ARE WE THERE YET?

Applying Sustainability Indicators to Measure Progress on Adaptation

ICLEI Local Governments for Sustainability

Clean Air Partnership

ICLEI is a champion of local governments. We are an international association of local governments that have made a commitment to sustainable development. We promote participatory, long-term strategic planning processes to support local-level sustainability, and have been working with communities on sustainability issues since 1990.

ICLEI Canada understands the unique needs of Canada's diverse communities. We work alongside practitioners in Canada and across the globe on climate change mitigation and adaptation strategies, sustainability management, green procurement, biodiversity management and community engagement. We deliver engaging projects, creative workshops, modern conferences, and extensive capacity building resources.

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Clean Air Partnership (CAP) is a registered charity that works in partnership to promote and coordinate actions to improve local air quality and reduce greenhouse gases for healthy communities. Our applied research on municipal policies strives to broaden and improve access to public policy debate on air pollution and climate change issues.

Clean Air Partnership's mission is to transform cities into more sustainable, resilient, and vibrant communities where resources are used efficiently, the air is clean to breathe and greenhouse gas emissions are minimized.

ACKNOWLEDGEMENTS

This resource was made possible thanks to the generous support of Natural Resources Canada: Adaptation Platform, Measuring Progress Working Group.

ICLEI—Local Governments for Sustainability and the Clean Air Partnership would like to acknowledge the assistance of the following people who contributed their time so generously to the development of this resource:

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Suggested Citation:
Clean Air Partnership (CAP) and ICLEI—Local Governments for Sustainability (Management) Inc. (2015) *Are we there yet? Applying Sustainability Indicators to Measure Progress on Adaptation*

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INTRODUCING INDICATORS

You cannot manage what you have not measured – an old management adage that remains accurate and relevant to adaptation indicator work today. The purpose of an indicator is to measure change; offering an understanding of where you are, where you are going, and how far you are from your desired outcome. A well-developed indicator can highlight the success of an action, identify potential problems, and can help in the selection of remedial actions.

Adaptation indicators gauge the progress and effectiveness of independent adaptation actions as well as those measures being implemented as part of proposed or existing adaptation plans. When monitoring adaptation, it is important to consider the changes in actual impacts across similar weather events. This allows for differentiation between the effectiveness of adaptation actions and the actual climatic changes and weather events occurring that will affect how you are being impacted.

The indicators examined as part of this project are not intended to inform understanding of a changing climate and its impacts. Traditional climate change vulnerability indicators achieve this by representing the state of a certain climate condition in a given area over a specific time frame, for example; increase in summer precipitation; number of consecutive days with night time temperatures over 30°C.

USE OF SECTORS AND SUSTAINABILITY AS A LENS

The case studies included in this anthology cover process and outcome-based indicators used to measure sustainability in four sectors: coastal management, flood management, infrastructure, and health. These are sectors for which climate change risks are of great priority. Additionally, a "general" sector is profiled to capture those indicators that cut across multiple sectors or do not "neatly" fit into one. Likewise, sustainability indicators were selected as an appropriate lens for this project as they take social, economic, and environmental metrics into account while sufficiently narrowing the scope to ensure the applicability of research findings to the field of climate change adaptation.

HOW DATA WAS GATHERED

The data gathered to identify the indicators for each sector was collected through voluntary surveys, interviews, and conference calls. There was minimal desktop research, rather efforts were focused on acquiring the indicators from those groups directly using them to measure progress and outcomes in their sectors. The data collected through surveys and interviews was vetted through an expert task force to ensure not only the relevance of the indicator but also to gauge the applicability of the sustainability indicator to measure progress on adaptation in that sector.

CHALLENGES WITH USING INDICATORS TO MEASURE PROGRESS ON ADAPTATION

Although this project has identified forty indicators that could be used to evaluate adaptation efforts it is important to note that the complexities inherent in climate adaptation call for a nuanced approach to monitoring and evaluation. A recent publication on the SEA Change Community of Practice outlines some of the key challenges in monitoring and evaluating adaptation. The most relevant six are outlined below:

1. Adaptation is not an objective or an end-point

Adaptation is a process of continual adjustment and there is no clear measure or benchmark that signals that an adaptation measure is "successful". Often evaluation of adaptation relies on proxy measures which relate to the achievement of broader societal and/or environmental aims.

2. Uncertainties are inherent when implementing adaptation interventions

Uncertainty is inherent in virtually all monitoring and evaluation processes, for example uncertainty regarding the rate and extent of sea-level rise is critical to adaptation planners in coastal areas but equally uncertain are issues of population growth and/or aging infrastructure.

3. In adaptation it is a case of measuring avoided impacts

Adaptation efforts are designed to reduce adverse impacts of climate change, in the absence of that impact or risk taking place, it is onerous to measure how much worse the situation would have been without the intervention.

4. Tracking towards a 'moving target'

In monitoring climate change one must recognize that natural and socio-ecological systems undergo continuous change over time and so the use of a fixed baseline may lose some validity. With this consistent variability, baseline data may not always provide a solid reference point.

5. Adaptation spans multiple scales and sectors

Adaptation encompasses diverse programming strategies, populations, and locales. While it is predominantly a local process, progress towards it is often examined at much higher levels, and often at a sector-scale. It can be very difficult to compare or aggregate results in an effective way because of the eclectic range of sectors, the varyingly availability of data, and because what is appropriate in one site might not be for another.

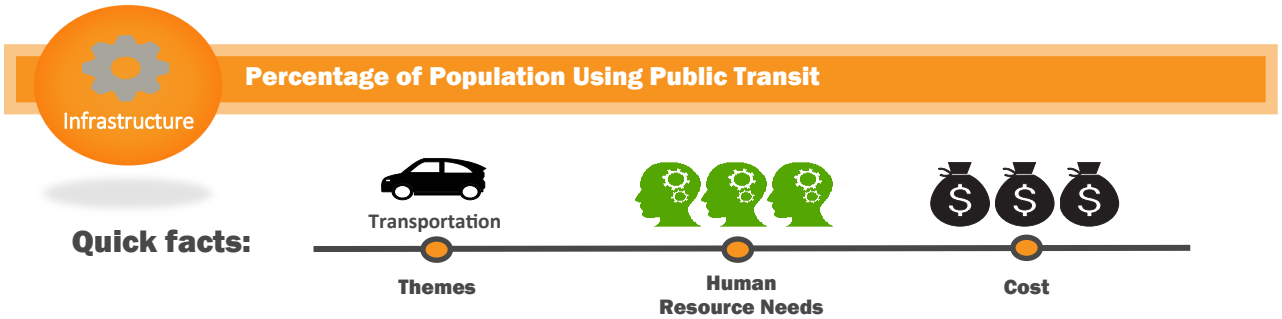
6. There is no one set of indicators or monitoring and evaluation approaches

As adaptation is a process rather than an outcome, individual indicators for climate change adaptation may not necessarily exist as "good" climate change adaptation indicators. In addition, as adaptation cuts across contexts, scales, and sectors no universal set of indicators will fit these divergent contexts.

ABOUT THE CASE STUDIES

This case study series presents forty indicators across four sectors, coastal management, flood management, infrastructure, and health. These indicators are applicable are varying orders of government; municipal, regional, provincial, and federal. Additionally, some case studies may be applied to other levels of jurisdiction such as a health unit, conservation authority or conservation council/district. The case studies are not evenly distributed between order of government or sector.

Case studies have been designed to be high-level and easy to read. The human and financial resource intensity, and sector of examination have been presented graphically in the header of each case study for a quick reference for the reader.



The geographic scale, theme and measurement scale/metric used are described first, followed by a description of how the indicator can be applied to adaptation, and any contextual information around the indicator. For each indicator, metadata include the rationale behind its development; frequency of collection; baseline information required; limitations; complimentary indicators, and; potential data sources.

The reader should note that this is not an exhaustive list of sustainability indicators that can be used or modified for use as adaptation indicators. Rather, the series presents examples of what is possible, and should serve as a starting point for the continual future examination of process and outcome-based indicators from varying sectors as potential indicators of progress on adaptation.

General

Annual Change in Wetland Area

Quick facts:

Factors to consider

Rationale	This indicator can be used to monitor progress in the protection and restoration of wetlands
Metric	Extent/area of wetlands (in acres). Number of wetlands restored, or lost /year
Geographic Scale	Local, Regional, National
Baseline	Historic wetland extent Wetland loss from pre-European settlement Mapping of existing wetlands
Applicability to Adaptation	Wetlands are an important adaptation strategy as they can buffer increased storm activity, reduce damage to local infrastructure, and minimize impacts on human health
Contextual Information	➲ A wetland is any area that holds water either temporarily or permanently. Some wetlands hold water year-round while others may only hold water for one or two months each spring (Ducks Unlimited, n.d.). ➲ Wetlands are some of the worlds most productive ecosystems and provide important habitats for many species of birds, fish and mammals. They also provide a variety of important services including carbon sequestration, water filtration, and the ability to mitigate the impact of floods and other hydrological events. ➲ Wetlands are one of the world's most threatened ecosystems. Commercial development, invasive species, pollution, and climate change are major threats to wetlands in Canada (WWF, n.d.).
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Percentage of total ground area covered by wetlands ✓ Number of wetlands protected
Limitations	To use this indicator, updated data may be needed from multiple jurisdictions (municipal, CAS, province etc.) and there is often a cost associated with obtaining wetland maps/data/info and significant staff time and resources required (e.g. mapping, policy analysis, communications, etc). It is also important to note that the indicator does not distinguish between different types of wetlands and that time series data for all of Canada does not yet exist.
Potential Data Sources	Satellite Remote-Sensing Data Conservation Authorities and Basin Councils Land use inventories NGOs Canadian Wetland Inventory
More Information	Environment and Sustainable Development Indicators for Canada Ducks Unlimited Canada—Conserving Canada's Wetlands Canadian Wetland Inventory Threats to Water Availability in Canada: Climate Variability and Change—Wetlands

Infrastructure

Annual Cost of Road Maintenance

Quick facts:

Factors to consider

Rationale	This indicator provides information on the annual cost of road maintenance
Metric	Total dollars spent on road maintenance
Geographic Scale	Municipal, Provincial, Federal
Baseline	Total road maintenance cost in a previous year
Applicability to Adaptation	Climate change will impact road maintenance costs across seasons in light of increasing flooding, road washouts, freeze-thaw cycles, and winter precipitation (as snow) and the subsequent need for maintenance processes such as resurfacing, snow plowing, salting, and pot hole repair.
Contextual Information	➲ More frequent freeze thaw cycles, increased use of salt, and higher snow loads will lead to added stress on infrastructure and increased operating and maintenance costs (McGillivray, 2009). ➲ In addition to increased annual cost of road maintenance, exposure to climate impacts (e.g. flooding, extreme snow) also reduces the life span and the performance of transportation infrastructure such as roads, culverts, and highways. ➲ The impacts of climate change on transportation infrastructure are further exacerbated by aging infrastructure systems that have exceeded normal service life as well as the current infrastructure deficit , which is expected to double in some parts of Canada (FCM, n.d.). ➲ While climate change is not the only contributing factor to increasing maintenance costs, there is a strong correlation between climate impacts and the increasing cost of maintaining roads and highways.
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Percentage of capital budget spent on road maintenance ✓ Percentage Probability of Unacceptable Performance in Infrastructure
Limitations	In some cases, a warmer climate may translate into savings for those who build, maintain and use Canada's transportation infrastructure (NRCan, n.d. B). Furthermore, this indicator does not provide information into the effectiveness of maintenance, only its total cost.
Potential Data Sources	Municipal budget Ministries of Transportation (all provinces) Transportation Canada Airport Authorities Private Land Owners
More Information	Impacts on Transportation Infrastructure

Flood Management

Area Covered by Integrated Stormwater Management Plans

Quick facts:

Factors to consider

Rationale	This indicator tracks how well watersheds are being managed and the extent to which stormwater considerations are integrated into land use planning	
Metric	Percentage of municipal land area that is covered by an established integrated stormwater management plan (ISMP)	
Geographic Scale	Municipal	
Baseline	Percentage of municipal land area covered by an ISMP in a previous year	
Applicability to Adaptation	Monitors the degree of implementation of efforts to adapt stormwater management to extreme precipitation events resulting from climate change	
Contextual Information	➲ The impact of increasingly frequent and intense extreme precipitation events in Canada is exacerbated by traditional stormwater management planning practices that fail to consider how increases in land development and the replacement of natural landscapes with grey infrastructure diminish the capacity of surfaces to effectively permeate precipitation. ➲ Integrated Stormwater Management Plans involve comprehensive ecosystem based approaches to rainwater management. They help balance land use needs with the natural values and function of watersheds, by incorporating land use planning, stormwater engineering, flood and erosion, as well as environmental considerations (City of Surrey, n.d. A; Province of BC, 2006).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Water quality ✓ Number of acres of wetlands (protected, restored, lost, influenced) per year ✓ Number of flood prone lands reclaimed from development area and returned to natural conditions	✓ Percentage of total area served by green stormwater controls (rivers, streams, retention ponds) ✓ Number of storms where the rate of rainfall (mm/hr) exceeds stormwater utility design standards
Limitations	The indicator only refers to integrated stormwater management plans, which are still in their evolutionary stages and not common in all municipalities. Furthermore, municipalities may not have an inventory of stormwater systems (grey or green).	
Potential Data Sources	Sustainability and Environmental Departments Conservation Authorities, Watershed Councils Stormwater Infrastructure Managers	
More Information	A Guidebook for British Columbia Stormwater Planning City of Surrey: Integrated Stormwater Management Plan City of Surrey Sustainability Dashboard	

Flood Management

Area of Catchment Directly Tied to a Stormwater System

Quick facts:

Factors to consider

Rationale	This indicator can be used to determine the area directly connected to the storm system and whether municipalities are able to reduce this over time	
Metric	Square meters of total catchment and square meters of catchment that is directly tied to the stormwater system	
Geographic Scale	Municipal, National	
Baseline	Square metres of total catchment and square metres of catchment that is directly tied to the stormwater system	
Applicability to Adaptation	This indicator helps evaluate the success of efforts to decrease the amount of impervious area connected to stormwater systems, thus reduce the vulnerability of stormwater infrastructure to climate change	
Contextual Information	➲ The growth of cities and resulting increase in land development which replaces natural landscapes often results in natural landscapes being replaced by grey infrastructure, such as roads, buildings, housing and parking lots. Accordingly, the capacity of surfaces to effectively permeate precipitation is diminished and stormwater runoff ensues. ➲ Across Canada, many municipalities use combined sewer systems. Stormwater systems are more likely to be inundated when impermeable surfaces are connected to the system. Reducing the catchment area served by a stormwater system is important in reducing risk to the system as storm intensities increase. ➲ Due to the high cost of combined sewer replacement, it is more cost effective to instead work to minimize potential inflows into the sewer system by reducing the impervious area served by the sewer, thus reducing the vulnerability of stormwater infrastructure to climate change. This can be achieved through a number of low impact development strategies and the retrofitting of existing homes through schemes such as downspout disconnections.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Water quality ✓ Number of reported basement floods per year ✓ Number of combined sewer overflows per year	
Limitations	There is a high degree of difficulty in collecting accurate information for this information. For example, a downspout disconnection program may be in effect, but to gauge the success of the program, a lot of resources are required to estimate the catchment area circumvented through the disconnection, and to gauge how effectively home owners are managing their captured water, i.e. releasing it at the appropriate time etc.	
Potential Data Sources	Municipal Stormwater Managers	
More Information	The Cumulative Impacts of Climate Change and Land Use Change on Water Quantity and Quality in the Narrangansett Bay Watershed	Capital Regional District: Impervious Surfaces The CADDIS Urbanization Module

Health

Asthma Emergency Department Visits: Volume and Median Length of Stay

Quick facts:

Factors to consider

Rationale	This indicator informs government key decision makers, raises awareness, and allows emergency department planners to make more informed decisions	
Metric	Number of emergency department visits and median length of stay (in minutes) for asthma (using ICD-10-CA, J45)	
Geographic Scale	National, Provincial	
Baseline	Number of emergency department visits and median length of stay (in minutes) for asthma (using ICD-10-CA, J45) in a previous year	
Applicability to Adaptation	This indicator helps health authorities monitor the impact of weather on the number of asthma emergency room visits, and their duration. It is particularly helpful to heath services where asthma is exacerbated by vulnerability.	
Contextual Information	➲ Climate change will intensify air quality issues, an existing public health concern, causing increases in air pollution, namely ground-level ozone and airborne particulate matter (Berry, Clarke, Fleur, & Parker, 2014). ➲ Increasing instances of extreme heat events are also suggested to increase pollens and other aeroallergens that can trigger asthma (World Health Organization, 2014). Furthermore, increases in the frequency of intense precipitation events is likely to lead to an increase in water ingress, mold and bacterial growth in built structures that can aggravate asthma and cause further respiratory distress (City of Vancouver, 2012). ➲ A strong scientific relationship exists between short-term exposure to ozone, asthma related emergency room and hospital visits and premature mortality in Canada (Government of Canada, 2012). ➲ The length of stay is the time elapsed from the patient's registration to the time they physically leave the emergency department.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Primary Care Asthma Performance Indicators ✓ Air quality health indicators ✓ Ragweed and pollen indicators	✓ Air quality indicators ✓ Asthma incidence and prevalence indicators
Limitations	There can be differences in how emergency room visits are coded and catalogued. For example, if a patient with a history of asthma presents, it will be coded as asthma. For a patient with no history or diagnosis, this would be 'breathing difficulties'. Using emergency room visit information can be complex, and requires considerable skill and epidemiological experience to correctly analyse the information. Furthermore, those with a known history of asthma, and can medicate accordingly, are less likely to present in emergency rooms as opposed to those who suffer less acutely and more infrequently.	
Potential Data Sources	Health Research Centres Local Health Units	Provincial Health Authorities
More Information	Human Health in Canada in a Changing Climate Asthma Emergency Department Visits and Median Length of Stay	World Health Organization: Climate Change and Health GLISA: Impacts of Climate Change on Public Health

Infrastructure

Budget Allocated to Green Infrastructure

Quick facts:

Factors to consider

Rationale	This indicator evaluates what program and projects are being put in place to ensure the maintenance and enhancement of green infrastructure in cities	
Metric	Amount spent on green infrastructure	
Geographic Scale	Municipal	
Baseline	Historic budget data	
Applicability to Adaptation	The relative amount spent by a city on green infrastructure can be seen as an indication of the city's capacity to implement adaptation actions related to flood mitigation and stromwater management	
Contextual Information	➲ Green infrastructure provides environmental services which help to address the impacts of climate change by cooling buildings in summer time, reducing airborne pollutants, recharging groundwater, purifying surface water, reducing health care costs due to air and water quality issues, reducing capital and operational costs of traditional gray infrastructure, retaining stormwater and reducing the urban heat island effect. Green infrastructure can also reduce the need for costly, large- scale solutions and the burden on built systems (Ministry of Infrastructure, 2012). ➲ Green infrastructure includes natural and engineered features that provide habitat, flood protection, air purification, and/or water filtration. Green infrastructure elements vary and may include parks and trees, rain gardens, pipe-to-pond stormwater systems, utility corridors, community gardens, bioswales, permeable pavements, and green roofs (USEPA, n.d. B).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Green infrastructure budget as a percentage of total infrastructure budget ✓ Green infrastructure spending as a percentage of total infrastructure spending ✓ Number of implemented green infrastructure projects	✓ Number of planning mechanisms implemented to protect against flooding ✓ Reported number of properties experiencing flooding
Limitations	It can be difficult to distinguish between green infrastructure and engineered infrastructure in a budget – typically departmental budgets lump infrastructure spending regardless of the type of infrastructure that was built. Calculations should include the city or municipality's staff budget as well as its operational and/or related project expenditures.	
Potential Data Sources	Municipal Budget Departmental Budget	
More Information	Green Values—Stormwater Management Calculator	

General

Change in the Number of Invasive Species

Quick facts:

Factors to consider

Rationale	This indicator measures the status of invasive species	
Metric	Total number of invasive species	
Geographic Scale	Local	
Baseline	Total number of invasive species in previous years	
Applicability to Adaptation	The ability to know when to act and what actions to take depends on understanding and projecting the effects of climate change on ecosystems (Gleeson, et al. 2011). This indicator can be used to help measure the effect climate change is having on local biodiversity and whether adaptive actions aimed at reducing the prevalence of invasive species (such as the Emerald Ash Borer) are effective.	
Contextual Information	➲ Scientists agree that climate change will have a direct impact on habitats and will increase vulnerabilities due to invasive species as a result of changing temperature and precipitation patterns, resource scarcity, and increased or decreased competition. Increasing temperatures in particular would allow for typically southern dwelling species to spread northward as a result of later freezes or warmer winter temperatures (Szyniszewska, n.d.). Invasive alien species out-compete native species and, thus, threaten the survival of native species and the integrity of ecosystems. ➲ Invasive species are defined as "non-native species that move into ecosystems and take over, disrupt food webs, degrade habitat, introduce parasites and disease, and can lead to species at risk" (OCCIAR, n.d.). ➲ The transition of ecosystems (e.g. central parkland to mixed grass) as a result of changing temperature and precipitation conditions due to climate change will have a profound effect on the presence of native and non-native species.	
Frequency of Data Collection	Every three years	
Complimentary Indicators	✓ Native biodiversity in built-up areas ✓ Native biodiversity in natural areas ✓ Proportion of natural areas in city	✓ Publicly owned green space ✓ Percentage of land area by vegetative type ✓ Spatial location of green space
Limitations	Alien species which are not invasive or detrimental to native species are not considered in this indicator. Furthermore, in order to ensure that a comparison of invasive alien species with that of native species is meaningful, it would have to be a comparison within identical taxonomic groups.	
Potential Data Sources	Conservation Authorities and Watershed Councils Ministries of Natural Resources	
More Information	Convention on Biological Diversity—City Biodiversity index The Living City Report Card Green Facts—Biodiversity and Human Well-Being City of Edmonton—Biodiversity Report	

General

Citizens Attending Emergency Preparedness Presentations

Quick facts:

Factors to consider

Rationale	Public participation in a preparedness meeting helps to develop citizen awareness, interest and shared responsibility	
Metric	Number of people in attendance at meetings	
Geographic Scale	Municipal	
Baseline	None	
Applicability to Adaptation	Presentations can include a discussion around climate impacts in the context of preparedness in order to integrate adaptation awareness into the presentation. Tracking the uptake of such outreach events will help inform the municipality of the degree to which residents are aware of the risks and have information on how they can prepare themselves.	
Contextual Information	➲ As climate change related risks increase, so too does the need for preparedness planning. It is important that residents understand that the frequency and severity of extreme events are increasing and that the municipality is preparing for these events. It is equally important to inform residents about how they can work to prepare themselves and their households in the event of an emergency. ➲ The resilience of a community with respect to disasters or extreme events is determined by the degree to which a community was aware of risks in advance, has put emergency preparedness responses in place, and has educated responders and residents on what they can do in the event of an emergency. Emergency management is a priority adaptation to extreme events since the major objective is protecting human life and property (SaskAdapt, 2014).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Number of households prepared for a seven day emergency ✓ Number of climate change related public events ✓ Total number of emergency preparedness presentations delivered to the community	✓ Number of emergency responders ✓ Percentage of people with high levels of social support ✓ Number of external partnerships on adaptation
Limitations	Attendance at meetings does not guarantee uptake of preparedness actions or awareness. Furthermore, attendance at public events is often limited.	
Potential Data Sources	Municipal Citizen Survey Head counts at events	
More Information	District of Saanich—Citizen Survey City of Surrey—Sustainability Dashboard Community Engagement—Sustainability Principles	

Flood Management

Daily Water Used Per Capita

Quick facts:

Factors to consider

Rationale	This indicator can be used to measure per capita water use and the success of water conservation efforts	
Metric	Liters of water/ per person per day (Lpd)	
Geographic Scale	Municipal, Provincial, National	
Baseline	Liters of water/per person per day consumed in previous years	
Applicability to Adaptation	Water scarcity in the face of climate change is a serious risk for a number of provinces and municipalities in Canada – particularly in the Prairies. As a result, water demand management is a crucial aspect of sound adaptation and resilience planning in relation to both health and water related infrastructure.	
Contextual Information	➲ This indicator is a great communication tool which can be used to engage residents to reduce their water consumption both individually and at the household level. ➲ Efficient use of water reduces impact on water resources and the energy required to treat and transport water to users. ➲ Most provinces track this information (as do certain regional and municipal governments) and therefore data is readily available. ➲ Watershed management plans that explicitly take into account the impacts of climate change on water supply and demand are crucial to inform the allocation of water resources across water users and infrastructure investments (TRCA and ESSA, 2012).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Percentage of population under a water quality advisory ✓ Estimated percentage of water loss in distribution system	✓ Rating of water quality measurements
Limitations	Figures generally include all water sent to distribution system for residential and non-residential use, and is measured before accounting for water loss due to leaks, seepage, or fire flows. Furthermore, water loss due to older infrastructure can form a significant proportion of consumption figures. Municipalities may use regional averages for estimated residential water consumption (e.g. for the Region of York).	
Potential Data Sources	Water consumption data from municipal or regional water utilities Ontario Municipal Benchmarking Initiative	
More Information	City of Vaughan—Environmental Sustainability Indicators City of Vaughan—Proposed Water and Wastewater/Storm Operating Budget City of Surrey—Sustainability Dashboard Mainstreaming Climate Change Adaptation in Canadian Water Resource Management Regina's Water Conservation Program The Living City Report Card	

Infrastructure

Estimated Percentage of Water Loss in Distribution System

Quick facts:

Factors to consider

Rationale	This indicator reflects the estimated amount of water losses arising from leaks in the water distribution system	
Metric	Percent difference between the total amount of water that has been produced and the quantity of water distributed to users	
Geographic Scale	Municipal	
Baseline	Estimated quantity of water produced and the estimate quantity of water distributed to users in a baseline year	
Applicability to Adaptation	Water availability issues resulting from climate change are exacerbated by vast leakages in water distribution systems. Leakages can largely be attributed to the abundance of aging water infrastructure systems that have exceeded service life, a lack of maintenance to water distribution systems due to infrastructure deficits, inefficient water usage and conservation practices, as well ballooning urban populations that were not accounted for in the design of water infrastructure systems.	
Contextual Information	➲ Climate change will have potentially significant impacts on Canadian hydrology, as well as the availability of water resources. ➲ Water resources in many parts of Canada are expected to become less abundant in the future. Ground water sources are also challenged by finite recharge in the face of increasing populations. Additionally, we expect increased future water demand particularly during summer months during extreme heat events. ➲ Water is a finite and vulnerable resources essential to sustain life, accordingly water losses have significant social, economic and ecological costs (Simon Fraser University Adaptation to Climate Change Team, 2011; TRCA and ESSA, 2012).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Water quality ✓ Daily volume of water used per person	✓ Percentage Probability of Unacceptable Performance (PUP)
Limitations	Depending on the quality of the monitoring technology used, the margin of error related to estimated water loss data at the municipal level may be high. In order to appropriately inform adaptation decision making, high quality meter monitoring technology must be installed on urban water distribution networks. Also, the indicator does not identify the location of the loss and instead focuses on the amount of loss only. Many water distribution systems operate with relatively high levels of inherent loss. As such, relatively high loss levels do not necessarily imply corrective action is required.	
Potential Data Sources	Water Supply and Distribution Infrastructure Managers Municipal Revenue Departments	
More Information	Mainstreaming Climate Change Adaptation in Canadian Water Resource Management Climate Change Adaptation and Water Governance	Montreal's Green CiTTS Report: Toward Sustainable Municipal Water Management

General

Incorporation of Risk Register Results in Strategic Planning

Quick facts:

Factors to consider

Rationale	To use the findings of a corporate risk register (risk and vulnerability assessment) in strategic planning processes
Metric	Risk register results (expressed as either high, low, medium or on a numeric scale) Documented use of the risk ranking
Geographic Scale	Local
Baseline	Risk category and risk effect statement
Applicability to Adaptation	With the incorporation of climate change related risks into existing corporate risk registers, agencies can assess the implications of these risks on corporate finances, operations and strategic planning and assist in the development of appropriate risk mitigation plans.
Contextual Information	➲ Local governments and other public sector agencies face a multitude of cross-enterprise risks and opportunities. Not only does the changing climate exacerbate these risks, it has the capacity to create further reaching risks, particularly in relation to increased costs and loss of revenue (NRTEE, 2011, Canadian Chamber of Commerce; Pollution Probe, 2006). ➲ External pressure on public entities to disclose and manage risks associated with climate change is growing. Definitions of "reasonably foreseeable" impacts are changing as future climate projections gather greater scientific certainty and become more accessible to the public. ➲ Building climate change considerations into existing risk management processes can help agencies proactively manage and address climate change related risks (NRTEE, 2011).
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Percentage probability of Unacceptable Performance (PUP) in Infrastructure
Limitations	Many barriers inhibit the incorporation of climate considerations into corporate risk management, including adversity to climate change language and terminology, lack of understanding of the costs of inaction. A further challenge is the uncertainty associated with the future climate scenarios; however local governments are already accustomed to managing uncertainty from other sources (NRTEE, 2011).
Potential Data Sources	Risk Managers Infrastructure Managers Public Works Departments Ratings Agencies
More Information	Risk Management Process in Climate Change Adaptation Managing the Business Risks and Opportunities of a Changing Climate

Coastal Management

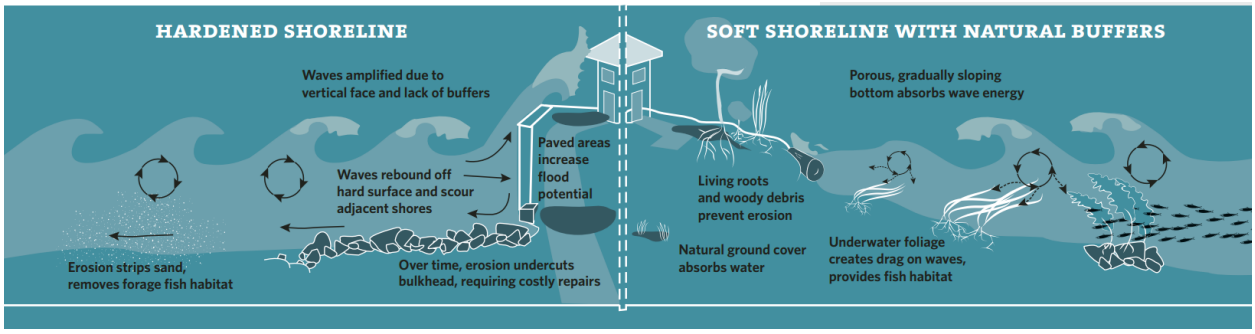
Length of Coastline Where Soft Shoreline and Natural Buffer Techniques Have Been Applied

Quick facts:

Factors to consider

Rationale	This indicator documents progress in transitioning from hardened to soft shorelines as a measure of increasing biodiversity and ecosystem function
Metric	Length in metres
Geographic Scale	Local, Provincial, Federal
Baseline	Locations where soft shoreline and natural buffer techniques have been applied
Applicability to Adaptation	Coastal and near-shore areas support a wide range of human activities. The removal and replacement of coastal vegetation with hardened infrastructure can lead to erosion and damage to natural habitats. In addition, as sea level rises and storm intensities increase with climate change, hardened infrastructure and built defences will not adequately protect shoreline development from damage as effectively as coastal plants and natural beaches.
Contextual Information	➲ As documented in the graphic below, a soft shoreline with natural buffers, is a much stronger defence against storm surges and sea-level rise. Underwater foliage creates drag on waves, porous and sloping bottoms absorb wave energy, and living roots and woody debris on shore can prevent additional erosion (RAO, 2014) .
Frequency of Data Collection	Bi-annually
Complimentary Indicators	✓ Percentage of coastline where soft shoreline and natural buffer techniques have been applied of total coastline
Limitations	Not all shore softening techniques are as effective as others, need to ensure that user is applying the correct technique for the correct location.
Potential Data Sources	Ministries of Environment Ministries of Natural Resources Department of Fisheries and Oceans
More Information	Protecting Your Community's Coastal Assets—Local Leadership in Marine Planning

Infographic from Protecting Your Community's Coastal Assets—Local Leadership in Marine Planning



Infrastructure

Local Renewable Energy Projects and kW Capacity

Quick facts:

Factors to consider

Rationale	This indicator can be used to measure local renewable energy capacity
Metric	Total number of renewable energy projects and kilowatts (kW) produced
Geographic Scale	Local
Baseline	Number of projects in previous years
Applicability to Adaptation	Enhancing local renewable energy sources enhances energy resilience and supply in the face of changing climate conditions
Contextual Information	➲ Renewable energy is produced from natural resources which can be replenished and includes the movement of water, wind, biomass, solar, geothermal, and ocean energy (Natural Resources Canada, n.d. C). ➲ Due to the diversity of energy-producing technologies, usable energy from renewable resources can be produced in the form of electricity, industrial heat, thermal energy for space and water conditioning, and transportation fuels. ➲ Renewable energy resources currently provide approximately 17% of Canada's total primary energy supply, the majority coming from the movement of water, wind, and biomass or bioenergy. Canada is the world's third largest producer of hydroelectricity (Natural Resources Canada, n.d. C).
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Actual kW generated from renewable sources ✓ Corporate Greenhouse Gas Emissions ✓ Community Greenhouse Gas Emissions
Limitations	There are freedom of information restrictions on lot level utility data so it may not be possible to obtain disaggregated data. Also, it is important to note that the capacity of projects (e.g. wind farms) is different from actual generation capacity. Furthermore, in certain provinces, such as Ontario, all energy generation gets fed into the provincial grid and therefore local renewable projects do not enhance local energy capacity but simply diversifies the provincial grid.
Potential Data Sources	Building permits issued for renewable projects (e.g. solar panels, wind, geothermal, etc.) Community Energy Associations Ministries of Energy Utilities
More Information	Planning for a Sustainable Future Sustainable Pickering Natural Resources Canada—About Renewable Energy

Health

Number of City Facilities Offering Extended Hours

Quick facts:

Factors to consider

Rationale	This indicator illustrates the additional capacity requirements that result from extended shoulder seasons and warmer summer temperatures which has budgetary and other resource implications	
Metric	Total number of facilities offering extended hours during summer and shoulder seasons	
Geographic Scale	Municipal	
Baseline	Total number of recreation facilities in the municipality	
Applicability to Adaptation	Extended hours at city facilities such as; splash pads, open cooling centres, swimming pools and libraries during hot summer days and extended shoulders season help to reduce excessive heat exposure and reduce heat related illness.	
Contextual Information	➲ Heat events often increase the frequency and severity of heat-related illness (i.e.: heat stroke), dehydration, degraded air quality leading to illness, premature mortality from cardiovascular and respiratory causes, increased risk of cancer, and vector borne infectious diseases. ➲ Populations particularly vulnerable to these heat effects include infants, seniors, chronically ill, those with existing cardiovascular and respiratory illness, those working outdoors for extended periods of time, individuals without access to adequate shelter or cooling mechanisms and those living in areas with poor air quality. ➲ Municipalities or health units provide cooling options to residents who do not typically have access to cooling	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Number of climate change related public events ✓ Percentage of people with high levels of social support ✓ Number of days when air quality index is poor	✓ Number of people reached out to/contacted via outreach efforts related to the adopted of a behaviour change
Limitations	There is a lack of uptake of cooling facilities during extreme heat alerts and therefore even though facilities may be offering extended hours they are not necessarily being used by residents. In applying the indicator to adaptation, the indicator assumes a policy on extending hours based on heat alerts within a municipality already exists.	
Potential Data Sources	Parks, Forestry & Recreation Departments Public Health - Heat Health Alert Systems Media Content Analysis	
More Information	City of Toronto: Extended Hours During Extreme Heat Alert Protecting Vulnerable People from Health Impacts of Extreme Heat Extreme Heat Event Guidelines: User Guide for Health Care Workers and Health	

General

Number of Climate Change Related Public Events

Quick facts:

Factors to consider

Rationale	The number of public events organized by the municipality speaks to efforts made to engage citizens and share important knowledge in-person with regard to climate change and is a measure of the public's access to decision-making processes	
Metric	Number of outreach or public awareness events held in the city per year on climate change related issues	
Geographic Scale	Municipal	
Baseline	None	
Applicability to Adaptation	This indicator can be used to account for outreach, community engagement, and other public awareness events that relate to the impacts of climate change (e.g. preparation for extreme weather events) and/or adaptation actions or measures being undertaken by the municipality	
Contextual Information	➲ Public engagement in municipal planning and decision making can provide valuable feedback for municipal staff, create broad-based support for projects and initiatives, identify community needs, and contribute to more inclusive and democratic decision making processes (City of Surrey, n.d. B). ➲ Face-to-face communication with a target audience is particularly important when trying to move people to act. In-person presentations or events which engage community members on climate change issues demonstrate the importance of the issue and can build the relationships, rapport, and trust required in order to inspire behavioral change and ensure the uptake of adaptive actions.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Number of people attending events over time ✓ Number of people reporting action as a result of attending an event ✓ Number of households prepared for a seven day emergency	✓ Number of external partnerships on adaptation
Limitations	The event should either be organized by the city, or there should be a heavy involvement of the municipality for the event to be considered for inclusion in the indicator. Events that simply take place within the city are not considered. The number of people attending events does not necessarily indicate the value of the event itself. It is also important to note that certain engaged community members attend all city events, so such events may not have a broad reach, and that hosting or attending community events does not imply action, only the transfer of information.	
Potential Data Sources	Implementation updates to local planning documents Departmental outreach calendars	
More Information	District of Saanich—Citizen Survey City of Surrey—Sustainability Dashboard Community Engagement—Sustainability Principles	

Flood Management

Number of Combined Sewer Overflows

Quick facts:

Factors to consider

Rationale	This indicator monitors progress in meeting stormwater and wastewater performance criteria, as well as the value of developing upstream stormwater management systems to reduce inflow volume and minimize overflows during heavy rain events	
Metric	Water quality at storm sewer outfall points	
Geographic Scale	Municipal	
Baseline	Number of combined sewer overflows in a previous year Number of extreme rainfall events in a previous year	
Applicability to Adaptation	This indicator helps illustrate the vulnerability of stormwater and waste water systems to extreme weather events. This information can be used in determining the necessity for replacement of combined sewers, and the rate and scale of extreme rain events.	
Contextual Information	➲ Considering climate risks is not yet standard practice in municipal asset management. Accordingly, extreme precipitation places stormwater and waste water utilities at high risk of asset loss, service disruption, and reduced lifespan. ➲ During extreme precipitation events, outdated combined sewers (a system designed to convey both sanitary and stormwater runoff through a single pipe to waste water plants) contribute to combined sewer overflows, the release of untreated sewage into local water bodies, and sewage treatment plant overloads. This leads to sewer backups, basement flooding and property damage; compromising both public health and safety. ➲ Municipalities are faced with economic loss due to damaged or overwhelmed stormwater and waste water systems and increased pumping requirements, as well as an increase in legal and insurance costs.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Improvement in quality of stormwater effluent ✓ Number and/or volume of non-treated sewage entering receiving waters ✓ Percentage of additional capacity retention on private property ✓ Percentage of population under a water quality advisory	✓ Total number of properties at risk of overland flooding during a major storm event ✓ Number of storms where rate of rainfall (mm/hr) exceeded the design standard of municipal stormwater utilities ✓ Quantity of stormwater entering receiving waters
Limitations	The indicator does not account for the duration or severity of the combined sewer overflow, the hydrological characteristics, or sensitivities in the receiving water body. It is also contingent on appropriate monitoring installations.	
Potential Data Sources	Municipal Stormwater Wastewater and Water Infrastructure Management	
More Information	Water and Transportation Infrastructure in Canada in a Changing Climate Sewage Overflows from Hurricane Sandy	City of Welland Stormwater and Wastewater Infrastructure Assessment

Health

Number of Days When Air Quality Index is Poor

Quick facts:

Factors to consider

Rationale	This indicator highlights local vulnerability to poor air quality	
Metric	Number of days when the Air Quality Index (AQI) reading is poor	
Geographic Scale	Provincial, Municipal	
Baseline	Daily AQI readings	
Applicability to Adaptation	This indicator helps evaluate the success of efforts to improve local air quality, thus gauge reductions in the vulnerability of human populations to climate change	
Contextual Information	➲ Warming temperatures are likely to increase the frequency of days with unhealthy levels of ground-level ozone and intensify air pollution, an existing public health issue (U.S. EPA, 2014-a). Ground level ozone can harm lung tissue, reduce lung function and inflame airways, causing an increase in hospital admissions for asthma, respiratory disease and acute respiratory disorders. Other air pollutants, such as; carbon monoxide, nitrogen dioxide, sulfur dioxide, reduced sulphur compounds, volatile organic compounds and small airborne particulates can impair lung function, aggravate symptoms of allergy sufferers and cause shortness of breath, wheezing, asthma attacks and premature death (David Suzuki Foundation, 2014-a). ➲ The AQI is often based on the aforementioned air pollutants. However, AQI metrics and the method used to interpret AQI readings vary across Canadian jurisdictions.	
Frequency of Data Collection	Annually, seasonally	
Complimentary Indicators	✓ Air health indicators ✓ Heat vulnerability indicators ✓ Allergy/pollen and ragweed indicators ✓ Asthma indicators	✓ Greenhouse gas emission indicators ✓ Ecological indicators
Limitations	Air pollution surveillance stations are not yet highly prevalent in urban spaces, thus AQI readings are often not representative of air quality conditions in vast urban areas	
Potential Data Sources	Local Health Units Sustainability and Environmental Departments Environment Canada Provincial Ministries of Health	Provincial Lung Associations Asthma Society of Canada
More Information	Human Health in Canada in a Changing Climate Environmental Assessment Report: Air Quality in Montréal	Sustainable Pickering: Measuring Sustainability Report City of Vaughan Environmental Sustainability Indicators

General

Number of External Partnerships on Adaptation

Quick facts:

Factors to consider

Rationale	This indicator evaluates the existence and the state of formal or informal partnerships between government and agencies to carry out all the activities, responsibilities, projects and programs with adaptation implications	
Metric	Number of agencies/ private companies/ NGOs/ academic institutions/ international organizations with whom government is partnering on adaptation activities, projects and programs	
Geographic Scale	Municipal, Provincial, Federal	
Baseline	Number of formal or informal partnerships as reported by government agencies in a previous year	
Applicability to Adaptation	Collaborative networks and partnerships are helpful in advancing climate change adaptation activities, projects and programs by pooling knowledge, strategies, and resources. Accordingly, an indicator that tracks and monitors government partnership on climate change adaptation activities, projects and programs (either formally or informally) helps to determine governments' interest in and action on adaptation.	
Contextual Information	➲ Due to the encompassing nature of climate change, government led adaptation initiatives alone cannot provide the level of resilience needed by society . Also, climate science and climate adaptation practice are both evolving at a rapid pace, with growing demand for involvement from stakeholders across disciplines. In light of these considerations, governments can reduce resource requirements and enhance knowledge surrounding adaptation issues and solutions by engaging in partnership with internal and external stakeholders, leveraging a wider network of resources and expertise in the process.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Use of climate change adaptation terminology in plans or policies ✓ Percentage of implemented adaptation actions	✓ Number of internal partnerships/degree of collaboration on adaptation
Limitations	Though climate change adaptation projects, program and activities have been enacted in all sectors of government, these initiatives are often not identified as such and therefore it may be difficult to track. It is also important to note that a partnership does not guarantee action or improved adaptive capacity and that many mechanisms that are less formalized than a partnership but can produce great results but can be difficult to quantify.	
Potential Data Sources	Interviews with government departments Review of government strategic documents Review of government reports Review of contracts/memoranda of understanding/agreement issued	
More Information	Toronto WeatherWise Partnership Canada's Regional Adaptation Collaborative Program	

General

Number of Households Prepared for a Seven Day Emergency

Quick facts:

Factors to consider

Rationale	This indicator is used to determine the level of citizens' emergency preparedness	
Metric	Number of households prepared for a seven day emergency in the municipality	
Geographic Scale	Municipal	
Baseline	Total number of households in a previous year	
Applicability to Adaptation	Climate change-related weather events cause local emergencies. Municipal efforts to better understand community level preparedness for these events is a proactive emergency planning measure that can help to reduce local vulnerability to climate change.	
Contextual Information	➲ The frequency and intensity of storms and weather extremes—including hurricanes, thunderstorms, ice storms, hail, flash floods, coastal storm surges, forest fires and droughts—are increasing and are likely to cause cascading public health and safety risks at the community level, much of which municipal emergency management will need to respond to. ➲ Efforts to understand the existing capacity of neighborhoods and individual households, namely their preparedness for extreme weather events is one of several adaptation measures municipalities can adopt to ensure that appropriate preparation and response plans are developed and effective actions are identified and executed at the neighborhood level (Halifax Regional Municipality, 2006).	
Frequency of Data Collection	Once every three years	
Complimentary Indicators	✓ Number of citizens attending emergency preparedness events ✓ Number of outreach or public awareness events held in the city per year on climate change related issues	✓ Number of emergency responders ✓ Number of city volunteers ✓ Percentage of total households with a preparedness plan/ total population
Limitations	Depending on the method used to collect this data and whether the municipality has already suffered long duration emergencies, citizens may not appropriately report on their respective levels of preparedness. Data is also provided on a voluntary basis, therefore response rate is limited. Collecting data on this indicator can be resource intensive when trying to gain a representative sample size.	
Potential Data Sources	Community/Citizen Surveys Emergency Management Departments	
More Information	HRM Climate SMART Community Action Guide to Climate Change and Emergency Preparedness Climate Change and Emergency Management in Nova Scotia District of Saanich Annual Report	

Infrastructure

Number of Implemented Green Infrastructure Projects

Quick facts:

Factors to consider

Rationale	This indicator can be used to track the adoption of green infrastructure projects	
Metric	Number of implemented green infrastructure projects per year	
Geographic Scale	Municipal	
Baseline	Cubic meters of storage capacity, square meters of green area	
Applicability to Adaptation	The adoption of green infrastructure helps to reduce the impacts of extreme precipitation and heat events and their resulting environmental, social and economic costs and helps to enhance the resiliency of stormwater management systems.	
Contextual Information	➲ The increasing frequency and intensity of extreme precipitation and heat events pose significant environmental, social and economic threats, namely; poor air quality, flooding, water quality issues, as well as urban heat island effects. Green infrastructure provides environmental services which help to address these impacts, including but not limited to; cooling buildings in summer time, reducing airborne pollutants, recharging groundwater, purifying surface water, reducing health care costs due to air and water quality issues, reducing capital and operational costs of traditional gray infrastructure, retaining stormwater and reducing the urban heat island effect. Examples of green infrastructure include; parks and trees, rain gardens, pipe-to-pond stormwater systems, utility corridors, community gardens, bioswales, permeable pavements and, green roofs.	
Frequency of Data Collection	Once every three years	
Complimentary Indicators	✓ Water quality ✓ Integrated Stormwater Management Plans ✓ Percentage of total area served by green stormwater controls (rivers, streams, retention ponds) ✓ Area of catchment directly tied to a stormwater system	✓ Flood prone lands reclaimed from development area and returned to natural conditions ✓ Tree canopy cover as a % of total area ✓ Budget allocated to green infrastructure
Limitations	The use of the term “green infrastructure” as opposed to “low impact development” can lead to misconceptions on what counts as one verses the other. This indicator does not capture the effectiveness of these interventions, only the number of them, and fails to capture interventions installed on commercial, institutional or private properties. To appropriately use this indicator, a definition of “green infrastructure” would need to be established.	
Potential Data Sources	Sustainability and Environmental Departments Stormwater infrastructure managers Conservation Authorities, Watershed Councils	
More Information	Sustainable Municipal Water Management: Measuring Progress and Reporting Publicly Montreal’s Green CiTTS Report: Toward Sustainable Municipal Water Management	

General

Number of Measures that Indirectly Address Adaptation

Quick facts:

Factors to consider

Rationale	This indicator is use to capture the measures that are not implemented specifically as a result of climate change but have direct benefits to climate change adaptation
Metric	Total number of indirect climate change adaptation measures/ mechanisms in a jurisdiction
Geographic Scale	Municipal, Provincial, Federal
Baseline	None
Applicability to Adaptation	In many instances, adaptive interventions have been brought about with climate change firmly in mind and are labelled specifically as being 'adaptation'. However, a large number of municipal actions have been taken without explicit mention of climate change but nonetheless play a significant role in increasing an agency`s adaptive capacity. These actions are being driven by a wide range of other priorities ranging from good governance, to emergency preparedness, cost savings, naturalization, or broader sustainability and greening efforts, and are emerging from all sectors and levels of government.
Contextual Information	➲ This indicator captures measures not identified specifically as adaptation or as climate change related (e.g. stormwater management measures, emergency management, health, etc). For example, Quebec City launched a program to fund downspout disconnection in its Maizerets neighbourhood without mentioning climate change however there are direct benefits to the capacity of the stormwater system to cope with a changing climate.
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Percentage compliance with municipal mandatory downspout disconnection program ✓ Percentage of implemented adaptation actions ✓ Number of planning mechanisms implemented to protect against flooding
Limitations	To use this indicator, would need to clearly define what counts as an indirect adaptation measure or mechanism and what would be excluded in this review (e.g. actions within an adaptation plan). It is also important to note that this indicator may be difficult to employ and that it would be resource intensive in order to quantify given the vast number of potential data holdings.
Potential Data Sources	Municipal Performance Measurement Program Municipal Clerks and Corporate Communications Department Integrated Stormwater Management Plans Building Codes and Standards Building Permits Incentive programs
More Information	Highlighting Adaptation Initiatives in Canadian Municipalities

Flood Management

Number of Planning Mechanisms Implemented to Protect Against Flooding

Quick facts:

Factors to consider

Rationale	This indicator illustrates the degree to which planning policies are in place to address flood related impacts and risks	
Metric	Number of land use planning mechanisms (e.g. setbacks, no development zones, buffer zones) implemented to protect against flooding	
Geographic Scale	Municipal	
Baseline	Historic number of land use planning mechanisms in a previous year	
Applicability to Adaptation	Planning mechanisms are effective tools to limit development in hazard prone areas, such as flood plains, and can encourage or prescribe standards that help build resilience at the local level	
Contextual Information	➲ Planning mechanisms can also be used to minimize lot level flooding. For example, the City of Ottawa created a by-law requiring installation of a backwater valve on all new sanitary sewer connections to reduce instances of sewer backups. ➲ Planning mechanisms may include setbacks, by-laws, no development zones, buffer zones, and/or low impact development. ➲ Flooding can occur as a result of extreme rain events, sea level rise and storm surge, sewer back up, and riverine flooding.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Number of rain events that exceed municipal stormwater utilities design standards ✓ Number of implemented green infrastructure projects	✓ Total number of residences at risk of coastal flooding ✓ Risk register ✓ Reported number of properties experiencing flooding ✓ Percentage of total area served by stormwater ponds
Limitations	The indicator is targeted at planners only and it doesn't speak to the effectiveness of the planning mechanisms in actually mitigating flood risk.	
Potential Data Sources	Review of planning By-Laws Interviews with Local Planning Office	
More Information	Flood Hazard Area: Land Use Management Guidelines Environment Canada—Water and Climate Change	

Flood Management

Number of Rain Events That Exceed Design Standards

Quick facts:

Factors to consider

Rationale	This indicator can be used to determine how frequently municipalities are experiencing weather events greater than their "design storm" and whether this standard needs to be updated	
Metric	Number of events where the rate of rain (mm/per hour) or total rainfall (mm) exceeds the design storm of stormwater utilities	
Geographic Scale	Municipal	
Baseline	Record of daily rainfall amounts and stormwater utility inventory	
Applicability to Adaptation	This indicator helps to determine whether existing rainfall intensity-duration-frequency (IDF) curves and extreme rainfall design standard values require adjustment	
Contextual Information	➲ Assessing climate related risks is not yet standard practice in municipal asset management, placing most stormwater utilities at high risk of asset loss or service disruption due to extreme precipitation events. This impact is further exacerbated by aging stormwater utility systems that lack maintenance or updates due to vast infrastructure deficits. ➲ Increasing urban populations and subsequent land development often results in impermeable surfaces that rely on outdated combined sewer systems, which in turn places additional stress on municipal stormwater infrastructure. ➲ Municipalities are at increasing risk of legal liability for flood damage attributed to negligent operational decisions, such as relying on outdated standards or processes when available information suggests that standards should be reconsidered (Zizzo, Allan, & Kocherga, 2014).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Percent of effective impervious cover ✓ Number of emergency sanitary sewer repairs ✓ Number of reported sanitary sewer overflows	✓ Number of properties that experienced flooding ✓ Total number of properties at risk of overland flooding during a major storm event
Limitations	This information is difficult to collect as it requires a record of all rain events that "tripped" the system specifically as a result of extreme rain (i.e. type of rain vs. maintenance related flooding). Furthermore, there is a disconnect between monitoring systems and the spatial distribution of rain events which may not be captured by monitoring systems. Extreme precipitation events are very much localized, while weather stations are typically sparse.	
Potential Data Sources	Municipal Stormwater Managers AECOM National Water and Wastewater Benchmarking Initiative	
More Information	Water and Transportation Infrastructure in Canada in a Changing Climate AECOM National Water and Wastewater Benchmarking Initiative	Stormwater Management in Ontario: Legal Implications in a Changing Climate

Infrastructure

Number of Weather Related Transit Service Disruptions

Quick facts:

Factors to consider

Rationale	This indicator can be used to determine the degree to which extreme weather events are affecting transit service and causing service disruptions as a result of infrastructure performance
Metric	Number of service disruptions
Geographic Scale	Local, Regional
Baseline	Historic weather information, historic service disruption information
Applicability to Adaptation	The increasing frequency and severity of extreme events – from torrential rains and flooding to extreme heat and winter storms – will result in a greater number of transit service disruptions as public transportation services and assets, particularly aging infrastructure, are vulnerable to these climate change impacts.
Contextual Information	➲ Transit service disruptions can result from extreme events such as flooding, storm surge, heavy snow or rain, and extreme heat which interrupt service by stranding vehicles or damaging facilities (e.g. rail buckling from heat, electronic equipment failure or overheating). ➲ Vulnerable populations – including persons with disabilities, the elderly, and low-income individuals – are also disproportionately represented as public transit users and will be directly affected by disruptions to transit services as a result of climate change (FTA, 2011).
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Maintenance costs resulting from weather events ✓ Annual cost of road maintenance ✓ Number of transit users
Limitations	To properly use this indicator, one must understand the level of service disruption directly related to weather events. Some transit authorities may track service disruptions by weather event however some may not. It is also important to note that this indicator does not account for weather related impacts to passengers (e.g. health effects due to heat).
Potential Data Sources	Local Transit Authorities Anecdotal References (e.g. newspaper) Media Content Analysis Environment Canada Transport Canada
More Information	City of North Vancouver—Climate Change Adaptation Plan Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation

Flood Management

Percent Compliance with Municipal Mandatory Downspout Disconnection Program

Quick facts:

Factors to consider

Rationale	This indicator provides an understanding of compliance with the mandatory downspout disconnection by-laws	
Metric	Number of private properties that comply with municipal mandatory downspout disconnection program	
Geographic Scale	Municipal	
Baseline	Total number of properties in the municipality	
Applicability to Adaptation	Compliance with downspout disconnection by-laws may help to reduce incidences of basement flooding, sewer backups and combined sewer overflow discharges in the event of extreme precipitation and resulting flooding events.	
Contextual Information	➲ Large volumes of water can be collected from roof tops during extreme precipitation events. When this water is directed to storm, sanitary or combined sewer systems, sewers can become overwhelmed, increasing the risk of basement flooding and the release of polluted rainwater into local waterways on account of combined sewer overflows (Kovacs, Guilbault, & Sandink, 2014). ➲ Downspout disconnection is as a key source control measure that helps to reduce the amount of stormwater runoff entering municipal storm, sanitary or combined sewer systems (City of Toronto, 2013).	
Frequency of Data Collection	Intermittently	
Complimentary Indicators	✓ Number of climate change related public events ✓ Citizens attending neighbourhood emergency preparedness presentations/events ✓ Percentage of population(s) under a water quality advisory	✓ Reported number of properties experiencing flooding ✓ Number of rain events that exceeds municipal stormwater design standards ✓ Number of implemented green infrastructure projects per year
Limitations	Mandatory downspout disconnection by-law enforcement may be limited in some jurisdictions. Furthermore, if impermeable surfaces exist at the lot level, downspout disconnection may not be an effective climate change adaptation measure.	
Potential Data Sources	Recorded results from partial and curbside property inspections Public Works divisions By-law Enforcement Services Water, Wastewater and/or Stormwater Management Departments	
More Information	Toronto Mandatory Downspout Disconnection Quebec City: Persistent Communication to Homeowners	

General

Percentage of Implemented Adaptation Actions

Quick facts:

Factors to consider

Rationale	This indicator is a reporting mechanism which allows for actions to be updated and to build upon ongoing successful programs. Updated plans are then able to build on the original, and reflect the progress that has been achieved to date.
Metric	Number of implemented (ongoing, short term, medium term and long term) adaptation actions /Total number of actions = % implementation rate.
Geographic Scale	Municipal, Provincial, Federal
Baseline	Total number of adaptation actions
Applicability to Adaptation	Reporting on the progress of adaptation actions or measures provides a snapshot of the state of adaptation planning within a given jurisdictional context.
Contextual Information	➲ This indicator can be used to assess progress towards a set of goals or objectives and overall progress on the implementation of adaptation actions over time. ➲ Increasingly, agencies are formally addressing climate change adaptation and implementing plans, policies, and programs at all jurisdictional levels. Communicating successes and progress is crucial to maintaining momentum for continued action and interest in climate change adaptation. ➲ In order to reduce the vulnerabilities and risks posed by climate change, the plans, policies, and programs that address adaptation issues need to be implemented in order to enhance adaptive capacity and reduce risks.
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Number of measures that indirectly address adaptation ✓ Use of climate change terminology in plans or policies
Limitations	This indicator requires staff time to review reports, conduct interviews across departments, review community programs, etc. to determine what activities were conducted in a given year that fulfill the actions set out in the planning document. Also, many actions may not be termed adaptation and therefore would not be captured by this indicator. Furthermore, this indicator typically requires a specific planning document to refer to which may not always be available.
Potential Data Sources	Adaptation Planning Documents
More Information	Town of Oakville—State of Environment Report Indicators for Sustainability—How cities are monitoring and evaluating their success The 2012 Progress Report of the Federal Sustainable Development Strategy

General

Percentage of Land in Food Production

Quick facts:

Factors to consider

Rationale	This indicator can be used to increase food self-sufficiency and to better understand and track how well agricultural land is being used for food production purposes
Metric	Total land area (acres) used for agriculture and total land area in a given jurisdiction (local, regional, provincial)
Geographic Scale	Local, Regional, Provincial
Baseline	Historic data on total area farmed (acres) and total area in food production
Applicability to Adaptation	Food security is affected by changing global climate conditions including changing precipitation patterns, increasing temperature, and extreme events. A robust local food system increases community resilience, reduces reliance on distant food supply chains, and strengthens food security.
Contextual Information	➲ Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2008). A sustainable food system supports farmers and considers how food is grown, processed and distributed. It ensures universal access to nutritious, safe, and culturally appropriate food. ➲ The amount of total farmland that is used to produce food can be a measure of a region's capacity to produce food locally and its contribution to local food security, however it is also important to note that land may be in use for food production that is then being exported to other regions or countries.
Frequency of Data Collection	Every five years
Complimentary Indicators	✓ Number of community garden plots ✓ Proportion of land used for urban farming (e.g. hobby beekeeping, backyard hens, edible landscaping)
Limitations	Municipalities do not collect raw data on this indicator which may make data difficult to obtain. It is also worthwhile to note that at any given time not all agricultural land will be in use, and that some land will be used for non-food producing purposes, such as fodder for horses. Furthermore, local food production may not be a guarantee of accessibility to food due to trade agreements.
Potential Data Sources	Farm Data, Census of Agriculture Agricultural Land Trusts (where available) Ministry of Agriculture Agriculture Canada
More Information	Working Lands—Agriculture in British Columbia Ontario Ministry of Agriculture, Food and Rural Affairs City of Surrey—Indicators Dashboard Climate Change and Food Security

General

Percentage of People with High Levels of Social Support

Quick facts:

Factors to consider

Rationale	This indicator can be used to measure social capital
Metric	Percentage of population with high levels of social support broken down by age and sex
Geographic Scale	Local, Provincial, National
Baseline	Percentage of population with high levels of social support in a previous year
Applicability to Adaptation	Social support networks can help reduce or circumvent human health and well-being related vulnerabilities to climate change and assist people in coping and adapting to the indirect impacts of climate change.
Contextual Information	➲ Social capital consists of networks, norms and values that ensure social cohesion. Measuring levels of social support is one of the dimensions used to monitor social capital. Socially isolated individuals often lack the financial resources necessary to take protective actions in the event of extreme weather variability and lack access to resources and services needed to cope with the indirect impacts of climate variability. They are also susceptible to higher levels of exposure to environmental risks. ➲ Social support networks comprised of families, friends, neighbors and community organizations can help reduce the social, economic and environmental impacts of climate change by providing emotional and/or informational support to affected individuals. These networks help people build connections with others, as well as relationships of trust and reciprocity that can help enhance individual resiliency to climate change (Gouvernement du Québec, 2014).
Frequency of Data Collection	Annually; Bi-Annually
Complimentary Indicators	✓ Number of outreach or public awareness events held in the city per year on climate change related issues
Limitations	Data is derived from voluntary survey responses provided by individual households, therefore the data may not be representative of provincial or regional populations and may not accurately inform decision makers at the local level. Also, aspects of social capital and determinants of health can be difficult to quantify. Furthermore, Canada-wide survey results are only released every two years – with specific health region survey results release annually.
Potential Data Sources	Canadian Community Health Survey (by Statistics Canada)
More Information	Canadian Community Health Survey, Statistics Canada Institut de la Statistique du Québec : Profil et évolution du soutien social dans la population québécoise Climate Change Adaptation and Health Equity : Background Report

Health

Percentage of Population Under Water Quality Advisory

Quick facts:

Factors to consider

Rationale	This indicator can be used to track compliance with regulated standards for drinking water treatment, particularly in rural areas with high prevalence of small water systems	
Metric	Number of people under a drinking water quality advisory/total population	
Geographic Scale	Local	
Baseline	Number of people under a drinking water quality advisory in previous years	
Applicability to Adaptation	Water quality is an important factor with regard to human health and well-being. Water security, namely the access to sufficient quantities of water of an acceptable quality, is a growing concern in the face of climate change. Concerns include taste and odor problems in drinking water, altered runoff and groundwater recharge due to higher temperatures, and water contamination issues due to run-off during heavy precipitation events.	
Contextual Information	➲ The quality of water is already under stress in many regions in Canada, due in large part to environmental stresses and water intensive industries (e.g. agriculture, manufacturing). Heavy rainfall or flooding can increase waterborne pathogens that are sometimes found in drinking water, and warmer water temperatures can lead to an increase in micro-organisms found in lakes and streams (Environment Canada, n.d. B). ➲ For low-lying areas and areas with higher water tables, water quality is an ongoing issue that gets exacerbated by a changing climate. Higher water temperatures could decrease dissolved oxygen levels and increase the growth of algae and bacteria, while rising sea levels increase the risk of salt water intrusion in groundwater. ➲ Boil water advisories are the most common type of advisory and are issued when the quality of drinking water is suspected or confirmed to be compromised. *Do not consume* or *Do not use* advisories are typically used when a chemical contaminant is suspected or confirmed in a drinking water supply (Environment Canada, n.d. C).	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Water quality ✓ Number of coliform forming units (CFU) of E-coli per 100 ml of surface water samples ✓ Duration of water quality advisory	
Limitations	This indicator does not speak to the duration of the advisory as some go on for years in certain areas. Furthermore, testing of private water supplies is typically the responsibility of the owner of the supply (e.g. wells on private property) and as such may fall outside of the responsibility of a municipality to track and issue advisories. As such, it is worthwhile to note that in certain instances, particularly in rural settings, it may be more appropriate to track this indicator within a watershed as opposed to a jurisdiction.	
Potential Data Sources	Municipal Water Departments Public Health or Regulatory Authorities Environment Canada	Provincial Health Departments Conservation Authorities Watershed Councils
More Information	Environment Canada—Drinking Water Advisories in Canada Centers for Disease Control and Prevention—Drinking Water	

Flood Management

Percentage of Total Area Served by Stormwater Ponds

Quick facts:

Factors to consider

Rationale	This indicator is used to determine the extent of area served by stormwater controls and to help manage stormwater quality and quantity	
Metric	Stormwater ponds that have controls	
Geographic Scale	Municipal	
Baseline	Number of stormwater ponds in a previous year	
Applicability to Adaptation	Stormwater retention ponds reduce human health and stormwater utility vulnerabilities to extreme precipitation events by removing pollutants from stormwater runoff and delaying peak stormwater flows with their storage capacity.	
Contextual Information	➲ Both grey and green stormwater controls help to reduce the impact of extreme precipitation events and their resulting environmental, social and economic costs in a local area. ➲ Stormwater utilities can be at high risk of asset loss or service disruption in the event of extreme precipitation events. This climate impact is exacerbated by aging stormwater utility systems, outdated combined stormwater, and sewer utility systems that lack maintenance due to vast infrastructure deficits in the face of increasing urban populations and impermeable surfaces. ➲ Stormwater Management Ponds (SWMPs) are designed to collect and temporarily hold runoff from the local storm sewer system following either a rainfall or snowmelt event at the end-of-pipe phase of stormwater management. The ponds provide treatment to remove pollutants concentrated in the runoff and then slowly release the treated runoff back into our waterways. Accordingly SWMPs help to reduce the risk of grey stormwater infrastructure asset loss.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Budget allocated to green infrastructure ✓ Number of implemented green infrastructure projects per year	✓ Annual change in wetland area ✓ Integrated stormwater management plans
Limitations	Stormwater ponds may not be appropriate in all areas, particularly dense urban neighbourhoods.	
Potential Data Sources	Water Management Division	
More Information	Town of Oakville: Stormwater Management Ponds Canada Mortgage and Housing Corporation: Retention Ponds Economic Assessment of Green Infrastructure Strategies for Climate Change Adaptation	

Infrastructure

Percentage Probability of Unacceptable Performance (PUP) in Infrastructure

Quick facts:

Factors to consider

Rationale	This indicator is used to assess risk and vulnerability, identify reliability, residual life, and the level of effective capacity of infrastructure assets for short, medium and long term	
Metric	Percentage probability of unacceptable performance	
Geographic Scale	Local	
Baseline	Age and condition of infrastructure	
Applicability to Adaptation	Infrastructure risk and vulnerability assessments can help identify and mitigate the engineering vulnerability of infrastructure to the impacts and risks of the current and future climate	
Contextual Information	➲ Exposure to the changing frequency and intensity of extreme weather is not currently accounted for in the design of infrastructure systems which were often constructed based on the assumption that historical climate extremes are representative of future climate conditions. ➲ Climate extremes such as accelerated freeze thaw cycles, snow and ice variability, hotter and drier summers, as well as extreme rain and flooding events negatively affect infrastructure performance by reducing the life span and performance of infrastructure systems. This increases maintenance and operating costs; disrupts operations; compromises public safety, and; generates severe and unanticipated economic losses owing to damaged infrastructure. ➲ These impacts are further aggravated by the existence of aged infrastructure systems that have exceed normal service life, the frequent co-location and interdependency of infrastructure systems, and vast infrastructure deficits and ballooning populations in urban centres.	
Frequency of Data Collection	1 to 3 year cycles	
Complimentary Indicators	✓ Number of storms where the rate of rainfall (mm/hr) exceeds the design standards ✓ Risk register	✓ Human/social/economic impacts due to infrastructure failure
Limitations	Action on this indicator often requires considerable costs and resources, particularly in light of infrastructure deficits. Also, a high percentage of unacceptable performance does not guarantee that an intervention is required or that it becomes a priority.	
Potential Data Sources	Infrastructure Managers Public Works Departments	
More Information	IBC Municipal Risk Assessment Tool National Engineering Vulnerability Assessment of Public Infrastructure to Climate Change: City of Welland	Climate Change Adaptation and Canadian Infrastructure: A Review of Literature Stormwater and Wastewater Infrastructure Assessment

Flood Management

Rating of Water Quality Measurements

Quick facts:

Factors to consider

Rationale	This indicator is used to track changes in water quality to better identify locations where Beneficial Management Practices can be implemented	
Metric	Total Phosphorus (ppm), Ammonia Nitrogen (ppm), Dissolved Oxygen (ppm, %), Turbidity (NTU), pH, and Flow (cfs/cms). For each individual element measured, results are assessed using a good, fair, poor, or acceptable/ unacceptable scale.	
Geographic Scale	Local, Regional	
Baseline	Historic water quality data Canadian Water Quality Guidelines	
Applicability to Adaptation	This indicator can measure how well water bodies are adapting to changing climatic conditions and assist in the development of appropriate adaptation plans, policies, and actions.	
Contextual Information	➲ Increasing heavy precipitation events, warming air and water temperatures, and incidences of drought contribute to an increase in water borne illness due to the increased microbiological concentrations in surface water, drinking water and ground water. More frequent heavy precipitation events can also increase the risk of chemical contaminants such as pesticides, nutrients, heavy metals and persistent organics infiltrating water waters. Links have also been suggested between climate change and the proliferation of blue-green algae blooms that can lead to unacceptable taste, odours and toxins in drinking water and recreational water and may contaminate fish and shellfish (Berry, Clarke, Fleury, & Parker, 2014; Canadian Council of Ministers of the Environment, 2011).	
Frequency of Data Collection	Monthly	
Complimentary Indicators	✓ Percentage of urban land use with stormwater quality control ✓ Percentage of population under a water quality advisory ✓ Number of observed anoxic events in estuaries per year ✓ Water quantity in rivers	✓ Agricultural manure and fertilizer application rates ✓ Agricultural and non-agricultural pesticide use ✓ Change in magnitude and frequency of base and peak flow events as well as annual runoff rates and volumes modelled at the watershed scale in watersheds where natural land cover is or will be altered
Limitations	Conservation authorities generally track this information in Ontario, however, this information is not available for all areas and outside of the province and may be more difficult to obtain.	
Potential Data Sources	Conservation Authorities Watershed Councils	
More Information	Human Health in Canada in a Changing Climate Selected Tools to Evaluate Water Monitoring Networks for Climate Change Adaptation	Indicators for Assessing Environmental Performance of Watersheds in Southern Alberta La Salle River Integrated Watershed Plan

Flood Management

Reported Number of Properties Experiencing Flooding

Quick facts:

Factors to consider

Rationale	This indicator can be used to determine the impact of overland flooding on local property owners	
Metric	Total number of proprieties that report overland flooding per year	
Geographic Scale	Municipal, National	
Baseline	Insurance claims in a previous year Number of property owners that report flooding to municipality in a previous year Number of extreme rainfall events in a previous year	
Applicability to Adaptation	This indicator helps evaluate the success of efforts to protect properties from flooding, consequently helping to enhance the climate resiliency of local properties	
Contextual Information	➲ The increasing frequency and intensity of extreme precipitation events is exacerbated by a high incidence of physical assets located in flood prone areas, the existence of flood management infrastructure that was designed without future climate considerations, the frequent inexistence of flood protection infrastructure in a given area due to infrequent historical flood events, as well as the increasing incidence of impermeable surfaces due to land development. ➲ Local governments are increasingly at risk of legal liability in the event of a flood on account of their failures to maintain infrastructure that can adequately withstand extreme weather, despite prior flooding and warnings. ➲ Property owners often suffer immense losses when affected by flooding due to the inexistence of overland flood insurance in Canada.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Number of reported sanitary sewer overflows ✓ Total number of properties at risk of coastal flooding during a major storm event ✓ Number of events where the rate of rainfall (mm/hr) exceeds the design standard of municipal stormwater utilities	✓ Number of land use planning mechanisms implemented to protect against flooding ✓ Number of basement floods due to sewer backup ✓ Number of combined sewer overflows
Limitations	This indicator alone may not accurately inform local decision making as property owners may not report flooding for such reasons as; lack of awareness of local flood reporting services, lack of incentive for property owners to report flooding, unreported flooding due to property owners fear of stigmatization by real-estate, lending and insurance entities.	
Potential Data Sources	Calls to 311 Systems Insurance Claims	
More Information	Partners for Action: Priorities for Advancing Flood Resiliency in Canada City of Edmonton Drainage and Flood Protection	

General

Spatial Location of Green Space

Quick facts:

Factors to consider

Rationale	This indicator provides the spatial location of green space within a jurisdiction which can be used to help manage and conserve biodiversity	
Metric	Hectares of green space by wards/municipal districts/postal code (or similar spatial unit)	
Geographic Scale	Local, Provincial, National	
Baseline	Total land area of the municipality	
Applicability to Adaptation	Green spaces provide shade, reduce run-off, and enhance permeability thereby helping urban areas adapt to the impacts of climate change	
Contextual Information	➲ The degree to which green spaces mitigates climate impacts is greatly influenced by the size, quality, and shape of the space, as well as vegetative type and coverage of the area (Communities and Local Government, n.d.). ➲ Green spaces provide a variety of ecological, recreational, and flood protection co-benefits and can be used as part of the stormwater management system to reduce flood risk and to reduce the urban heat island effect. ➲ Protecting green space supports biodiversity enhancing flora and fauna in our ecosystem and is universally comparable with other green city indexes.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Proportion of natural areas in the city ✓ Proportion of tree canopy coverage in urban centres ✓ Publicly owned green space ✓ Percentage of land area by vegetative type	✓ Urban forest species composition ✓ Tree canopy cover as a percentage of total area ✓ Spatially distributed green space per capita
Limitations	To appropriately use this indicator, a definition of "green space" would need to be established (e.g. publicly or privately owned). It is also important to consider that the quality of green space can differ significantly (i.e. golf course vs. naturalized area, natural vs. invasive species) and that the form of the green space will have an affect on the adaptation and biodiversity benefits.	
Potential Data Sources	Satellite Imagery Urban tree counts or urban tree canopy survey (if available) Geo-database of postal codes Normalized Difference Vegetation Index (NDVI) Publicly owned green space	
More Information	The Living City Report Card City of Vancouver—Climate Change Adaptation Strategy City of North Vancouver—Climate Change Adaptation Plan The Value of Green Infrastructure for Urban Climate Adaptation	

General

Total Number of Emergency Responders

Quick facts:

Factors to consider

Rationale	This indicator illustrates response capabilities and where there is a need for more response personnel (e.g. firefighters).
Metric	Total number of emergency responders, volunteers, or safety service personnel in a municipality.
Geographic Scale	Municipal
Baseline	Number of emergency responders in a previous year.
Applicability to Adaptation	This indicator can be used to better understand disaster resilience and emergency response capabilities, particularly as the frequency and severity of extreme weather events will increase in light of climate change.
Contextual Information	➲ When equipped with the appropriate resources and training, emergency responders, and volunteers in particular, can help to build awareness among fellow community members about the risks associated with extreme weather events. ➲ The connection that volunteers in particular have with the community helps to further strengthen community resilience. ➲ Emergency responders are just one part of an effective emergency response and should be considered within the wider context of emergency management operations.
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Citizens attending emergency preparedness events ✓ Number of households prepared for a 7 day emergency ✓ Number of emergency responders per capita
Limitations	Need to define the limitation of who gets counted as an emergency responder (i.e. firefighters, community emergency response volunteers, paramedics, etc). For instance, in certain municipalities in the event of an emergency municipal staff are often considered emergency responders.
Potential Data Sources	City Manager's Office Offices of Emergency Management Emergency Services Red Cross
More Information	Surrey Emergency Program - Volunteer Program Climate Change Adaptation: Linkages with Social Policy BC Ministry of Public Safety and Solicitor General: The Critical Role of Volunteers HRM Climate SMART Community Action Guide to Climate Change and Emergency Preparedness The social network: How Bowness stayed strong after the flood Red Cross Youth Volunteers Take on Climate Change

Coastal Management

Total Number of Residences at Risk of Coastal Flooding

Quick facts:

Factors to consider

Rationale	This indicator can be used to assess the degree to which residents in coastal communities are being affected, or could potentially be affected, by coastal storm events	
Metric	Number of residences at risk of flooding during a major coastal storm event	
Geographic Scale	Municipal	
Baseline	Number of storm events affecting residences in a previous year Potential number of homes affected by a certain height above sea level (sea level rise, storm surge, and wave affect)	
Applicability to Adaptation	Indicator helps monitor and evaluate efforts to reduce exposure to and risk of coastal flooding events at the community level	
Contextual Information	➲ Increasingly frequent and intense rain events are exacerbated by a high incidence of residential areas located in coastal zones vulnerable to flooding, in addition to the prevalence of outdated flood management infrastructure, inadequate flood protection infrastructure, the increasing incidence of shoreline erosion, and natural buffer damage due to land development. ➲ Property owners often suffer immense losses when affected by flooding due to the unavailability of overland flood insurance in Canada.	
Frequency of Data Collection	Annually	
Complimentary Indicators	✓ Total number of properties that experience flooding ✓ Number of communities that use setbacks, buffers or land use policies to direct development away from floodplains or coastal zones vulnerable to flooding ✓ Area of flood prone lands reclaimed from development area and returned to natural conditions	✓ Number of public awareness activities related to coastal or riverine flood hazards ✓ Integrated stormwater management plans
Limitations	This indicator is not meant to capture flooding as a result of precipitation events. Also, in order to use this indicator a clear set of criterion would be required in order to define what constitutes a “coastal storm event”.	
Potential Data Sources	Watershed Managers Engineering—Stormwater departments Coastal Impacts Visualization Tools Floodplain Maps	
More Information	Sea Level Rise Adaptation Primer: A Toolkit to Build Adaptive Capacity on Canada’s South Coasts CLIVE: Coastal Impacts Visualization Environment Planning for Climate Change and Coastal Zone Management Climate Impacts on Coastal Areas	

General

Tree Canopy Cover as a Percentage of Total Area

Quick facts:

Factors to consider

Rationale	This indicator measures the amount of tree or shrub cover and can be used to assess how well a municipality is doing to maintain a healthy urban environment	
Metric	Amount spent on green infrastructure	
Geographic Scale	Local	
Baseline	Tree canopy cover in previous years	
Applicability to Adaptation	Tree canopies provide climate regulation and carbon storage, while also improving air quality and mitigating the impacts of extreme rain and storm events through the absorption of water runoff. Urban forests can also reduce energy consumption, in relation to both heating and cooling, and reduce urban heat island effects and heat impacts by shading buildings, people, and public spaces in warmer summer months.	
Contextual Information	➲ Climate change is expected to further increase threats to the health and viability of urban tree canopies in municipalities across Canada. Certain cities have been forced to intensify replanting efforts to help combat loss of tree species. Estimating canopy cover is essential for cities to estimate if they are meeting their canopy goals, and in allocating resources where they need to. ➲ Shrub, and tree canopy cover in particular, provide carbon storage and cooling effects. As a general rule, a 10% increase in vegetation cover reduces the temperature by about 3 degrees (CBD, 2010). Plants, through shading and evapotranspiration, reduce the ambient heat in the air and the surface temperature in the urban landscape.	
Frequency of Data Collection	Every three years	
Complimentary Indicators	✓ Proportion of natural areas in city ✓ Proportion of tree canopy coverage in urban centres ✓ Publicly owned green space ✓ Percentage of land area by vegetative type	✓ Spatial location of green space ✓ Urban forest species composition ✓ Economic and ecological value of urban forest
Limitations	The use of this indicator is typically only possible if an urban forest inventory is available. Urban forest inventories can be expensive and resource intensive depending on the inventory method chosen. It is also important to note that alien species, which can be invasive or detrimental to native species, are not distinguished in this indicator.	
Potential Data Sources	Satellite Images Urban Forest Inventory (if available) (e.g. i-Tree/UFORE) Ortho-imagery	
More Information	City of Vaughan—Environmental Sustainability Indicators City of Edmonton—Urban Forest Management Plan Convention on Biological Diversity—City Biodiversity index Urban Forests: The Value of Trees in the City of Toronto City of Surrey—Sustainability Dashboard Every Tree Counts—A Portrait of Toronto's Urban Forest	

General

Use of Climate Change Adaptation Terminology in Plans or Policies

Quick facts:

Factors to consider

Rationale	This indicator can be used to determine the degree to which climate change adaptation language is present within plans, policies, and programs at the municipal, provincial, or federal level
Metric	Survey of adaptation and/or climate change language that is present in a plan, policy or procedure
Geographic Scale	Municipal, Provincial, Federal
Baseline	None
Applicability to Adaptation	Explicit mention of climate change and/or adaptation language in planning documents and policies is an acknowledgement of the impact that climate change will have on various planning processes and helps illustrate the degree to which this issue is being mainstreamed.
Contextual Information	➲ As climate change will not affect agencies in isolation, it is important to take an integrated approach to adaptation planning. In order to assess the degree to which adaptation is already being addressed and to ensure that efforts are not duplicated, a review of adaptation terminology is an important first step to incorporating adaptation considerations across departments, programs, and jurisdictional levels. ➲ In any review of terminology, it is importance to consider the level of the document where the reference is found (i.e. Official Community Plan or Transportation Strategy) as this dictates the weight of importance that the jurisdiction is placing on the issue. ➲ Climate change adaptation language can be quite broad and could also be labeled as “resilience”, “preparedness” or similar.
Frequency of Data Collection	Annually
Complimentary Indicators	✓ Number of Implemented Actions ✓ Number of Planning Mechanisms Implemented to Protect Against Flooding ✓ Number of Measures and Degree of Uptake
Limitations	In order to use this indicator, a definition of what should be considered “adaptation” or “climate change” language would need to be established. It should also be acknowledged that even explicit mention of climate change adaptation does not guarantee an improved capacity to address the impacts of climate change. Furthermore, there may be adaptation actions happening, regardless of whether plans or policies have mentioned adaptation or not. Similarly, many planning documents are not prescriptive and may mention adaptation, but this does not mean adaptation is in fact happening on the ground.
Potential Data Sources	Documents, policy statements, or plans to consult may include: Emergency Management Plans, Energy Management Plans, Integrated Community Sustainability Plans, Fire Master Plans, Official Plans, Urban Forest Master/Management Plans, Tree Protection Policies, etc.
More Information	Town of Oakville—Climate Change Strategy Department of Defense—2014 Climate Change Adaptation Roadmap

FINAL THOUGHTS

This collection of case studies is intended to illustrate examples of how existing outcome and process based indicators in Canadian sectors may apply to adaptation monitoring and evaluation efforts. They should not be considered a climate adaptation indicator framework for Canadian health, coastal, flood and infrastructure management sectors. This compendium is not exhaustive. Future work could examine new and emerging sustainability indicators in these four sectors of focus, and their potential application to adaptation. Additionally, a similar review of sustainability indicators in other sectors would further our collective understanding of how we can measure adaptation progress using proven methodologies in those areas not covered by this review.

As climate change adaptation remains an emerging and rapidly evolving field of research and practice, there is a need for sector agencies to undertake efforts to measure progress in an ongoing and consistent fashion that is both resource efficient and appropriate to their unique adaptation actions and the climate impacts affecting them. Accordingly, these case studies are intended to serve as a first step in broader efforts to examine how available metrics from varying sectors and orders of government can contribute to measuring adaptation to climate change, both in terms of effectiveness and progress on implementation.

Indicators are invaluable in identifying trends and helping us gauge an understanding of where we are with regard to a predetermined trajectory. They quantify information so that its significance is more readily apparent, and they simplify information about complex phenomena so as to improve communication. In a field as complex as climate change adaptation, these characteristics are more important than ever. As such, the continual emergence of new and interesting indicators is anticipated as we progress into a more erratic climate future.

What indicators cannot do, is inform those behavioral and organizational changes required to achieve them. Sustained success in adaptation will require constant (albeit often small) changes to how we work. Focusing on the attainment of a set level of a certain indicator runs counterproductive to those iterative organizational and behavioral changes required for the implementation of successful adaptation strategies.

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