptible to harm from extreme heat:

- 15% of its residents are over 65 years of age compared to 12% city-wide;
- 21% live on low incomes compared to 16% city-wide; and
- 84% of the housing units are renter-occupied compared to 64% city-wide.

Older residents are more sensitive to extreme heat. The heat plan notes that those who live on low incomes or live in rental units are less likely to have control over indoor air temperatures and more likely to have chronic health conditions that make them more susceptible to harm from extreme heat.

Assessing Strategies and Community Engagement

Community engagement for the heat plan included a series of five “listening sessions” in each of the five focus areas to appreciate how heat is affecting the lives of their residents and to hear about the critical needs of residents in those areas.

The strategies identified by staff and the community were assessed according to their heat resilience benefits and co-benefits including those related to heat reduction, heat relief, adaptive capacity, public health, environmental impacts, and environmental justice & equity.

A simulation model was used to estimate the reduction in surface temperature and in perceived temperature for cooling strategies such as light-colored roads, shade canopy, green roofs, and cool roofs.

Cool Roofs Program

One of the 26 strategies included in Boston’s heat plan was a Cool Roofs Program:

“The City will launch a cool roofs program, which will provide grants to a nonprofit organization to complete cool roof installations on eligible properties. The City will explore additional near-term opportunities to demonstrate large-scale cool roofs on public buildings.”

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“Dark-colored roofs can absorb much more heat than lighter-colored roofs,” explained Davis. “In dense urban spaces, they can contribute substantially to urban heat island impacts. Modelling demonstrated that light-coloured or “cool” roofs can reduce extreme temperatures in localized areas.”

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The Boston heat plan notes that cool roofs were also strongly supported by community members with 45% of respondents indicating that they would like to see more cool roofs in their neighborhoods.

“In 2022, we put out a Request for Applications for a Cool Roofs Pilot Project,” said Davis. “We were looking for a non-profit organization to do the work because the City cannot really do work on private property. We had \$120,000 we could direct towards this project.”

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“We wanted an organization that could implement the project with an equity lens; that would prioritize disadvantaged and underserved populations,” explained Davis. “We wanted cool roofs to be applied to community assets such as public housing and non-municipal community facilities that provide essential services to vulnerable populations.”

“We awarded the contract to Local Initiatives Support Corporation Boston, a non-profit organization with a lot of experience managing similar projects. In the end, three roofs on sizable, subsidized housing projects and a homeless services center were treated with the reflective coating,” said Davis. “The program funded 16,000 square feet of cool roof coating. The three buildings were in the neighbourhoods of Allston and Dorchester.”

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Challenges Encountered and Lessons Learned

Boston’s Cool Roof Program has met with three major challenges; one related to a trained labour force, one related to the timing of funding and approvals, and one related to funding for cool roofs.

“When we initiated this project three years ago, it was difficult to find roofers who were trained or experienced in the use of reflective paints for flat, dark-coloured roofs,” noted Davis. “Hopefully, that will change over time.”

“We noticed some timing issues,” said Davis. “If roof repairs are needed or additional elements like solar panels are to be added to the project, it’s important to consider the amount of time required for building permit processes. For this grant, the timing of the end of the grant period didn’t align with the permit and installation timeline.”

“Unfortunately, we have not been able to take this program beyond the pilot stage,” explained Davis. “While there is funding for our work on energy efficiency and carbon mitigation retrofits for buildings in underserved neighbourhoods in the city, there is not currently funding for projects that improve climate resiliency, and cool roofs are not currently recognized in energy efficiency and carbon programs as a retrofit that can address these co-benefits.”

“Some jurisdictions, such as Cambridge, have been able to fold cool roofs into their energy efficiency projects, but in Boston, that type of change has to be made when a program is being developed or re-funded. We are interested in integrating more resilience solutions including cool roofs into our energy efficiency and carbon mitigation programs in the future,” offered Davis.



In 2011, the borough, Rosemont–La Petite-Patrie, made it mandatory for all new public and private buildings to have a white or green roof. Four years later, the borough went one step further. It adopted a new by-law which stipulates that all new flat-roof constructions must be composed of a white, energy-efficient membrane. This by-law, which was passed “to promote sustainable development, combat heat islands and contribute to public health by improving air quality” prohibits the use of “multi-layer waterproofing systems composed of bitumen, bitumen felt, fiberglass and gravel” on flat roofs for new buildings. Rosemont-La-Petite-Patrie was the first borough in Montreal, and perhaps the first jurisdiction in Canada, to require white or cool roofs. It is estimated that there are nearly 6000 white roofs in Rosemont–La Petite-Patrie. Since then, several boroughs of Montreal have followed its example.

Research focus: Cool Roofs Can be a Great Choice for High Density, Low-Income Neighbourhoods

Cool Roofs Cool the Air

Research conducted at Boston University has demonstrated that cool roofs can greatly reduce heat exposure in high density, low-income neighbourhoods that can be home to people who are at high risk of harm from extreme heat.

Dr. Ian Smith, a post-doctoral researcher at Boston University, studies urban environmental adaptation for vulnerable communities. He has published several studies on the potential of cool roofs to reduce air temperatures and exposure to heat in high density neighbourhoods that are home to vulnerable populations such as older people, people of colour, and those living on low incomes.

Cool roofs are those that reflect light instead of absorbing it as heat. They are either constructed or renovated with materials that are light in colour or reflective in nature.

“While we believe that we can cool the air in a neighbourhood by adding reflective surfaces to all roofs, this measure is particularly effective on flat, dark roofs,” Smith explained. “In Boston, many of the roofs are flat and coated in dark, rubbery material that absorbs the heat. This makes cool roofs a strong climate adaptation measure for the City of Boston.”

A 2022 study published by Smith and his colleagues found that:

- rooftops account for 20% of the total land area in Boston;
- flat, dark roofs account for over 50% of the roof area within the most vulnerable communities and 23% in the least vulnerable communities, leading to disparities in residential neighbourhoods;
- residents living in the most vulnerable city blocks experience mean summer land surface temperatures that are 3.0°F warmer than the average temperatures in the least vulnerable city blocks;
- the conversion of all residential buildings with flat, dark roofs to cool roofs could reduce the mean summertime temperature disparity between the most vulnerable and the least vulnerable residents by 37% (i.e., by 3.0 to 1.9 °F).

Cool Roofs can Reduce Exposure for Vulnerable Populations

In 2025, Smith and his colleagues compared the potential for tree canopy expansion and cool roof measures to reduce air temperatures in neighbourhoods across Boston. The study found that cool roof measures are overall more effective at reducing heat exposure among vulnerable populations in Boston. Although an expanded tree canopy can reduce air temperatures in a given neighbourhood by a greater amount than cool roofs measures, cool roofs can be applied in dense, low-income neighbourhoods where it can be difficult to find the space needed to grow trees.

The 2025 study emphasizes that strategies to reduce climate-driven heat should “not only consider the potential magnitude of air temperature reductions, but also the availability of space to implement solutions that reduce air temperatures in densely populated areas.”

How do Cool Roofs Compare with Trees?

To assess which solution would have the most beneficial impact on the health of Boston residents, the research team developed a model that estimates the effect of implementing cool roofs or expanding tree canopy in areas without them. The model includes air temperature data from a range of urban and rural environments and data related to populations who face higher exposure to, and greater risk from, extreme heat.

“We assessed heat exposure and vulnerability through several determinants including population density, age, income, race, and education,” Smith explained. “The model demonstrated that many areas of Boston where new tree planting is suitable are located far away from the communities most in need of cooling interventions.”

“For communities that cannot afford or access air conditioners, it is critical that we reduce air temperatures in their neighbourhoods,” offered Smith. “Cool roofs can reduce ambient temperatures at the neighbourhood level, which benefits individuals who rely on passive cooling measures such as open windows.”

“Another factor to consider is timing – how long it takes for residents to experience cooling benefits from an intervention,” Smith explained. “Trees offer significant mental and physical health benefits for cities and their residents, but you have to wait many years before communities experience their cooling benefits. The benefits of a cool roof are immediate. They’re as effective as they’ll ever be on the day that they’re installed.”

“Factoring in the time frame, cost of solutions, and where vulnerable populations are located, our model suggests that cool roofs are more effective in a context similar to Boston’s,” said Smith.



Case Study 5: Greening Underserved Schools & Preventing Floods in Chicago



Space to Grow Program

Since 2013, the Space to Grow program in Chicago has transformed over 36 schoolyards, with 5 more currently under construction, serving more than 36,000 students, families, and community members in under served neighbourhoods with greenery and green stormwater infrastructure.

“When mandated recess was brought back to schools in Chicago in 2011, communities noted that the schoolyards where children played were neither safe, nor healthy,” explained Emily Zhang, Space to Grow Project Manager at the Healthy Schools Campaign. “Many schoolyards had broken equipment and asphalt-dominant grounds, along with flooding issues in nearby neighbourhoods.”

The Space to Grow program was established that year when two non-profit organizations partnered with Chicago Public Schools and two public water agencies to transform schoolyards in under-resourced neighbourhoods into green oases that reduce flooding.

The Space to Grow program prioritizes historically disinvested and underserved areas in Chicago,” explained Zhang. “These communities have been shaped by historic policies that systematically restricted public investment in communities of color.”

Multi-Sectoral Collaboration

The Space to Grow program operates through a collaboration between the non-profit organizations, the Healthy Schools Campaign and Openlands, along with three public agencies, the Chicago Public Schools, the Metropolitan Water Reclamation District of Greater Chicago, and the Chicago Department of Water Management.

Each partner organization has its own goals. The two water agencies are working to reduce the risk of floods and protect water quality in the city. Chicago Public Schools aims to provide safe and welcoming schoolyards for its students and their families. Openlands is dedicated to connecting people with nature and greening urban areas. And the Healthy School Campaign seeks to address systemic barriers; to provide children in under-resourced neighbourhoods with safe and vibrant outdoor spaces that support health and well-being.



"Through our aligned goals, we work together to redesign and revitalize outdoor school spaces. The non-profit organizations coordinate work between the partners, facilitate community engagement on all elements of the work, and provide technical assistance and educational programming to schools. The public agencies provide leadership, expertise, and funding for the design and construction of the schoolyards. Funding from the two water agencies is guided by each schoolyard's potential to reduce stormwater runoff through green infrastructure," Zhang explained.

Green Infrastructure and Green Space

Space to Grow uses green stormwater infrastructure, systems and features that incorporate or mimic nature-based solutions to capture stormwater on-site and reduce sewer system strain. Chamber systems are installed below the surface to catch water on schoolyards. Asphalt is replaced with permeable surfaces, native plants, rain gardens, and bioswales to absorb and filter stormwater.

These measures offer significant benefits for flood prevention. At Grissom Elementary School, for example, it was estimated that the project would entirely eliminate runoff volume and remove nearly all pollutants from the water for over 99% of all storms.

The infrastructure and landscaping design for each schoolyard is informed by the needs of the students and the surrounding community.

"At our recent renovation at Brown Community Academy, the schoolyard design had to support students from pre-kindergarten to grade 8, so we wanted to ensure that there were spaces for different activities and sports, while also integrating a nearby rain garden to absorb water," said Zhang.

The community design process identified key priorities for the school, including creating opportunities for outdoor learning, nature play, and growing food.

"We transformed a courtyard space into a nature play area and an outdoor classroom, and we added raised planters and edible garden beds," said Zhang.

"Partners at Loyola University and the University of California's Nutrition Policy Institute have done studies around the use of renovated schoolyards and have seen an increase in the use of physical space across genders and all age groups and found that these schoolyards promote a more positive relationship between the schools and community," explained Zhang.

Engaging the Community

Space to Grow uses a participatory approach so the community is involved at every stage of their schoolyard's transformation.

"Once a school is selected, we begin with a planning process that includes meetings with school leaders, parents and caregivers and neighbours," explained Zhang. "We also help form a Space to Grow Committee for each schoolyard that includes trusted messengers from the community who can communicate with various stakeholders."

"Trusted community members are the best messengers," said Zhang. "Committee members with strong local networks help ensure that the school community feels heard and stays informed."

During the planning phase, students and community members share what they want from their schoolyards. Landscape architects and engineers, who participate in these meetings, translate the community's visions into schematic designs. Ongoing workshops allow designers to get real-time feedback from community members before finalizing a design.

"The design team is involved in every conversation with community members," explained Zhang. "This project is not just about us relaying information about the schoolyards to the community. It is about co-creating spaces that reflect local needs while allowing communities to build climate resilience."

Prioritizing Schools Based on Flood Exposure and Social Equity

The initial school selection process is based on three primary criteria:

- High flood risk areas;
- High need for playground or playground renovation; and
- The Chicago Public Schools Equity Index.

The city's water department uses a geospatial approach to identify schools that are in locations with a high risk for basement flooding. The Chicago Public School Equity Index assesses school conditions, community conditions, and historical capital investment patterns to prioritize schools most in need of upgrades.

"Almost all the schoolyards that we have renovated are located on the south and west sides of Chicago," noted Zhang. "Many of these communities have a legacy of redlining and disinvestment. When you overlay maps of historic redlining with tree canopy, heat vulnerability, and other health disparities, the patterns are striking. These are the communities that have been overlooked for too long and where intentional investment can make the greatest impact."



Redlining was a racist policy that prevented people of colour from obtaining mortgages based on neighbourhood value. Although the practice has been illegal since 1968 in the United States, its legacy endures. Residents living in redlined neighbourhoods today experience higher exposure to air, water, and noise pollution. Beyond redlining, other discriminatory housing policies and practices such as exclusionary zoning, inequitable code enforcement, and disinvestment continue to result in the lack of access to safe, healthy and affordable housing.

Once a school meets the initial eligibility criteria, it can apply to the Space to Grow program. Final selection is based on flood risk, feasibility of schoolyard development, access to green spaces, socioeconomic factors, and school participation readiness for renovations. Three or four schools are selected each year. It can cost between \$1.5 - \$4 million to transform a schoolyard.

Challenges and Lessons Learned

The Space to Grow program found that the maintenance and management of the transformed schoolyards was an initial challenge. Now, school caretakers are better trained on the maintenance needs once the renovations are completed. Chicago Public Schools have also contracted firms with specialized training to steward the spaces. Teachers receive professional development to orient them to the green spaces, to understand their benefits, and learn how they can use them in classes and after-school programming.

“Through evaluation processes, school staff have reported increased job satisfaction because of transformed schoolyards,” said Zhang.

The transformed schoolyards are also open to the community for use. The Space to Grow team has found that the schoolyards are generally treated with respect by the community.

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“The best way to maintain these spaces over the long term is by involving the community in their development,” Zhang concluded. “When communities are empowered through community building, they feel ownership over their schoolyards and want to care for them.”

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However, ongoing maintenance remains a challenge. While community involvement fosters a sense of stewardship, school staff and partners have noted that clear roles, consistent resources, and dedicated funding streams are essential to keep the schoolyards vibrant and functional. Tasks like garden care, trash removal, and green stormwater infrastructure upkeep require coordination between the school district, individual schools, public agencies, and communities. The Space to Grow partners continue to explore innovative models for shared maintenance - leveraging volunteer days, student engagement and interagency collaboration to sustain these vital green spaces over time.

Case Study 6: Toronto's Equity-Based Green Streets Program



Green Streets Program Goals

Toronto is increasing the city's climate resilience with an equity-based Green Streets Program. Established in 2017, Toronto's Green Streets Program integrates green infrastructure into the design of its streets, sidewalks, and boulevards to reduce air temperatures, enhance air quality, and manage stormwater in neighbourhoods across the city.

This green infrastructure is built into the City's right-of-way which includes roads, curbs, and sidewalks; all of the publicly owned land that stretches from one property line to another. By reimagining how these spaces are designed and managed, Toronto is replacing traditional infrastructure with features that reduce urban heat islands (UHIs), manage stormwater, and improve water quality.

The City is giving priority to neighbourhoods that can benefit the most from green infrastructure in terms of stormwater management, air quality, social equity, tree canopy distribution, and climate resilience.

Building Climate Resilience

With human-induced global warming, air temperatures and the risk of flooding are increasing in many Canadian cities. Flooding is also becoming a greater concern in the city. In July 2024, for example, a flash flood led to power outages and almost \$1 billion in insured damages.

Extreme heat events and flooding resulting from extreme weather and a dense urban environment motivated the City to plan how its rights-of-way could deliver environmental and social benefits. Green streets integrate features such as bioswales, permeable pavement, rain gardens, and bioretention assets, that can capture and filter stormwater while also cooling surrounding air through evapotranspiration.

Initiating a Green Streets Program

Toronto's work on green streets began in 2013 after 60 mm of rain fell overnight and the Don River flooded some of the city's major highways including the Don Valley Parkway.

"This large storm gave rise to a City Council directive to develop green infrastructure standards to help manage the city's stormwater in the right-of-way," explained Kristina Hausmanis, Senior Project Manager, Green Streets Program, City of Toronto.

From 2013 to 2017, City Planning and Toronto Water collaborated to develop Green Streets Technical Guidelines while also piloting green infrastructure projects. Early work focused on large, underused right-of-way areas such as traffic islands. These were converted into bioretention sites by removing excess asphalt and adding curb cuts to direct runoff on to the greenery.

When a new General Manager, who had experience with Seattle's Green Streets Program, joined Transportation Services, the Green Street vision was expanded.

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“With the new General Manager on board, it was decided that the Transportation Division, which has responsibility for the city’s right-of-way, should play a bigger role in the implementation of green streets infrastructure,” explained Hausmanis. “To scale up the program, it was recognized that we needed a clear governance model and defined asset ownership.”

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Multi-Sectoral Collaboration

The installation and maintenance of green streets infrastructure involves several divisions within the City so there is a need to work collaboratively across all divisions. A governance model was established in 2017 that brought several divisions together including Transportation Services, Engineering and Construction Services, City Planning, Parks, Forestry, and Recreation, (now Environment, Climate and Forestry), and Toronto Water.

A Steering Committee was created, supported by a staff-level working group, to coordinate the development and implementation of green streets infrastructure across the city. As the primary owner of the right-of-way assets, Transportation Services assumed leadership for the Green Streets Program.

“We, in Transportation Services, own and are responsible for the green infrastructure assets in the right-of-way, but other divisions are essential to the project’s success,” offered Hausmanis. “For example, Toronto Water is responsible for flushing out catch basins going into green infrastructure and Urban Forestry takes care of street trees.”

“The City has also partnered with non-profit organizations. For example, the City is collaborating with the Toronto Region Conservation Authority (TRCA) via their Sustainable Technology Evaluation Program (STEP) on the evaluation and monitoring of green infrastructure sites in the city,” explained Hausmanis.



The City has also collaborated with non-profit organizations on its workforce development program, GreenForceTO, that was initiated in 2021. Transportation Services partnered with two local Employment Social Enterprises, RAINscapeTO and Building Up, to hire and train individuals from Neighbourhood Improvement Areas in the city and people experiencing barriers to employment, for the maintenance of green streets infrastructure. Neighbourhood Improvement Areas are neighbourhoods that need support to improve the wellness of their residents based on economic opportunities, social development, health, community engagement, and physical characteristics of their communities.

Prioritizing Neighbourhoods for Green Infrastructure

With over 5400 km of roadways, Toronto required a systematic approach to prioritize locations for green infrastructure.

“We are moving from a model that was based solely on opportunities to pilot green infrastructure to one that considers program benefits,” explained Anisha Patel, Project Manager, Green Streets Program, City of Toronto. “We are looking for neighbourhoods that would benefit most from green infrastructure interventions by assessing both vulnerabilities and opportunities in neighbourhoods across the city.”

This approach evaluates where green infrastructure can be most beneficial at reducing climate vulnerabilities, improving the quality of life for residents, and decreasing social inequities, while also considering the physical opportunities for installation.

This selection process involves three stages:

1. **Geospatial Analysis:** With the first stage, a model is used to prioritize projects based on the co-benefits that can be gained with green infrastructure. This model allocates a score for five green infrastructure co-benefits:
 - **Stormwater Management** which is based on data related to combined sewer overflow areas, storm sewers that flow into environmentally sensitive areas, impervious surfaces, and rainfall distribution;
 - **Air Quality** which is based on data related to the density of senior or childcare facilities within areas with high levels of traffic-related air pollution;
 - **Tree Canopy Cover** based on tree canopy distribution;
 - **Social Wellness** which is based on “Neighbourhood Improvement Areas” identified by the City; and
 - **Climate Resilience** which is based on extreme heat vulnerability maps and areas identified as vulnerable to storm-related floods.
2. **Desktop Analysis:** Projects in the top percentile are then selected for the second stage where the suitability of the site for green infrastructure implementation is evaluated using factors such as space available, soil conditions, site coordination conflicts, and public visibility.
3. **Stakeholder Coordination:** The third stage draws upon the expertise of the Green Streets Working Group and others to identify the scope and budget needed for the project and to coordinate implementation.

The City is in the process of developing key performance indicators and implementation processes to guide how green infrastructure will be installed and evaluated in these targeted neighbourhoods.

Community Engagement

Community engagement plays an important role in Toronto's Green Streets Program. The City works directly with communities. It offers choices to impacted residents to select the green infrastructure options that work best for them.

"Some neighbourhoods have open ditches that can be transformed into bioswales," said Hausmanis. "When the City installs these bioswales, residents are provided with native and suitable plant options, which they are expected to maintain after installation. However, if residents prefer not to have a garden, they can opt for sod, which still provides the water quality benefits of green infrastructure."

Challenges and Lessons Learned

The Green Streets team has learned that project feasibility varies by location.

"Suburban areas such as Etobicoke and Scarborough provide more space for green infrastructure than Toronto's urban core," stated Hausmanis.

City staff have learned that education and outreach are important for public acceptance of green infrastructure.

"While attitudes are shifting towards natural gardens, many residents still prefer the look of manicured sod," said Hausmanis. "It is important that we educate residents about the benefits of green infrastructure. We plan to develop educational materials such as infographics to help them understand the value of these features."

There have also been challenges with utility contractors and construction activity damaging green infrastructure assets.

"The City has the Municipal Consent Requirements that outline requirements for working within the city right-of-way. However, these requirements do not reference how developers or utility contractors are to work within or around green infrastructure assets," explained Patel. "We need to update these requirements to ensure that green infrastructure is protected when it is worked around".

Funding

The cost of green infrastructure is project dependent. The standard cost of reconstruction in the right-of-way is calculated and the Green Streets Program covers the additional cost of incorporating green infrastructure, which is typically about 30-40% more for linear green infrastructure.

"We have not been able to estimate the cost savings created with green infrastructure yet," noted Patel. "The reduction in air temperature and stormwater management are incremental with each project, so it is hard to say how much harm and damage is being prevented with each project. Over time and cumulatively, we expect that there will be considerable financial and health savings, but we don't have the data to demonstrate that yet."

Toronto's green infrastructure features include the following:

- **Continuous Soil Trenches and Stormwater Tree Trenches:** Trenches placed beside walkways that collect stormwater into planters and direct it to trees.
- **Bioretention Assets:** Garden-like structures including cells, planters, and curb extensions that collect and filter stormwater, allowing some of the water to support native plants.
- **Bioswales:** Linear, vegetated channels that slow down, treat, and store stormwater temporarily.
- **Enhanced Grass Swales:** A gently-sloped channel that reduces stormwater runoff and cleans stormwater as it flows.
- **Green Gutters:** Shallow, vegetated planters installed along a street's length to capture and filter runoff while separating transportation corridors (e.g., vehicle traffic, bikes, transit lanes).
- **Vegetated Filter Strips:** Gently-sloped, vegetated areas that are installed adjacent to impervious surfaces to treat and reduce stormwater runoff.
- **Permeable Pavement:** Paving materials that consist of small pores and allow rainwater to drain into an aggregate storage layer temporarily before being conveyed into native soil or other drainage systems. These materials include permeable interlocking concrete pavers, porous asphalt, and pervious concrete.
- **Infiltration Trenches:** An underground trench made up of geotextile-lined excavations that temporarily holds and treats stormwater.
- **Rain Gardens:** A shallow, sunken planting bed composed of highly permeable soil that collects rainwater filters it through the soil and plants, and prevents standing water.



Case Study 7: Managing Coastal Erosion with an Equity Lens in Vancouver



Managing Coastal Flooding

Flood hazard modelling that began in 2012 indicates that Vancouver, a coastal city, needs to be prepared for a 50 cm rise in sea levels by 2050 and 100 cm by 2100, in addition to storm surges and more extreme rainfall events as a result of human-induced climate change. The City is aiming to prepare for the changing climate with an equity lens that combines community values with technical criteria and solutions drawn from nature as well as traditional grey infrastructure such as concrete.

“Vancouver is a coastal city that has had little experience with major coastal flooding in a settler time period so we have very little flood management infrastructure,” explained Angela Danyluk, the Manager of the Climate Change Adaptation and Equity team in the Planning Department with the City of Vancouver. “Using a risk-based approach, we have been thinking about how we can make the city more resilient to rising sea levels and an increasing flood risk in a way that protects people, buildings, infrastructure and the natural environment.”

“We plan to use a variety of adaptation options to manage coastal flooding,” Danyluk said. “We will use a mix of grey infrastructure such as dikes and nature-based solutions to manage exposure to rising water levels and reduce erosion. We will also use non-structural tactics such as planning policies and by-laws to manage where and how high buildings can be built. We will also look to preserve the space needed along shorelines to build flood management infrastructure and apply nature-based solutions well into the future.”

Bringing Equity into Coastal Flood Management

When an equity lens is applied to coastal flood management, it involves prioritizing where the work is done and how the work will be done. In 2018 and 2020, Vancouver’s Planning and Engineering Departments initiated a comprehensive planning process for coastal flood management for the Fraser River and False Creek. The City’s goal was to manage coastal flooding in a way that produced many benefits for the community.

“Traditionally, coastal flooding is managed by teams led by engineers who usually apply a hard infrastructure approach that results in grey infrastructure such as dikes,” explained Danyluk. “In Vancouver, we wanted to approach this process differently. We wanted the pilot project to be evaluated using the seven values-based criteria that were identified by community engagement, as well as technical criteria. Those values-based criteria included factors related to safety, housing, Indigenous perspectives, recreational opportunities, transportation, culture, and environmental benefits.”

“We wanted a new approach that fostered open discussions about the trade-offs associated with different designs,” said Danyluk. “We also wanted to allow room for the process to be informed by the lived experience of those participating.”

Sea2City Design Challenge

One step in this process was a pilot project called the Sea2City Design Challenge. This project, which ran from September 2021 to September 2022, was developed to inform the next phase of the City's Climate Change Adaptation Plan and the City's coastal adaptation work. It employed an approach that aimed to restore relationships with the Host First Nations, rebuild connections to the Salish Sea, and employ a "two-eyed way of seeing", which recognizes and integrates the strengths of both Indigenous and Western ways of knowing.

Two design teams participated in the Sea2City Design Challenge. Each one was led by a Designer rather than an Engineer and both teams were supported by a Cultural Advisor. The Sea2City Design Challenge included:

- a 28-member City Advisory Team composed of City staff and representatives and knowledge keepers from the Host First Nations - the Musqueam, Squamish, and Tsleil-Waututh peoples;
- a 21-member Technical Advisory Committee composed of experts from local consulting firms, academia, non-governmental organizations, and asset operators such as BC Hydro and Metro Vancouver;
- a 17-member Community Advisory Group with residents representing various perspectives from local communities; and
- a 15-member Youth Adaptation Lab.

One of the key recommendations from the process relates to the language used by the City when addressing coastal erosion. It was recommended that the language be changed away from "resist, accommodate, and move/avoid" which was seen as colonial language that "sees the water as separate and distinct from the land". It was suggested that the language be changed to "acknowledge, host, and restore" to recognize water as "part of a larger, interconnected, and holistic system".

The Sea2City Design Challenge report defines this new coastal language as:

- **Acknowledge:** spaces are retrofitted or relocated over time to improve their resilience and better care for and steward natural systems.
- **Host:** a dynamic place where water, nature, and culture are welcomed and stewarded. Human uses are flexible, adaptable, and leave a light-touch. Infrastructure works with nature to enhance resilience.
- **Restore:** a revitalized and rehabilitated shoreline that restores natural functions, features, and ecosystems, and includes improved flood protection for upland communities.



Outcome from an Equity-based Approach

The Cooper Tidal Terrace will be the first pilot project to move forward from the Sea2City Design Challenge. Construction will begin early in 2026 as part of a larger bridge seismic rehab project and end early in 2027.

“With this stretch of shoreline, a traditional, flat concrete sea wall will be replaced with a terraced design. The crest of the terrace will be raised to mitigate flooding. The terrace will be constructed with two tiers of pre-cast concrete. The outside walls will be textured to encourage sea life, such as seaweed and invertebrates, to attach to the surface. Inside the terrace will be native plants, shrubs and logs that provide habitat for pollinators and birds. The plants were reviewed by Host Nations plant knowledge keepers in this area,” said Danyluk. “The terrace will include inter-tidal habitat and provide pedestrians with access to enjoy and explore the waterfront. We will also be looking for ways to acknowledge and celebrate the Host First Nations language.”

Lessons Learned

The City has had a Sustainability Group for over 15 years. In 2022, it reorganized and repurposed an existing branch to focus on climate adaptation and equity.

“It is useful to have a team of staff who have the time to plan, problem solve, and project manage climate change adaptation projects in collaboration with other departments,” offered Danyluk. “Our group is also tasked with securing the funds for pilot projects such as the Coopers Tidal Terrace project”.

The Sea2City Design Challenge became “a collective learning and capacity-building opportunity for the City, project partners, and design teams” about a “more decolonized planning approach” to coastal management, offered Danyluk.



Case Study 8: Managing Floods with Sponge Parks in Montreal



Overview

In 2021, the City of Montreal launched a program to promote two complementary initiatives: green street drainage infrastructure and sponge parks. The team responsible for these initiatives, led by Marie Dugué, Section Head of Planning and Major Projects, Water Services, was tasked with providing tools, advice, and financial assistance to boroughs and central services regarding green infrastructure for street drainage and sponge parks. Although these two components were developed simultaneously, they have distinct characteristics in terms of their scale and functions.

Green infrastructure on streets includes, among other things, vegetated curb extensions located at a lower level than the roadway that capture and infiltrate runoff during light rainfall. The main purpose of such interventions is to reduce sewer overflows by managing small amounts of precipitation. This also promotes greening, reduces heat islands, and improves pedestrian safety.

For their part, sponge parks temporarily capture large volumes of water during heavy storms. Water from surrounding streets is directed at the surface toward a low-impact area (the park), held there, and then returned to the sewer once capacity becomes available again. The purpose of sponge parks is to reduce the frequency of flooding for the surrounding neighbourhoods.

Referring to the severe storms that hit Montreal in recent years, Dugué explains, "Every time it rains, water enters the street drains. Recently, we've had some very severe storms. We had two in 2024, we had others in 2023, and for several years now, we have been experiencing events that exceed all the statistics we usually have. And now, in the sewer system, the water can no longer get in because there is too much water falling on the street. That's when we try to direct these rivers of water flowing along the streets toward these parks. We want to flood an area of lesser impact in order to protect or reduce the frequency of flooding in residential and commercial areas. So we often hold the water temporarily until the sewer has capacity again. Then, we return the water to the sewer system."

Since 2022, the City of Montreal has implemented 23 sponge parks as green infrastructure and has built, or will build, enough to reach 2,500 "cells" (meaning individual units or functional modules that make up a stormwater management system) for a total area equivalent to about 6 soccer fields, or roughly 45,000m².

Related Benefits

Although these two components bring greenery to the city and reduce heat islands, one aspect of this project that should not be overlooked is the effort and motivation of the teams. As part of a project that is now proving its worth, each team involved is proud to be part of such an initiative.

As Dugué explains, "What also helps a lot is when you have good examples. Then things start to fall into place."

During this period, Ms. Dugué's team not only carried out pilot projects in urban areas but also thought strategically about how to continue the actions thereafter.

Hugo Bourgoïn, media relations officer with the City of Montreal's Public Affairs and Protocol Department, added, "What's wonderful about sponge parks is that 99% of the time, they provide co-benefits. These spaces are used by citizens. Children can go play there, families can picnic in these parks, they use them. And the 1% of the time when rain is too intense and the sewer system can't keep up, the park is partially flooded to accommodate that volume of water and relieve some of the pressure on the sewer system."

A Now Quantifiable Goal

In 2022, the city set a quantitative target: to build 8,500 m² of green infrastructure on streets between 2022 and 2025 and to provide 9,000 m³ of retention capacity in parks over the same period.

These projects would not have been possible without funding from the Ministry of the Environment. Through the green economy program, the city obtained \$117 million for various elements, including \$15.5 million dedicated to water services. This made it possible to assemble a team of experts to support the boroughs and central services carrying out the projects, producing tools, and conducting research.

As Dugué explains, these projects are multi-sectoral: "Of course, the project leaders are mostly in the boroughs; they are either in the boroughs or the central service, which is actually the Urban Planning and Mobility Department. The Parks and Sports Department also own these spaces and initiate the projects, commission consultants or design them internally, and supervise the work afterwards. My team is really there to support these teams in integrating water management. One of the interesting players is the Office of Ecological Transition and Resilience, which helps us find funding and increase various benefits."

Finally, other sources of funding came from the Green Municipal Fund, the Flood Resilience and Adaptation Program (Programme de résilience et d'adaptation face aux inondations - PRAFI in French only), and the Sustainable Stormwater Management Program (Programme pour la gestion durable des eaux de pluie - PGDEP in French only), which are programs of the Ministry of Municipal Affairs, as well as the Disaster Mitigation and Adaptation Fund (DMAF), which is a federal program.

Implementation Approach

To properly analyze the neighbourhoods targeted by the project, the team used topographical data. This made it possible to assess street slopes, catchment areas draining towards a park, and vulnerable low-lying zones.

Montreal's Largest Sponge Parks

The retention capacity of Montreal's Five Largest Sponge Parks in 2025:

- Pierre-Bédard Park - 5,735,000 liters
- Pilon Park - 1,373,000 liters
- Park at the intersection of Joseph and Dupuis streets (name to be determined) - 1,067,000 liters
- Howard Park - 750,000 liters
- Pierre-Dansereau Park - 627,000 liters

As Dugué explains, "It's important to understand that we took a very opportunistic approach, which may be a little different from other municipalities. In other words, the City carries out a great deal of rehabilitation work to maintain its assets, including its sewer and water systems under the streets. So we are rebuilding the entire street with sewers and water mains, and we are also doing a lot of work to refurbish our parks. So whenever work was planned, we tried to integrate water management into it as well as we could."

The goal is to better understand the basin areas in the city in order to identify the most vulnerable areas. Subsequently, the structures built in Montreal's database are listed for asset management purposes.

Challenges and Governance

The main challenge in this project is to train and coordinate a multitude of stakeholders across 19 boroughs. These stakeholders may include planners, landscape architects, engineers, planning and specification teams, contractors, maintenance workers, and external professionals. The team chosen must therefore consolidate and coordinate all of these stakeholders, which can be a challenge in itself.

Tools have been put in place to strengthen the capacities of those involved in this project. Approximately 200 training sessions have been provided citywide, as well as internal and external webinars on planning and design, developed by the Regional Council for the Environment (Conseil régional de l'environnement - in French only). In terms of published tools, catalogs, design and construction checklists, and videos documenting maintenance have been used to support those involved.

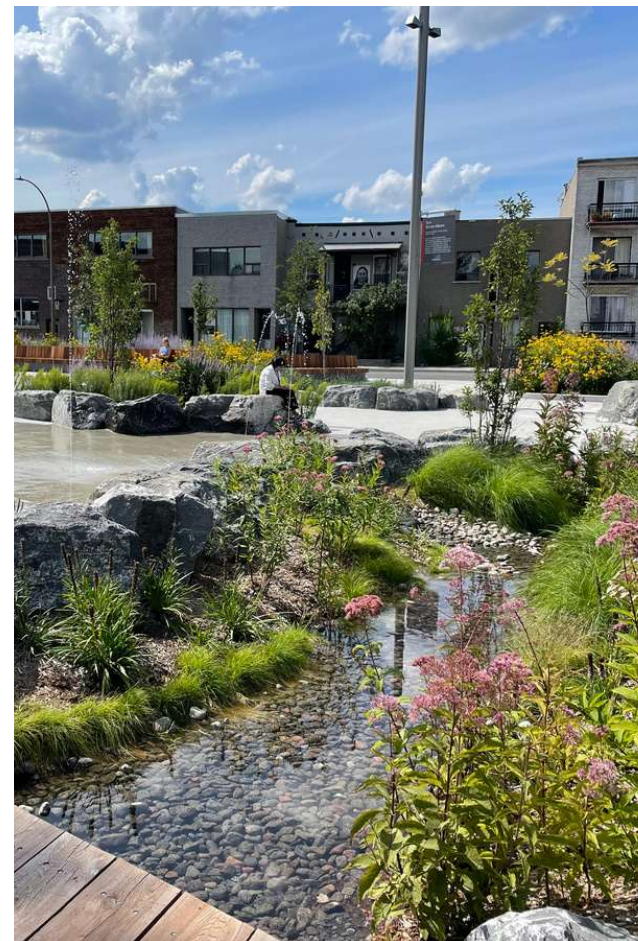
Outreach and external exchanges

The sponge parks project in Montreal attracts many visitors and encourages the sharing of experiences. In fact, many municipalities in Quebec, as well as countries such as South Korea and New Zealand, are interested in this project.

"We also participate in pan-Canadian working groups to share our experiences. We were recently invited to Singapore to present our projects. This has helped raise our profile," explains Dugué.

The comments from Montreal citizens about sponge parks are generally very positive. There is increasing use of these spaces by the population. However, the current issue hanging over this project, an issue that could be described as a challenge, is its popularity:

"We are actually victims of our own success! The workload is increasing significantly," says Dugué. "The success of sponge parks and green infrastructure on streets in the City of Montreal demonstrates an innovative approach that can inspire communities here and elsewhere. With this growing interest, it will be interesting to see where new collaborations will emerge to build a more sustainable urban future."



Case Study 9: Peterborough's Rain Gardens for Private Property



Background

In July 2004, the City of Peterborough was flooded when 9.5 inches of rain fell in a single day and overwhelmed the city's storm water and sewer systems. The fire department, utility and social services were inundated with calls. One hundred and seventy-one people had to be evacuated from a long-term care facility. Flooding resulted in 28 vehicle collisions and trapped 25 people in or on their cars. Basements were flooding. Electric meters and gas lines had to be disconnected. And water heaters were damaged. Over a thousand residents needed emergency food and clothing.

"The 2004 flood made it clear that we needed a more robust stormwater management system in the city," explained Curtis Mei, Acting Manager, Water Resources, Asset Management and Capital Planning with the City of Peterborough. "It was the motivation behind the development of the 2005 City of Peterborough Flood Reduction Master Plan which laid the groundwork for the city's work in this area."

Evolution of Stormwater Management

"There has been a learning process in the stormwater management field," offered Mei. "At first, cities worked to capture stormwater in grey infrastructure that delivered the water to a nearby body of water. But that system delivered a lot of pollution picked up from roads and pavement such as dog waste, fertilizer, and vehicle leaks and emissions, directly into our watercourses."

"Then it was thought that we should direct storm water to man-made settling ponds where the pollutants were captured, but those settling ponds have to be dredged which is a costly undertaking" Mei continued. "So now, cities work to control run-off at the source so that water can be filtered through the soil on the site where it falls."



“Recognizing that we need to manage the water that falls on private property as well as public property, the City’s Stormwater Quality Master Plan that was completed in 2011 recommended the establishment of a program for rain gardens on private property,” said Mei.

What is a Rain Garden?

“A rain garden is a bowl-shaped garden that collects and absorbs the rain and melted snow that runs off impervious surfaces such as rooftops on a property,” offered Laura Keresztesi, the Coordinator, Neighbourhood & Residential Programs with GreenUP, a local non-profit organization. “It is designed to have a shallow depression that is 20 to 30 centimeters deep. It is planted with native species that have deep root systems that help absorb and naturally filter stormwater on site. The bowl should hold water for up to 24 hours; it is not a water garden. The bowl of the garden should be planted with species that can tolerate ‘wet feet’. The top of the berms can be planted with drought tolerant species. Choosing the right plants for each zone of the rain garden can help reduce maintenance as the garden matures.”

Rain gardens can remove 90% of the chemical pollutants and 80% of the sediment from stormwater runoff. They also allow 30% more of the water that falls on a property to soak into the ground than regular grass lawns.

How does the Rain Garden Program Work?

The rain garden program began in 2020 with a collaboration between the City’s Water Resources team and GreenUP.

“Our goal is to encourage residents to incorporate rain gardens into their properties while promoting greater awareness of stormwater management and community involvement,” said Mei. “Rain gardens play an important role in reducing urban runoff from private lands, filtering pollutants from surface water, and replenishing groundwater supplies. They also enhance local biodiversity by attracting butterflies, dragonflies, and other beneficial insects, as well as native bird species.”

“The first few years of the program, we ran a number of workshops to educate people about how to design, install and maintain a rain garden,” said Keresztesi. “We found it was difficult for people to arrange their schedules around workshops so we developed instructional videos that are now available 24-7 on our website so people can access them at their convenience. Through our partnership with the City, we also offer onsite consultations and support people with their applications and installations”.

Each year, both organizations advertise the program with ads and social media. GreenUP will also leaflet neighbourhoods. Residents can get a one-time subsidy up to \$1000 to help them establish their rain gardens. The funds, which can be used to cover the cost of plants or to help prepare the garden, can be claimed with receipts once the project is completed.

The City has hired GreenUP to make the program as friction-free and accessible as possible. GreenUP answers calls from residents, distributes intake forms, conducts on-site consultations, and provides technical advice about the design of the garden and the plants that can be used.

Challenges and Lessons Learned

“There has been a lot of interest in the rain garden program from residents but only a handful move forward with one each year,” noted Keresztesi. “Those who do move forward are quite committed to the idea of having a naturalized yard that supports biodiversity.”

“Funding does not seem to be the barrier for residents,” offered Keresztesi. “Some residents cannot install a rain garden on their property because they do not have enough space. For others, the rain garden is part of a larger landscaping vision and other things need to happen first before the rain garden can be installed. For many, the barrier may simply be having the time and energy to dig, shape and plant.”

“We do allow residents to use the program funding for landscaper related costs to conduct the work,” offered Mei. “We try to make it easy for people to claim the funds from the program.”

“We have made the subsidy program available to community centres and schools. While we have received inquiries from these organizations, there have not yet been any rain gardens installed on these properties.” said Keresztesi. “In some cases, the property was not eligible for the program, and in other cases, I think the teachers simply did not have the capacity to lead the project on top of everything else they are responsible for.”

“Currently the reduction of water volume to the storm water system has not been significant; that would require widespread implementation,” noted Mei. “But the program has been very effective at educating the public about stormwater management and the benefits of capturing water on site. It helps them to understand the work the City is doing to prevent future floods, improve water quality in local rivers, and replenish ground water.”

Case Study 10: Food Forests in Fredericton for Climate Resiliency



In 2025, the City of Fredericton initiated a new food forest pilot project in response to requests from the community. The goal is to plant fruit trees in parks for use by the community. This program grew out of the City's work on climate change adaptation and the development of its Urban Forest Management Strategy.

Climate Change Adaptation Plan

Human-induced climate change is increasing temperatures in summer and winter months and increasing the risk of drought, while also increasing the number and intensity of heavy rainfall, storms, flood events, and long lasting floods in the City of Fredericton in New Brunswick. While the City is working to mitigate its greenhouse gases, it has also prepared a Climate Change Adaptation Plan to prepare for the changes in its climate that are now locked-in.

Published in 2019, this plan identifies six goals:

- Maintain Health and Safety
- Minimize Risk to Buildings and Properties
- Strengthen Resilience of Core Built Municipal Infrastructure
- Strengthen Resilience of Natural Infrastructure and Assets
- Minimize Disruption to Municipal Services and Programs Offered
- Create Partnerships and Empower the Community



Three of the recommendations included under these goals align with, and support, the food forest pilot project:

- Recommendation 1.4 - Whenever possible, maintain and continue to incorporate natural and constructed shade and/or cooling structures into public infrastructure and public spaces.
- Recommendation 4.8 - Continue to integrate climate change adaptation considerations into City park plans and practices, including preserving biodiversity and ecology, the use of native species, water and shade features, adequate tree canopy and natural drainage features.
- Recommendation 6.2 - Stay engaged with climate change work happening through the actions of individuals, groups and businesses in our community.

“We are in the process of renewing our climate change adaptation plan now,” offered Jillian Hudgins, Environmental Strategist & Program Manager for the City of Fredericton. “Flooding and extreme heat are real concerns in our community so issues related to trees, green space and parks are hot topics with our residents, as is food security.”

Urban Forest Management Strategy

To meet goal #4 in the Climate Change Adaptation Plan, to Strengthen Resilience of Natural Infrastructure and Assets, the City conducted an assessment of its urban and rural forest, consulted with the public, and developed an Urban Forest Management Strategy. This strategy applies to “all trees within the geographic City of Fredericton including street trees, forests, private lands, parks, and natural areas”.

The City has a very high tree canopy cover compared to other cities across Canada. For canopy heights greater than 2 metres, Fredericton has an average tree canopy coverage of 63.4% with 44.2% in its urban area and 69.6% in its rural areas. Its urban tree canopy is much higher than Toronto’s (28%), Vancouver’s (23%), Montreal’s (20%) and Calgary’s (8%). The City is committed to maintaining that coverage and building the resiliency of its forest to the impacts of climate change, introduced and existing pests, and development pressures by increasing its tree-planting goal to 750-1000 trees/year and diversifying the tree species across the community.

Folding Equity into the Forest Strategy

The assessment conducted for the forest strategy included the development of a socioeconomic index using Canadian census dissemination areas (DAs). Median values for the DAs were calculated for several factors including education level and annual income. The populations in the DAs that had higher education and income levels than the median were deemed to be less vulnerable to extreme heat, while the populations in the DAs that had education and income levels lower than the median were considered to have higher vulnerability to extreme heat. These socioeconomic data sets were then overlaid with data for mean and peak summer temperatures to identify the DAs that have both exposure to higher summer temperatures and populations that are more susceptible to harm from higher temperatures. It was recommended that the occurrence of these factors be one factor that is considered when prioritizing future tree planting and the protection of existing trees.

“Planting trees in the neighbourhoods that are home to the newcomers in our City is really important,” offered Rich Hall, City Forester with the City of Fredericton. “A lot of the newcomers to our City live in high density neighbourhoods and don’t have backyards so they make really good use of our parks for barbecues and family outings in the summer months. We want to make sure that the parks in their neighbourhoods have shade and other amenities that make them cool and comfortable places for residents in these neighbourhoods.”

Public Engagement Led to Food Forest

Public engagement for the City’s Urban Forest Management Strategy involved one open house, written submissions, and on-line engagement which included interactive mapping, video content, and the draft report. Some of the submissions highlighted ideas that were not proposed by staff. One of those ideas was the planting of fruit trees or food forests in the City’s parks. This idea was raised several times from individual residents as well as by resident groups. So, a recommendation was added to the strategy to select a park and plant fruit trees as a pilot project.

“We picked a park, Wilmot Park, for our pilot project. It is used a lot for summer camps and is located close to a multi-cultural community centre” explained Victoria Cray, Forest Technician with the City of Fredericton. “We purchased 30 fruit trees. We selected five different species - cherry, apple, peach, plum and mulberry. And we planted them with partner plants that will deter pests, and with plants that can be used as herbs or as medicinal plants, and with plants that support pollinators”.

“Last summer was our first summer with the food forest pilot project so it is too early to tell how this is going to work out,” explained Hall. “It is going to take 5-8 years before we have any fruit from our trees but people seem really excited about the project already. Staff have already noticed that people are using herbs and the other plants that have been planted with the trees.”

“The food forest pilot project has so many co-benefits,” noted Hudgins. “In time, the trees will provide shade and fruit in an underserved neighbourhood that experiences higher temperatures and some food insecurity. But already the process of planting the trees, herbs and flowers in this park has helped to build a sense of community in that neighbourhood. Social cohesion is an important element in climate resiliency; one that can save peoples’ lives in an extreme heat event.”



VI Themes and Conclusions

Municipal Context

The ten case study vignettes highlight a range of municipal approaches to climate adaptation, from large-scale strategies and programs to targeted neighbourhood-level interventions. While each case study reflects a distinct local context, several common themes emerge across the examples. This section summarizes these cross-cutting themes.

Goals and Co-Benefits

Five of the ten case studies are directed primarily at the reduction of flooding from overwhelmed storm water systems, rivers or a coastline. In several cases, and with the cool streets and cool schools cases in particular, cooling of the neighbourhood is identified as a secondary co-benefit. In Vancouver, the restoration of the coastline is identified as a way to rehabilitate the natural ecosystem and reclaim the use of the coastline for recreation and other purposes, as well as managing coastal flooding. In Montreal, the sponge parks program has been welcomed by the community as a way to gain parkland that can provide mental and physical health benefits to nearby residents.

Five of the ten case studies are focused on extreme heat. The cool roofs project is seen as a way to cool the inside of the buildings as well as the neighbourhood. The urban forest strategy in Winnipeg, which is seen as a way of protecting the community from extreme heat, is likely to provide direct mental and physical health benefits as well. The policies and programs being implemented in Montreal to increase heat resiliency are seen as actions that will promote biodiversity and improve mental and physical health directly as well. And the food forest pilot project in Fredericton is seen as a way to build a sense of community and increase food security while cooling parks in neighbourhoods that are home to susceptible populations.

Nature-Based Solutions

Nine of the ten case studies utilize nature-based solutions as climate adaptation measures. Three of those case studies, the urban forest strategy in Winnipeg, the rain garden project in Peterborough, and food forest pilot in Fredericton employ nature-based solutions on their own. Six of the case studies, the equity-based heat response program in Hamilton, the green streets program in Toronto, the green schools program in Chicago, the heat resiliency policies in Montreal, the restoration of the coastline in Vancouver, and the sponge parks project in Montreal, combine nature-based solutions with grey infrastructure.

Multi-sectoral Collaboration

Eight of ten case studies involve multi-sectoral collaboration. In several of these cases, multi-sectoral collaboration across departments within the municipality and with outside agencies is seen as essential to the success of the work.





In Chicago, Emily Zhang from the Healthy Schools Campaign explained: “Through our aligned goals, we work together to redesign and revitalize outdoor school spaces. The non-profit organizations coordinate work between the partners, facilitate community engagement on all elements of the work, and provide technical assistance and educational programming to schools. The public agencies provide leadership, expertise, and funding for the design and construction of the schoolyards. Funding from the two water agencies is guided by each schoolyard’s potential to reduce stormwater runoff through green infrastructure”.

In Toronto, Kristina Hausmanis from the Green Streets Program noted that: “We, in Transportation Services, own and are responsible for the green infrastructure assets in the right-of-way, but other divisions are essential to the project’s success. For example, Toronto Water is responsible for flushing out catch basins going into green infrastructure and Urban Forestry takes care of street trees.”

In Hamilton, Shelly Rogers from Public Health Services explained: “One of the strengths of our strategy is that it has been developed with expertise and resources from so many departments. Opportunities that we may not have considered have been brought to the table by other departments along with the resources to implement them.”

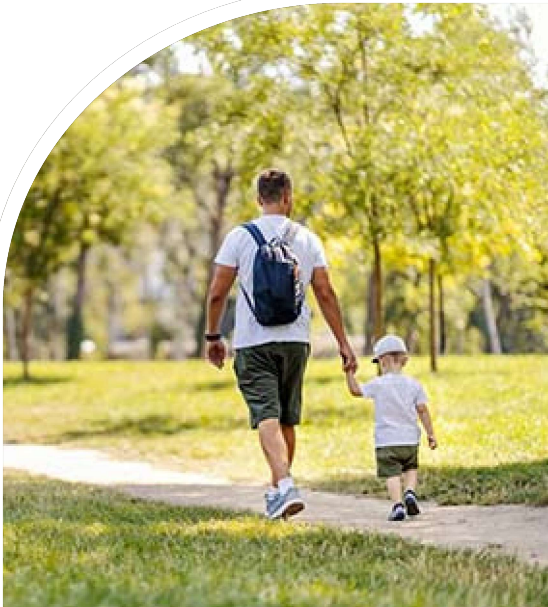
Together, these examples demonstrate that successful climate adaptation often depends on sustained collaboration across municipal departments, public agencies, community organizations, and other partners, each bringing complementary expertise, resources, and implementation capacity to the table.

Community Engagement

Community engagement is an integral component in all ten case studies. In some cases, the community is engaged in the identification and development of priorities, practices and programs, while in other cases, the community is engaged during the implementation of a project or program. In several of the case studies, the engagement and mobilization of the community is seen as essential to the realization of the climate adaptation goals.

In Hamilton, Shelley Rogers indicated that: “Community engagement has been crucial to the development and implementation of the strategy. Community members have offered fresh ideas and practical advice that is based on their lived experience or that of the people they serve. The community groups have also brought resources and support to the table. For example, they helped us distribute Cool Kits and health information to the at-risk populations that we are trying to reach.”

In Chicago, Emily Zhang noted that: “Trusted community members are the best messengers. Committee members with strong local networks help ensure that the school community feels heard and stays informed.”



Folding Equity into Climate Adaptation Measures

In eight of the ten case studies, equity considerations have been explicitly applied to the project.

In Winnipeg, low-income neighbourhoods have been prioritized for tree canopy investments because of the health equity benefits that can be realized. City Forester, Martha Barwinsky, explained: “Poverty can be a significant barrier to health, wellbeing, and social equity. People living in poverty may have few means to access private amenities that can reduce vulnerability to heat, such as shady back yards and in-home or in-care air conditioning. For some people, public trees and forests provide a main opportunity to keep their homes cooler, provide shade as they walk to school or work, or to experience nature.”

With the cool schools program in Chicago, underserved racialized neighbourhoods have been the focus of work as explained by Emily Zhang: “The Space to Grow program prioritizes historically disinvested and underserved areas in Chicago. These communities have been shaped by historic policies that systematically restricted public investment in communities of color.”

In Boston, the cool roofs pilot project was applied to community assets that serve disadvantaged and underserved populations. Zoe Davis from the Office of Climate Resilience said: “We wanted an organization that could implement the project with an equity lens; that would prioritize disadvantaged and underserved populations. We wanted cool roofs to be applied to community assets such as public housing and non-municipal community facilities that provide essential services to vulnerable populations.”

In Vancouver, the equity lens was applied more in the approach taken to consultation and development of the project. Public engagement was extensive, gave a prominent role to Indigenous advisors, drew heavily on the knowledge of Indigenous people, and created opportunities for technical advisors from many different fields to interact directly with a wide cross-section of people from the community. Angela Danyluk with the Climate Change Adaptation and Equity Team in the City’s Planning Department explained: “Traditionally, coastal flooding is managed by teams led by engineers who usually apply a hard infrastructure approach that results in grey infrastructure such as dikes. In Vancouver, we wanted to approach this process differently. We wanted the pilot project to be evaluated using the seven values-based criteria that were identified by community engagement, as well as technical criteria. Those values-based criteria included factors related to safety, housing, Indigenous perspectives, recreational opportunities, transportation, culture, and environmental benefits.”

Geospatial Analyses

Geospatial tools were used in varying degrees in all but one of the ten case studies.

In Montreal, staff are developing an index that will be used to identify vulnerable neighbourhoods that should be prioritized for action to protect people at greatest risk. Rachel Mallet with the Climate Change Adaptation team in Montreal explained that: “The index for greening, for example, is based on data related to urban heat islands, the tree canopy index, areas vulnerable to heat for health reasons such as age, neighbourhoods that are vulnerable to harm for socioeconomic reasons, and living environments where people live or congregate....”

In Toronto, the green streets program will prioritize neighbourhoods for green infrastructure using a geospatial model that includes data related to: stormwater management, air quality benefits for childcare and long-term care facilities, tree canopy cover, social wellness, and climate resilience.

Challenges

Challenges have been encountered by staff involved in all of the ten case studies. In some cases, the challenges are related to funding or the difficulty demonstrating return on investment when employing new practices that involve additional expenses.

In Toronto, for example, Anisha Patel from the Green Streets Program explained: “We have not been able to estimate the cost savings created with green infrastructure yet. The reduction in air temperature and stormwater management are incremental with each project, so it is hard to say how much harm and damage is being prevented with each project. Over time and cumulatively, we expect that there will be considerable financial and health savings, but we don’t have the data to demonstrate that yet.”

Table 1: Overview of the Ten Case Studies – Goals, Co-Benefits and Approaches

Community	Hamilton	Winnipeg	Montreal	Boston	Chicago
Focus	Heat Response	Forest Strategy	Nature-based heat resiliency	Cool Roofs	Green Schools
Goal	Protect lives	Cool Neighbourhoods	Cool Neighbourhoods	Cool Buildings	Reduce Flooding
Co-Benefits	Reduce health costs	Improve health	Reduce flooding & Improve Biodiversity	Cool neighbourhoods	Reduce heat & improve health
Nature-Based	Yes plus	Yes	Yes plus	No	Yes plus
Multi-Sectoral	Yes	Yes	Yes	Yes	Yes
Community Engagement	Yes	Yes	Yes	Yes	Yes
Geospatial Tools	Yes	Yes	Yes	Yes	Yes
Equity Lens	Yes	Yes	Yes	Yes	Yes

Community	Toronto	Vancouver	Montreal	Peterborough	Fredericton
Focus	Green Streets	Managing Coastline	Sponge Parks	Rain Gardens	Food Forest
Goal	Reduce Flooding	Reduce Coastal Flooding	Reduce Flooding	Reduce Flooding	Cool Neighbourhood
Co-Benefits	Reduce heat & improve health	Increase equity & improve ecosystem	More Park space & health benefits	Improve water quality	Increase social cohesion; reduce food insecurity
Nature-Based	Yes plus	Yes plus	Yes plus	Yes	Yes
Multi-Sectoral	Yes	Yes	Yes	No	No
Community Engagement	Yes	Yes	No	Yes	Yes
Geospatial Tools	Yes	Yes	Yes	No	Yes
Equity Lens	Yes	Yes	No	No	Yes

In other cases, the challenges are related to practical realities. In Winnipeg, for example, where they are working to expand the tree canopy, they are confronted with the limitations of space. City Forester, Martha Barwinsky offered: “It is a challenge to grow the tree canopy in a city when we are trying to densify neighbourhoods, create more walkable neighbourhoods with more or wider sidewalks, and build more cycling infrastructure. Infill development and trees are competing for the same space within a city. There is a lot of infrastructure below and above ground that needs to be considered when looking for space for tree planting and for long term maintenance of trees.”

And in some cases, the challenge is bringing everyone on board; training people from different disciplines and in different locations about the new policies, practices and goals. In Montreal, for example, Marie Dugué with Water Services for the City, explained that the main challenge with the Sponge Parks program is training and coordinating a multitude of stakeholders across 19 boroughs when the stakeholders can include planners, landscape architects, engineers, planning and specification teams, contractors, maintenance workers, and external professionals. The team chosen must therefore consolidate and coordinate all of these stakeholders, which can be a challenge in itself.



Conclusion

The ten cases examined demonstrate that climate adaptation measures can generate health, environmental, and social benefits simultaneously. Successful municipal interventions tend to integrate localized data and engage communities in co-designing and/or co-complementing solutions. These case studies suggest that it is possible to implement climate adaptation measures with an equity lens that can maximize health benefits by reducing negative health outcomes for the populations in the community that are most susceptible to harm and often prone to the greatest exposure to extreme climate events.

These case studies also demonstrate how geospatial tools, such as the HealthyPlan.City tool, can be used to assess climate-health vulnerability to reveal which neighbourhoods face the greatest potential for exposure and/or the greatest health risks from potential exposures. The case studies demonstrate how geospatial analyses that include demographic and socioeconomic data can inform and support evidence-based planning and enable investments in climate adaptation measures to be directed at the neighbourhoods that will benefit the most from them.

These case studies also provide examples of climate adaptation measures that have the potential to prevent illness, injuries and deaths, increase social equity and cohesion, while protecting buildings, infrastructure, and municipal services.



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