



Ontario Provincial Climate Change Impact Assessment

Adaptation Best Practices Report

January 2023





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This report was prepared for the Ontario Ministry of the Environment, Conservation and Parks by the Climate Risk Institute in collaboration with Dillon Consulting Limited.

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Key Terms, Definitions and Acronyms

– A –

Adaptation: Process of adjustment to actual or expected climate hazards and its effects.

Adaptive Capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

APGO: Association of Professional Geoscientists of Ontario

Area of Focus: The five Areas of Focus defined by the Ontario Ministry of the Environment, Conservation and Parks for the PCCIA are: Business and Economy; Food and Agriculture; Infrastructure; Natural Environment; and People and Communities.

ASP: Adaptive Social Protection

– B –

BOMA: Building Owners and Managers Association

– C –

Climate Change: Refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climate Hazard: Changes in climate (events or stressors) that have the potential to cause harm or benefit.

Consequence: (In the PCCIA context) the severity of an impact, assessed as a consequence in one of four criteria (human health and safety, environmental damage, financial loss, disruption to services).

CRI: Climate Risk Institute

Critical Infrastructure: Critical infrastructure is defined as interdependent, interactive, interconnected networks of institutions, services, systems and processes that meet vital human needs, sustain the economy, protect public health, safety and security, and maintain continuity of and confidence in government.

Cross-Sectoral Impacts: Climate change impacts that span multiple Areas of Focus. For the purposes of Ontario's PCCIA, cross-sectoral impacts are characterized based upon five themes: 1) food security, 2) water security, 3) energy security, 4) human health, 5) community function; human health, safety and well-being .

CSA: Canadian Standards Association

CSIRO: Commonwealth Science and Industrial Research Organisation

CVC: Credit Valley Conservation



– D –

Direct Impact: Effects of changes in climate that in and of themselves cause an impact. Also referred to as primary effects of climate change. In the context of Ontario's PCCIA, direct impacts are those resulting from climate hazards on the Areas of Focus, which has been quantified.

– E –

EPA: United States Environmental Protection Agency

Equity Lens: Within the context of the PCCIA, this is a term specifically used as part of cross-sectoral analysis (Section 7.6). An equity lens has been applied to every cross-sectoral theme, which identifies unique factors or populations that may be disproportionately impacted associated with the cross-sectoral theme.

ESSCO: Engineering Student Societies' Council of Ontario

Event: Occurrence or change of a particular set of circumstances.

Expert [evidence, experience]: Expert refers to the subject matter expertise held by the Consulting team consultants, all of whom have significant experience and knowledge of their respective Areas of Focus. This can also refer to external expertise in the form of engaged Stakeholders.

– F –

Frequency: The number of occurrences of a repeating climate hazard per unit of time (e.g., a flood event that is reasonably expected to occur 1 time in a 100 year time span has a frequency = $1/100$ yrs. = 1×10^{-2} or is sometimes called "Annual Frequency"). Using this example, "1 time in a 100 year time span" is expressed as 1:100 year, which is called a "Return Period".

– G –

GBON: Global Basic Monitoring Network

GHG: Greenhouse gas

GLWQA: Great Lakes Water Quality Agreement

– H –

HIRA: Hazard Identification Risk Assessments

– I –

ICLR: Institute for Catastrophic Loss Reduction

IESO: Independent Electricity System Operator

Impact: Effect on natural and human systems.

Indirect impacts: Effects of changes in climate that occur as a secondary result. These impacts result from changes in one or multiple climate hazards. Also referred to as secondary and tertiary effects of climate change.



Information: Within the Methodology Framework, information means knowledge, facts, and data that is qualitative or quantitative in nature. Information will be collected through a variety of sources such as: stakeholder input, expert experience, literature review, climate models, geospatial data, and numerical data.

Interaction: The pairing of an asset/service/operation with a climate hazard that has the potential to impact the asset/service/operation.

IRENA: International Renewable Energy Agency

IPCC: Intergovernmental Panel on Climate Change

– L –

LCA: Low-Carbon Asset (through life cycle assessment)

LCC: lifecycle costing

LIDAR: Light Detection and Ranging

Likelihood: (In the PCCIA context) the likelihood, as an annual probability, that a near worst-case scenario will occur.

– M –

MECP: Ministry of Environment, Conservation and Parks

MINES: Ministry of Mines

MMAH: Ministry of Municipal Affairs and Housing

MND: Ministry of Northern Development

MNRF: Ministry of Natural Resources and Forestry

MoE: Ministry of Energy

– N –

Nature-Based Solutions (NBS): Nature-based Solutions are actions and policies to protect, sustainably manage, protect and restore natural and modified ecosystems. They address societal challenges, like climate change, effectively and adaptively, simultaneously benefiting people and nature.

NCC: National Construction Code

NERC: North American Electric Reliability Corporation

NRCan: Natural Resources Canada

– O –

OFA: Ontario Federation of Agriculture

Ofwat: Water Services Regulation Authority (United Kingdom non-ministerial government department)



OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs

ONEIA: Ontario Environmental Industry Association

OSPE: Ontario Society of Professional Engineers

– P –

PCCIA: Provincial Climate Change Impact Assessment

Peer Review Panel (PRP): The PRP is made up of ten subject matter experts from across Ontario, and from a variety of organizations (including Cambium Indigenous Professional Services, Association of Municipalities of Ontario, Council of the Great Lakes Region, Intact Centre on Climate Adaptation, Conservation Ontario, Ontario Association for Impact Assessment, Real Property Association of Canada, Institute for Catastrophic Loss Reduction, Ontario Federation of Agriculture, and Ontario Soil and Crop Improvement Association). The PRP review draft PCCIA products and provide commentary on the utility of PCCIA products for decision-making support and communication among their stakeholder/membership base. The PRP did not provide technical peer review, rather their feedback was used to improve a) clarity, and b) the ability of draft products to meet the needs of Ontario stakeholders and Indigenous peoples such as communicating relevant risks or adaptation actions for implementation. Feedback received from the PRP was reviewed and used to revise drafts. These edits were made prior to draft products being submitted to Ministry staff for their review periods as per the work plan.

PEO: Professional Engineers Ontario

PIEVC: Public Infrastructure Engineering Vulnerability Committee

– R –

Resiliency: The ability of systems and structures to absorb the shocks of climate change related events and impacts, and return to normal functioning without major delays.

Rights holder: Indigenous Peoples; holding constitutionally protected rights.

Risk: The positive or negative level of uncertainty of an event. In the context of the PCCIA, risk is measured as the product of frequency (of climate hazard), likelihood (of impact) and consequence (of impact).

Risk Analysis: Process of understanding the nature of risk and its characteristics including likelihood and consequence.

Risk Assessment: Process used to identify, analyze, and evaluate risk.

Risk Criteria: Criteria to evaluate the significance of risk.

Risk Evaluation: Process of comparing the risk results with the risk tolerance criteria and determining where further actions are required.

Risk Identification: Process of finding, recognizing, and describing risks.



– S –

SOFF: Systematic Observations Financing Facility, a financing mechanism to allow for the improvement of "surface-based observational" climate data worldwide

Stakeholder: Individuals engaged throughout the PCCIA process; these individuals contribute to the information gathering and provide their Area of Focus expertise.

– T –

TEK: Traditional Ecological Knowledge

TRCA: Toronto and Region Conservation Authority, one of 36 Conservation Authorities in Ontario, created to safeguard and enhance the health and well-being of watershed communities through the protection and restoration of the natural environment and the ecological services the environment provides.

– U –

UK: United Kingdom

UNFCCC: United Nations Framework Convention of Climate Change

– V –

Vector-borne Diseases: Human illnesses caused by parasites, viruses, and bacteria that are transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails, and lice.



1.0 Introduction

1.1 Provincial Climate Change Impact Assessment Overview

Ontario's climate is changing, and there is an urgent need to both understand the nature of the change and future impacts, as well as to invest in the capacity of the people, communities, industries, and governance organizations to adapt.

To this end, the Province of Ontario through the Ministry of Environment, Conservation and Parks (MECP) commissioned the Provincial Climate Change Impact Assessment (PCCIA) in 2020, to undertake a scientifically based assessment of risks, opportunities, and Adaptive Capacity for key sectors of Ontario.

The PCCIA examined five Areas of Focus along with five Cross-Sectoral Themes for analysis. Each of these sectors and systems broadly represent the diversity of ecological, social, and business systems in Ontario.



Figure 1-1: Areas of Focus and Cross-Sectoral Themes as Identified Within the PCCIA



To represent the inherent connectedness and complex interactions between Areas of Focus, cross-sectoral analyses were conducted. For the purposes of Ontario's PCCIA, cross-sectoral impacts were qualitatively characterized based upon five themes: 1) food security, 2) water security, 3) energy security, 4) human health, safety and well-being, and 5) community function. An equity lens was applied to every cross-sectoral theme, identifying unique factors or populations that may be disproportionately impacted.

In each Area of Focus, a series of categories labelled either 'Level 1' or 'Level 2' were used to guide and develop risk scenarios for evaluation. Each Level 1 category represents a primary branch of the Area of Focus, similar to how a sector is defined under the North American Industrial Classification System (NAICS). Level 2 categories are primary branches of a Level 1 category and provide additional details, similar to how subsectors and industries form the hierarchy for each sector in NAICS.



Figure 1-2: Structure of the Assessment of Impacts in the Ontario Provincial Climate Change Impact Assessment

This Adaptation Best Practices report is a companion document to the PCCIA Technical Summary Report, providing a library of Adaptation Best Practices* to support policy-makers and decision-makers in the identification and consideration of adaptation measures that can build Adaptive Capacity in the businesses, communities, infrastructure, and natural systems of Ontario, with the ultimate goal of reducing the potential for catastrophic losses across the Province. In addition, the adaptation actions identified also include suggestions on improving interprovincial and international negotiations and coordination across transboundary issues such as floods (where rivers cross borders), as well as societal and economic issues.

**Note: The adaptation actions put forward in this report are not presented in any particular order or priority; they are intended as potential actions to limit risk in light of prioritized areas of higher vulnerability.*



1.2 Climate Change Adaptation

The United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) define climate change adaptation as adjustments to ecological, social, or economic systems, in response to actual or expected climatic effects or impacts. In plain language, this means understanding risks and impacts related to the changing climate, and then making changes to managed systems in order to reduce impacts.

Climate change mitigation, according to the IPCC and UNFCCC, is defined as human intervention that reduces the rate of climate change by limiting or preventing greenhouse gas (GHG) emissions, and by enhancing activities that remove GHGs from the atmosphere.

The PCCIA team recognizes that climate change mitigation is crucial to the reduction or deceleration of global climate change, and that an ideal response to climate change includes both mitigation and adaptation. It should be noted, however, that the scope of the PCCIA and all companion reports is focused on climate change adaptation, and does not specifically address climate change mitigation. Elsewhere, the Province of Ontario is working on climate change mitigation, and has produced important reports focused on reducing GHG emissions, including the Preserving and Protecting our Environment for Future Generations: A Made-In Ontario Environment Plan (MECP, 2018), which sets a goal of 30% reduction in GHG emissions by 2030 (based on a 2005 baseline).

Climate change adaptation is increasingly being recognized as a core component of both current and long range planning exercises, bolstered by the evident need to reduce damage and loss as well as human health and wellbeing impacts from climate change. As the IPCC 6th Assessment Report (AR6) Summary for Policymakers (2021) notes, “It is unequivocal that human influence has warmed the atmosphere, ocean and land...Human-induced climate change is already affecting many weather and climate extremes in every region across the globe”.

The call to action on adaptation is therefore urgent – as the IPCC (2022) lays out, the window for meaningful action is now: “Climate Resilient Development is already challenging at current warming levels. It will become more limited if global warming exceeds 1.5°C (2.7°F). In some regions it will be impossible if global warming exceeds 2°C (3.6°F). This key finding underlines the urgency for climate action, focusing on equity and justice. Adequate funding, technology transfer, political commitment and partnership lead to more effective climate change adaptation and emissions reductions.”

The following summary highlights key elements in the case for adaptation.

The global climate is changing.

Shifts in atmospheric greenhouse gas (GHG) concentrations have been studied and documented, some of which can historically be attributed to factors such as variations in the solar cycle. However, the reasons for previous changing climate events cannot explain the change in climate that has been occurring over the past 200 years.



This increase in GHG emissions is causing global climate change and has led to global average temperature rise. Since the 1800's, human activities have been responsible for approximately 1.1°C of global average temperature warming. Climate change, and the resulting global average temperature rise, is leading to a wide range of impacts and consequences, felt around the world. These include droughts, severe wildfires, rising sea levels, flooding, melting polar ice and permafrost, intense storm events, and changes to the hydrologic cycle.

In Canada, the rate of rapid warming is happening two times faster than the global average, creating increased vulnerability and urgency to adapt to a changing climate even with an ongoing effort to curb GHG emissions (Environment and Climate Change Canada, 2022).

Impacts from climate change have already affected Ontarians.

Climate change impacts already affecting Ontarians include recent events such as flooding, heat waves, and unusually high climate variability and extremes, such as tornados in the Barrie area that led to over \$100 million in insured losses in 2021. The history of insured catastrophic losses related to extreme weather events is one important indicator of the impacts from climate change.

As the Insurance Bureau of Canada (2022) reports, insured catastrophic losses have been on the rise since the 1980's, with significant spikes in 2013 and 2016; In 2021 alone, insured catastrophic losses across the country reached \$2.1 billion dollars, and Ontario has not been immune to these trends.

The social and health costs of not adapting to climate change would be catastrophic.

Estimates of insured catastrophic losses do not, however, consider the social costs of climate change. These can be significant and include impacts such as service loss due to damaged infrastructure, forced migration, cultural losses, harms to mental health and community wellbeing, and more. In addition, the loss of life and wellbeing impacts (particularly for people who are more vulnerable) are often not well considered in economic evaluations of climate change (Boyd and Markandya, 2021).

The Canadian Institute for Climate Choices (CICC) also strongly recommends integration of a health lens into the consideration and design of climate adaptation, recognizing that broader resilience is not possible without prioritizing the health and wellbeing of people and the environment (CICC, 2021).

Indigenous knowledge should be integrated and prioritized in developing adaptation responses.

It is critical to heed Indigenous voices on climate change, privileging Traditional Ecological Knowledge and bridging Indigenous knowledge and Western science. Indigenous peoples and local communities have wisdom and values oriented towards nature, and amassed through generations. According to the United Nations, they steward over 80% of the planet's remaining biodiversity. First Nations, Inuit and Métis peoples in Ontario and across Canada face unique and disproportionate risks to their health, due to their interlinked ways of being with the environment and nature (National Collaborating Centre for Indigenous Health, 2022). These direct and indirect impacts extend to future generations and cultural practices, creating additional layers of trauma.



Climate resiliency therefore requires a deeper re-connection with the land, an intimate understanding of how to live and survive on the land, and the unique challenges that each community is facing in order to better identify how to adapt and change with it. Truth and Reconciliation is inherently central to this process (Charles-Norris, 2020).

As the world scales up climate action, Indigenous practices offer solutions. Native tree plantations, community-managed natural forests, active revitalization of traditional technologies connected to agriculture, aquaculture and natural resource management, and sustainable fishpond systems that have the potential to produce thousands of kilograms of sustainable protein annually, can be key components of climate change mitigation and adaptations strategies. Mental health concerns are also better integrated into adaptation planning and responses in Indigenous communities (McBean et al., 2021).

There are regional differences in adaptation priorities and urgency of adaptation in different sectors.

The Provincial Climate Change Impact Assessment (PCCIA) Technical Summary Report highlights some of the regional variability in how climate risks currently manifest and how these may change into the future. In particular, it is crucial to consider the relative differences for Northern Ontario communities, particularly with respect to infrastructure and investment in securing the necessities of life such as medical care, clean drinking water, and secure, climate adapted housing. Understanding these differences is crucial to identifying the appropriate responses in the context of cascading impacts to the wellbeing of people and communities from inadequate transportation infrastructure, housing, or energy supply (Canadian Climate Institute, 2022).

Adaptation has a number of co-benefits – it is more fiscally responsible to invest in adaptation, compared to recovery from climate induced disasters.

Estimates indicate that the ratio of benefits to costs from investing in climate adaptation is in the order of 6 to 1 (Green Analytics Corp., 2020). The sooner investments are made, the greater the benefits will be - for every \$1 spent on adaptation measures today, future indirect and direct benefits amount to \$13-\$15. These benefits derive from a range of sources, connected to where the local risks are greatest and identifying the appropriate interventions, particularly related to flooding and erosion, and protecting buildings, dikes, and roads, as well as investing in protective measures to preserve human health and wellbeing.

The benefits include improvements to the levels of employment, energy costs, improved air and water quality, community livability and wellbeing, and provision of social services. The co-benefits with climate mitigation include reducing the resources involved in recovery from climate events and the associated GHG emissions, as well as making the best use of available infrastructure to integrate risk management and emergency mechanisms during extreme climate events.



As a global community, in Canada, and in Ontario – immediate action against climate change needs to be taken.

As noted, governments across Canada have declared climate emergencies, indicating both the need for, and the action steps towards mitigation of GHG emissions aimed at reducing our impact on climate change. However, even significant efforts to reduce GHG emissions cannot keep changes in climate from unfolding over the next half century. The impacts of climate change will continue to be felt, regardless of emissions reductions.

Therefore, strong action is needed to reduce the impacts resulting from climate change – to adapt to the changing climate – in order to protect critical infrastructure, systems and communities from experiencing catastrophic failures and losses.

Adaptation should be a process fully involving all parties and aspects in society, incorporating Indigenous knowledge and experience alongside other data; and should involve the development and implementation of policies and programs, capital and operational expenditures, research and technological development – all with the goal of reducing impact from the changing climate.

1.3 Ontario's Capacity to Adapt

Within the framework of the PCCIA, the capacity to adapt to current and projected climate risks was explored through an Adaptive Capacity assessment. Adaptive Capacity is a way to measure inherent adaptability in a system, organization, or industry. It can be defined as “the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences”.

This Provincial Climate Change Impact Assessment analyzed five main categories of Adaptive Capacity:

1. Technology
2. Resource Availability
3. Equity
4. Governance
5. Complexity

Technology refers to the availability of technological resources that can build resilience into the systems being assessed. These can include hard technologies (e.g., advanced field irrigation technology, real-time weather monitoring for road conditions, etc.), but can also include practices and planning (e.g., climate change-related best practices) as they relate to expertise in the field, lessons learned databases, best practices implementation, and capacity to innovate. This component was applied to all Areas of Focus and Regions.

Resource Availability relates to an organization, industry, or system's capacity to apply and/or redistribute resources where and when needed. This component includes financial, human, and natural resources. This component will be applied to all Areas of Focus and Regions.

Equity refers to the presence of equally distributed opportunities such as access to healthcare, employment opportunities, distribution of income, and social cohesion. This component was applied only to the People and Communities Area of Focus.

Governance will address how an organization/industry is prepared to adapt for, and respond to, climate change hazards and shocks, including implemented policies, programs, and recognition of climate change. This component was applied to all Areas of Focus.

Complexity relates to the number of stakeholders or decision-makers present in a sector or at a regional level. The capacity to make decisions and change course at the sector or regional level can be inversely correlated to the number of decision-makers/stakeholders. This component was applied to all Areas of Focus and Regions.

This provincial-scale impact assessment assessed Adaptive Capacity within each of the five Areas of Focus and across each of the six regions presented in Figure 1-3.



Figure 1-3: ONTARIO PROVINCIAL CLIMATE CHANGE IMPACT ASSESSMENT REGIONS

The Adaptive Capacity results were used to help guide the identification of areas of research for adaptation best practices. The results are summarized for each Area of Focus in the respective sections of this report, and explained in greater detail in the PCCIA Technical Summary Report.



1.4 Adaptation Best Practices Overview

Adaptation to climate change requires education, cross-sectoral and cross-jurisdictional collaborations, and implementation of measures, strategies, and policies and programs designed to reduce climate risk and resulting impacts.

The term “best practice” often refers to practices that have been shown by research and/or experience to produce optimal results. These practices are suitable for widespread adoption, with appropriate adaptation for local contexts. Climate change is a slow, multi-decadal process, which means that adaptation is a constant journey. Indigenous communities have been adapting to a changing climate for thousands of years; by contrast, climate change adaptation planning in a non-Indigenous context is still considered a young science. The overarching practices in this report therefore highlight the need to integrate Indigenous knowledge and expertise into planning for adaptation, while also developing monitoring and reporting mechanisms to track progress and gather data to enable future evaluation exercises and improvements.

While many adaptation interventions that are designed for North American application are therefore quite recent, there is a significant amount of research, reporting, and adaptation mapping from Canada and internationally that can be capitalized on to mobilize towards action.

For purposes of this report, the included best practices are intended to be considered as a starting point for closer investigation to select locally and contextually appropriate measures to address climate risks, which vary significantly across the Province. It is critical to integrate an equity lens into the selection and design of adaptation actions, taking into account the needs and circumstances of vulnerable populations, and considering intersecting factors such as access to affordable, secure housing community accessibility for people with disabilities, language barriers, state of infrastructure, food and energy security, and disaster preparation for future pandemics or other large-scale challenges.

1.5 Report Methodology

Adaptation best practices were developed through a variety of data capture and review methodologies, including:

- Engagement with subject matter experts with each of the Areas of Focus and Ontario government representatives, through a series of workshops dedicated to each Area of Focus.
- Research and literature review conducted by the consulting team, focusing on adaptation practices that have been implemented, and/or have been researched and peer-reviewed, and drawing on the results of the Adaptive Capacity assessment for each Area of Focus as described in Section 1.3. The full reference list is provided at the end of this document, with over 400 documents cited. These references include peer reviewed journals; government documents; Indigenous community reports and research papers; and non-government and professional association reports, databases, and websites.
- Inclusion of low-risk, high-reward practices identified by subject matter experts for each Area of Focus.



- Review and assimilation of findings from the literature review and workshop feedback, by the consulting team’s subject matter experts for each Area of Focus, who have extensive experience in adaptation planning for communities, organizations, governments and Indigenous Communities. The literature review supported the development of recommended adaptation best practices.
- Peer review of the utility of the report and gaps content by the Peer Review Panel (PRP). A description of the PRP can be found in the Key Terms, Definitions and Acronyms section above.

1.6 How to Read and Interpret this Report

This report identifies adaptation best practices (ABP) as measures that have been implemented (either in Ontario or in other jurisdictions), researched and peer-reviewed, and/or identified by subject matter experts (both through consultation with external participants, and in collaboration with internal consulting team specialists). The lists of adaptation best practices presented in this report were developed based on the resources available, and within the time constraints of the project. Efforts were made to compile as many practices as possible; however, the lists presented herein should not be considered exhaustive.

Intended to be read in conjunction with the Technical Summary Report prepared for the PCCIA, this ABP Report serves as a compendium of adaptation actions as a starting point to consider potential avenues to address the highest risks highlighted through the technical work and risk assessment.

The intended audiences of this report are policy-makers, decision-makers, and technical climate change adaptation practitioners within Ontario. These audiences are positioned to take appropriate action where possible, and to transfer adaptation information to relevant public and private stakeholders, as needed, in support of climate change adaptation in key sectors of the Province (as identified and prioritized in the PCCIA technical and summary reports).

Additionally, the adaptation best practices presented in this report are not specifically recommended for implementation by the Government of Ontario; rather, the lists of best practices are meant as a compendium, or scan of options that practitioners, government organizations, and decision-makers can choose from. Identifying implementation priorities and mechanisms would fall to a more geographically scoped review that includes consultation with affected communities, underlined by local risks and the needs of vulnerable populations.

1.6.1 Presentation of Adaptation Best Practices

Adaptation best practices have been identified by Area of Focus, using the main Level 1 Category of assessment to organize and group the best practices. This report is laid out as follows:

- Section 3.0 presents overarching ABPs, which present opportunities to address multiple risks across multiple Areas of Focus, and/or Cross-Sectoral Themes. This section also documents ABPs related to each of the five Cross-Sectoral Themes that emerged from the PCCIA: Food Security, Water Security, Energy Security, Community Function, and Human Health, Safety and Wellbeing.



- Sections 4.0 to Section 8.0 of this report document ABPs for each of the Areas of Focus: Business and Economy, Food and Agriculture, Infrastructure, Natural Environment, and People and Communities. Readers may find relevant ABPs within the overarching and cross-sectoral sections, and then additional, more specific ABPs within their Area of Focus sections of interest.

Within each section, ABP tables identified as “overarching” include ABPs that are relevant to most/all Level 1 categories of that Area of Focus. Area of Focus sections contain tables of ABPs grouped by category, and may include specific reference to sub- categories.

The ABPs are documented in tabular format. Adaptation best practice table headings and descriptions of information contained in each table are presented in Table 1-1.



Table 1-1: Description of Information Contained In ABP Tables

Type of Adaptation Best Practice	Description of Adaptation Best Practice	Implementation Timeline	Implementation Responsibility and Partners	Reference
<p>Categorization of the ABP, using the following categories:</p> <p>Policy and Regulation</p> <p>Investment and Incentives</p> <p>Research and Development</p> <p>Projects or Programs</p>	<p>The adaptation best practice description, including information for report user review and consideration. There may be hyperlinked to resources and references contained within this content, for access to additional information.</p>	<p>Timeline for implementation: Short (Less than 5 years), Medium (5-10 years) or Long Term (More than 10 years).</p> <p>Timelines have been determined based on urgency of action needed, as well as high level feasibility of implementation. For example, an action may be recommended to be implemented in the short term; however, it may not be feasible to implement within 5 years; in this case, it will be identified as medium term implementation. In addition, some items identified as ‘short term’ may be partially in effect in Ontario.</p>	<p>Description of the decision maker and/or partners that would most likely lead the implementation of the associated ABP, and would be responsible for undertaking the measures identified in the Ontario context.</p> <p>Provincial Government includes ministries and departments within the government.</p> <p>Agencies includes Conservation Authorities, other Provincial bodies, Canadian Federal agencies, and other government entities, for example cross-border authorities in the United States.</p> <p>Municipalities and/or Indigenous Communities refers to municipal governments and Indigenous Peoples.</p> <p>Associations and Non-government includes non-ministerial regulatory and governing bodies, professional associations, and service providers (e.g., conservation authorities, utility companies, etc.), as well as non-governmental community based groups.</p> <p>Private Sector or Individual includes companies and individual citizens.</p> <p>Academia refers to academic institutions.</p>	<p>Additional references. These are references that are not linked to the text in the description of the ABP.</p> <p>The references are provided in a numbered list at the end of this document.</p> <p>While all actions incorporate refinements from Subject Matter Experts, the notation [SME] indicates an action specifically recommended by a Subject Matter Expert as part of the PCCIA project process.</p>



The first column of the ABP tables identifies the category of adaptation best practice into which they have been grouped, as described below. Despite the ABP categorization into one of these four categories, many ABPs can be categorized into several of these groups, and ABPs that fall within these groups are broad and wide-ranging. There is no “one size fits all” solution to climate change adaptation.

- **Policy and Regulation:** A set of policies, regulations or plans used to support decision-making and/or operational regulations.
- **Investment and Incentives:** Investment into existing or new programs, and development of incentive programs and opportunities.
- **Research, Development and Capacity Building:** Primarily focused on expanding knowledge through research and development. These are science-based opportunities and may lead to program development, investments and incentives, or projects.
- **Projects or Programs:** Projects or longer-term programs that support Ontario stakeholders and rights holders in adoption of adaptation measures.

1.7 Implementation and Action Planning Recommendations

The contents of the ABP Report provide a range of actions to support the development of area-specific or sector-specific action plans. Action plans that are timely as well as informed by consultation with affected communities, developed in conjunction with up-to-date data, allow for the allocation of funds towards the adaptation interventions that will most directly address specific risks at a given point in time.

The process of identifying what specific actions should be undertaken is essentially the ‘narrowing’ of the space between the broader universe of potential options/opportunities, constrained by what is possible based on available resources and technology, and guided by the need to mitigate climate risk and impacts to the most vulnerable areas and communities (Chambwera et al., 2014).

There may be situations in which full adaptation is not possible, due to technology or resource constraints. In such situations, it is important to consider the ‘residual impacts’ of climate change and identify ways to address these through integrated approaches with the community and those affected (Chambwera et al., 2014).

Key Steps in Developing an Implementation Plan

The following are the key steps in developing an adaptation implementation or action plan:

1. **Assess and build institutional Adaptive Capacity:** Work with regional and local agencies, as well as Indigenous rights holders and stakeholders to understand where capacity shortfalls might exist (related to resources, technology, etc.), and develop ways to address these in advance or in tandem with developing an action plan.
2. **Engage with Indigenous rights-holders, community members and groups, and stakeholders:** Build relationships and recognize work that has already been done, engage those taking action and who have built up networks and foundations in climate action, and meaningfully integrate Indigenous traditional knowledge.



3. Map and prioritize climate risks based on the local context: Leverage data to visualize how climate hazards will impact various areas in a community, consider where key infrastructure, community assets, and vulnerable populations are located geographically relative to their exposure to climate risks such as flooding, areas with increased heat island effect, etc.
4. Define targeted actions with a specific timeframe for implementation: Utilize economic and social analysis tools to define the extent to which prioritized climate risks can be mitigated through adaptation, mapping these out with clear allocation of roles and responsibilities of government and all involved groups.
5. Implement the identified actions: Implement adaptation actions and interventions, putting in place processes to collect data on the effectiveness of the actions.
6. Monitor and report on progress, continually assess emerging priorities: Recognize that adaptation is a dynamic process that needs to respond on an ongoing basis to emerging priorities and changing conditions, and develop mechanisms to monitor and report on progress using the data collected in the implementation phase, and through clear indicators for success.
7. Share knowledge and lessons learned: Throughout the implementation process, seek and leverage ways to share knowledge, engage in storytelling, and allow for the integration of lessons learned to inform future steps.



2.0 Adaptation Best Practices: Overarching Principles

Effective action on climate change adaptation is complex, and requires coordinated efforts across governments, individuals, and businesses. The World Bank's Guide for Designing Strategies for Climate Change Adaptation and Resilience (Hallegatte et al., 2020) offers a high-level perspective of climate change adaptation and universal guiding principles that can direct adaptation practice. The guide's six guiding principles for climate change adaptation, corresponding to common policy domains, include:

- Ensure resilient foundations through rapid and inclusive development.
- Facilitate the adaptation of businesses and people.
- Adapt land use patterns and protect critical public assets and services.
- Increase people's capacity to cope with and recover from shocks.
- Anticipate and manage macroeconomic and fiscal risks.
- Ensure effective implementation through prioritization and continuous monitoring.

Similarly, the United Nations Convention on Climate Change (UNFCCC) developed guiding principles on the basis of national-level adaptation planning, which can be scaled to Provincial-level planning as well:

- Follow a gender-sensitive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems.
- Be based on and guided by the best available science and traditional and Indigenous knowledge.
- Not be prescriptive, nor result in the duplication of efforts.

Additional guidance can be drawn from the mission of the Ready2Respond emergency preparedness document from the World Bank (2017), including:

- Protect public safety, a core responsibility of government, including through sound emergency preparedness and response planning.
- Build institutional capacity, through information sharing within and across governments, private sector, and others.

Climate change disproportionately impacts specific populations, such as people with disabilities, older adults and young children, those engaged in outdoor occupations, unhoused or inadequately housed populations, and low-income populations. And many significant social and health costs of climate change can be difficult to measure. While the adaptation practices identified in this report cover a broad range of sectors, it is important to integrate an equity lens into adaptation planning. The PCCIA recognizes that unequal effects of climate change and the potential impacts of any implementation action on vulnerable populations must be central to decision-making.

Lastly, it is important to consider the implications of maladaptation when developing adaptation plans. According to the IPCC, maladaptation is an unintended consequence of adaptation, referring to actions that may lead to increased risk of adverse climate-related outcomes (such as increased GHG emissions); increased or shifted vulnerability to climate change; exacerbated inequity; and/or diminished welfare, now or in the future.



The concept of maladaptation has thus far received little attention in the literature, and generally accepted mechanisms to avoid maladaptation are undeveloped. However, a recent study published in *Environmental Sociology* (Bertana et al., 2022), identifies four key structural challenges that contribute to maladaptation that, if understood, can be used to avoid it. The challenges faced by adaptation practitioners that can cause maladaptation include:

- Focus on technological fixes versus holistic approaches;
- Difficulty of distinguishing the difference between adaptation and development;
- Difficult in quantifying unquantifiable metrics and thus using inaccurate indicators to measure success; and
- Competing challenges that lead to adaptation not being prioritized.

Consideration of maladaptation demonstrates that when adaptation is implemented to address only the impacts of climate change, rather than the underlying drivers of what makes people vulnerable to climate change in the first place (e.g., gender inequity, marginalization, and other power inequalities), it may not be effective (Schipper, 2022).

The following section (Section 3.0) presents a series of Overarching and Cross-Sectoral Adaptation Best Practices that can support broad climate resiliency across multiple areas of action in Ontario. The sections that follow (Sections 4.0 through Section 8.0) present adaptation actions for consideration organized based on the five Areas of Focus in the PCCIA.



3.0 Overarching and Cross-Sectoral Adaptation Practices

Climate change impacts occur against the backdrop of complex and dynamic social and ecological systems, and can cause cascading and compounding effects, depending on the exposure and Adaptive Capacity of systems. Adaptation actions that cover overarching and cross-sectoral themes have the capacity to address a wider range of potential risks, and can align the Province with a greater capacity to adapt to climate change.

3.1 Overarching Adaptation Best Practices

The following overarching adaptation best practices were selected to highlight key areas for action that cover a wide range of potential risks and are relevant to multiple Areas of Focus.

Table 3-1: Overarching Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation Projects or Programs	<p>Apply a climate lens to government decision-making</p> <p>Develop strategies to improve coordination between municipal and provincial planning, in collaboration with municipal governments. This would support consistent ways for decision-making, planning, and policy at all levels to factor climate change impacts into infrastructure, people, businesses, the natural environment, and assess the associated medium to long term implications. For example, considering impacts to the natural environment, identify and implement strategies to strengthen natural environment organizations and facilitate their participation in provincial dialogue and decision-making as well as integrating natural environment adaptation considerations into land use planning processes and mechanisms.</p>	Short Term	Provincial Government, Municipalities, Agencies	[1] [2] [3] [4] [5]
2	Investment and Incentives Projects or Programs	<p>Develop programs and enhance policies that support Nature-Based Solutions and increase protection of green spaces and green infrastructure</p> <p>Leverage federal funding, where available, and support the advancement and de-risking of Nature-Based Solutions (NBS) as a priority and general practice in infrastructure projects and adaptation planning. Ontario Nature’s Nature Reserve Program is an example of NBS, with 26 nature reserves across the province, with conservation supported by local volunteers.</p> <p>Nature-Based Solutions (NBS) can enhance protection and restoration of natural ecosystems, contribute to sustainable management of lands and resources, and provide mental health and well-being benefits to communities. Current NBS practices are ad-hoc and underfunded, and would benefit from a more coordinated approach across the province.</p>	Short Term	Provincial Government	[6] [7] [319]
3	Projects or Programs	<p>Facilitate access to relevant climate and hydrological data</p> <p>Facilitate the provision and accessibility of updated climate observations (e.g., temperature, precipitation, sea level rise, solar radiation, wind) and hydrological observations (e.g., soil moisture, groundwater, runoff, evaporation, and flooding). Consider developing sector-specific portals of information, to support a variety of industries and regions and support understanding and application of existing data such as that available through climatedata.ca, which is categorized by sector. Include both historical and projected climate data as sources of information.</p> <p>While access to climate data has become more widespread, caution and climatological expertise would be needed to apply quality control and support interpretation of some data and trends, particularly when considering climate extremes. Otherwise, the risks from misinterpretation and subsequent maladaptation could be significant. Efforts are needed to amalgamate the Environment and Climate Change Canada official climate archive with other provincial climate data holdings (e.g. snow course, MTO RWIS, Air Quality, etc.).</p> <p>Provide climate/hydrological observation and projection datasets in a temporal and spatial resolution that are relevant to business decision-making if possible, respecting the limitations of both the historical data and the climate projections (e.g., hourly/daily data, near term timescales and spatial resolution of 50 km or less), and in a business-friendly format (e.g., in the form of indices avoiding the need for data manipulation).</p> <p>Data provision can also include potential climate impacts related to projections, such as flood risk maps, surface/ground water hydrographs, fire risk maps, land use maps and rainfall intensity-duration-frequency (IDF) curves. An example of a tool tailored to businesses is the India Water Tool, co-sponsored by the World Resources Institute based in Washington, DC. The 2019 Guide, "CSA PLUS 4013:19 on Development, Interpretation and Use of Rainfall IDF Information: Guideline for Canadian Water Resources Practitioners", includes guidance on the realistic interpretation of IDF calculations and updated climate change science and tools for projections into the future climate. Climatological expertise is recommended when using and interpreting projected future precipitation extremes.</p>	Short Term	Provincial Government, Private Sector or Individual, Academia	[8] [9] [10] [11] [12] [13]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Projects or Programs	<p>Review and implement flood risk strategies in high-risk areas</p> <p>Implement flood risk strategies (including programs and policies) and adaptation measures in high-risk areas. The Intact Centre's 'Under One Umbrella: Practical Approaches for Reducing Flood Risks in Canada' and 'Water on the Rise: Protecting Canadian Homes from the Growing Threat of Flooding' are guidance documents that offer practical adaptation solutions to urban flooding.</p> <p>International examples of flood risk strategies through green infrastructure and technology include:</p> <ul style="list-style-type: none"> Germany: allow flood insurance to be offered to home and commercial owners (split responsibility between government and insurance companies). Korea: develop a flood alert application, such as that used in the Mushim Stream watershed which can help communities avoid loss of life and property. The application is called HEC-HMS (Hydrologic Engineering Center's Hydrologic Modeling System), and provides forecasts with sufficient lead time to help communities cope with flood events. <p>Denmark: allocate retention areas for high volumes of water (e.g., parks become temporary pond areas), and develop "green roads" to retain and hold back water in smaller streets.</p>	Short to Long Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government	[14] [15] [16]
5	Research and Development Investment and Incentives	<p>Integrate monitoring and evaluation of adaptation planning</p> <p>Develop key performance indicators for different climate change adaptation initiatives and make these publicly available. For example, Wilfrid Laurier University has a partnership with the Government of the Northwest Territories, providing research on boreal forest dynamics including water flux and carbon cycling, land changes due to permafrost thaw and forest fires, mapping and biomonitoring, as well as infrastructure monitoring and development and tourism studies (related to the management of human activities on the land). Research projects also include topics related to local food security, and local climate change adaptation planning.</p> <p>Monitor and evaluate implemented climate change adaptation measures as well as new or innovative approaches, to de-risk efforts by demonstrating the value of a particular approach and encouraging replication. As part of monitoring and evaluation of adaptation plans, document current conditions to establish an existing baseline relevant to the scope or area of planning for adaptation, followed by social, environmental, and economic monitoring to measure changes from baseline conditions. Partnerships with research institutions and programs can be leveraged to support monitoring and evaluation efforts.</p>	Medium Term	Provincial Government, Private Sector or Individual, Academia	[17]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Policy and Regulation Investment and Incentives Projects or Programs	<p>Embed climate risk in land use planning and policy</p> <p>Integrate climate change risk and vulnerability considerations into land use planning and policy more systematically across the province. Effective land use planning and land designation can identify specific areas of high vulnerability to climate impacts, such as flooding. Ontario has historically been successful in flood management, with conservation authorities mapping out and prohibiting construction in flood zones after Hurricane Hazel (see also Brown (1997) for a comparison of Michigan and Ontario flood costs from the same set of events). However more can be done to incorporate a climate change lens.</p> <p>Ontario's Flooding Strategy states that flooding along Ontario's rivers, lakes and streams can occur at any time of the year and there is concern that the likelihood of extreme weather and flooding will increase with a changing climate. The Flooding Strategy provides priorities and actions that could be followed by decision makers to mitigate flooding. The Provincial Government of Ontario could consider adding a climate change lens to the evaluation criteria to ensure spending from Ontario Community Environment Fund prioritizes projects with greatest mitigation impact(s) to existing communities and Ontario Community Infrastructure Fund investment is directed by municipalities in alignment with climate resiliency considerations in the municipal asset management regulation. Further, municipalities with the assistance of conservation authorities may deploy advanced computational modeling to determine most vulnerable areas to climate change.</p> <p>Additional steps could include:</p> <ul style="list-style-type: none"> • Identify vulnerable areas to be reflected in land use documents (i.e. Official Plan and Secondary Plans) with specific policies to address identified risks. An example would be a requirement for enhanced stormwater infiltration for proposed development in an identified special-policy areas known for flooding or heat island effect. • Integrate sustainability criteria into evaluation of proposed developments at the development review stage, based on incorporating climate change adaptation measures (e.g. connectivity, proximity, stormwater management measures, landscaping). • Develop guidance for municipalities on climate risk reduction tactics particularly for vulnerable populations that can be integrated into existing policy tools such as Community Improvement Plans, which can be used to incentives the private sector to undertake 'green' retrofits to existing structures or to offset some capital costs associated with installing 'green' infrastructure (e.g. green roofs, geothermal heat pumps, electrical vehicle charging stations, etc.). Municipalities may also set out the criteria for grants under Community Improvement Plans to better support the creation of a climate resilient community. 	Short to Medium Term	Provincial Government, Municipalities, Private Sector or Individual	[23] [24] [25] [326] [327] [328] [341]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	Projects or Programs	<p>Adopt Nature Based Solutions</p> <p>Use nature-based solutions to address climate change by harnessing the earth’s natural processes to mitigate and address the challenges that a changing climate presents. As an alternative to “hard” engineering such as dikes to prevent flooding or engineered covered areas for shade, identify ways to integrate natural or ‘green’ infrastructure that bring co-benefits to the natural environment and species biodiversity alongside mitigating climate risks. In the context of Urban Ontario, solutions such as urban forestry and nature-based stormwater management can be two methods to work with nature to restore urban settings.</p> <p>Urban tree cover helps considerably reduce urban heat islands, especially while shading large swaths of asphalt. They also help reduce noise pollution, improve wildlife habitat, increase property value, and citizen well-being. Some municipalities such as Ottawa have also mentioned in climate change reports that the carbon sequestration of trees also provides a significant benefit in the context of reducing global carbon emissions.</p> <p>Stormwater management techniques such as using porous concrete can help distribute rainwater in soil more efficiently, and replenish urban water tables. Use of grasses in drainage ditches or rain gardens also help reduce pressures on drainage systems and helps increase water quality and the quantity of water kept in water tables. Some grasses, herbs and flowers themselves can sequester carbon in their roots and increase soil quality through nitrogen fixation.</p> <p>In more rural settings there are also different opportunities to use nature based solutions. For example, the use of native plants to stabilize eroding river shorelines, can be extremely effective and cost much less than “hard engineering” options. Some remote communities have experimented with growing produce such as potatoes in fire breaks to ensure that vegetation does not overgrow, while also contributing towards increased food security.</p>	Medium Term	Provincial Government, Agencies, Municipalities	[335] [336] [337] [338]
8	Research and Development	<p>Leverage larger city-based resiliency networks in Canada and internationally</p> <p>Provide more opportunities for knowledge sharing and transfer through networks of like-minded organizations. For example, Making Communities Resilient 2030 is an initiative guided by the United Nations Office for Disaster Risk Reduction (UNDRR) to ensure that cities are well equipped to deal with and manage disasters. The initiative has Ten Essentials to follow, most of them relate to planning and resiliency through design. Cities, Provinces and Territories, as well as select agencies are eligible to sign up as MCR2030 member cities, where they can share progress and create connections with cities who have been involved in resiliency work on a global scale.</p>	Short to Medium Term	Provincial Government, Municipalities, Agencies	[394]
9	Projects or Programs	<p>Develop a suite of decision-support tools for climate change adaptation</p> <p>Develop a suite of decision-support tools that help organizations, governments, and communities understand and assess their climate change risks and opportunities, and/or identify and select adaptation actions related to specific sectoral and geographic needs. This can include tools, resources and training opportunities to generate cost-benefit analyses of various adaptation options, sector-specific diversification strategies to adapt to climate change, trends in operational performance and/or demand for climate-sensitive products or services (e.g., trends in crop productivity vs. trends in climate), and sector-specific information about geographical vulnerabilities to climate change (e.g., hazard maps).</p> <p>The Climate Atlas of Canada would be an integral item in such a toolbox, as it is an interactive tool developed for climate change adaptation for application in planning specific to Canada. The tool combines climate science, mapping and storytelling to bring the global issue of climate change closer to home, and is designed to inspire local, regional, and national action and solutions.</p>	Short to Medium Term	Provincial Government	[290]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
10	Policy and Regulation	<p>Apply an equity lens to all climate change adaptation planning</p> <p>Draw on existing frameworks and approaches to integrating an equity lens into climate adaptation, recognizing that climate change impacts are not experienced equally by all and that there is significant potential for health, social, and economic impacts to increase disparities in communities. Consider appropriate indicators and ways to ensure that equity is centered with respect to local context and evidence based approaches that integrate local community knowledge, subject matter expertise, lessons learned.</p> <p>Examples of equity based adaptation approaches and tools that can serve as a starting point include:</p> <ul style="list-style-type: none"> • The New Westminster Climate Equity Framework (2021) (https://sustain.ubc.ca/sites/default/files/2021-036_A%20Climate%20Equity%20Framework%20for_Tlhotlhalemaje.pdf), that considers climate and environment indicators as well as built environment and mobility indicators including housing and transportation elements, and recognizes the importance of health, identity, and demographic dimensions related to assessing vulnerability of different populations within the community. • The California Governor's Office of Planning and Research 2018 Report on Defining Vulnerable Communities in the Context of Climate Change (https://opr.ca.gov/climate/docs/20200720-Vulnerable_Communities.pdf), as well as the Resiliency Guidebook Equity Checklist (https://opr.ca.gov/docs/20180312-Equity_Checklist.pdf) which provide guidance on the important questions related to equity considerations and appropriate indicators for assessing vulnerability to climate change at the community level. 	Short to Medium Term	Provincial Government, Municipalities, Associations and Non-Government, Private Sector or Individual, Academia	[371] [372] [373]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
11	Policy and Regulation	<p>Apply an Indigenous lens to all climate change adaptation planning</p> <p>In recognition of the need to support Indigenous self-determination and strengthen Indigenous-led planning, draw on existing resources and work with Indigenous Elders and knowledge-keepers to apply a decision-making approach that places Indigenous community members in leadership positions and allows for diverse viewpoints and knowledge systems to be integrated, reflecting the diversity of Indigenous Nations and advancing climate-solutions that are interconnected, interdependent, and multi-dimensional (Reed et al., 2021).</p> <p>Examples of adaptation approaches that center Indigenous perspectives include:</p> <ul style="list-style-type: none"> • The 'Indigenous Lens on Climate Change Adaptation' module (2020) developed by Kerry Ann Charles-Norris for a project collaboration between the Public Health Agency of Canada, Ontario Region (PHAC), the Simcoe Muskoka District Health Unit (SMDHU) and Cambium Indigenous Professional Services (CIPS). This document provides an overview of key elements in applying Indigenous perspectives to climate change adaptation, specifically Two Eyed Seeing and Seven Grandfather teachings. • UpNorth on Climate: Climate Change Impact and Adaptation for the North of Ontario and the adaptation resources it developed with Indigenous communities. • The One Health approach, a framework that can be used as the foundation for responding to climate change in policy and planning in a holistic and interconnected way, as it relates to the health of people, animals, and ecosystems. The World Health Organization defines One Health as an approach to “designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes”, considering the planet’s most complex animal, human and environmental health problems. Climate change is a considerable health problem that is affecting all life on the planet, and is closely interconnected with the health and wellbeing of people and the environment. The One Health approach closely aligns with Indigenous approaches to wellness, and allows for integration of Indigenous knowledge into climate change related planning. The four guiding principles of this approach are: <ul style="list-style-type: none"> ○ Recognize that infectious diseases are very much interconnected with climate change, as are livestock vitality and availability of other food sources, and incorporate this perspective into broader public health planning; ○ Facilitate understanding of risk interconnectivity on climate change and One Health (e.g., impacts from poor air quality and extreme weather events); ○ Promote open science and international partnerships (to support data sharing); and ○ Enhance multi-stakeholder partnerships (to coordinate action). <p>The University of Guelph’s One Health Institute uses this approach in research of pressing issues, including community water quality, food security, vector-borne diseases and pollinator health. Research outcomes could be considered in policy and planning using the One Health approach.</p>	Short to Medium Term	Provincial Government, Municipalities, Associations and Non-Government, Private Sector or Individual, Academia	[374] [375] [444]



3.2 Cross-sectoral Adaptation Best Practices

Within the context of the PCCIA, cross-sectoral impacts are defined as climate change impacts that span multiple Areas of Focus. The five Cross-Sectoral Themes identified within the PCCIA are:

- Water Security
- Energy Security
- Food Security
- Community Function
- Human Health, Safety and Well-being

Adaptation best practices are presented in the sections below, for each of the cross-sectoral themes.

3.3 Water Security

Ensuring access to adequate quantities and acceptable quality of water is key for sustaining human well-being and socio-economic development, ensuring protection against water-borne pollution and water-related disasters. Preserving the functionality of natural ecosystems plays a vital role in maintaining water security. The impacts of climate change on water resources will manifest within each of the Areas of Focus as disruptions and changes in:

- **Water transmission:** The transport of water from water body sources to municipal storage facilities and/or to distribution networks to the point of use, which takes place through water transmission pipelines.
- **Water treatment:** Any process that involves physical, chemical, physicochemical, and/or biological operations to eliminate and/or reduce contamination or non-desirable characteristics of water to make it appropriate for a specific end-use.
- **Water storage:** Holding water in a contained natural or artificial area for a period of time for later use for a variety of purposes.
- **Water distribution:** Provision of uninterrupted supply of water from a central location to a location of end-use.
- **Water use:** Public and private use of water, including withdrawn water for a variety of household, commercial, and industrial purposes/activities without returning it to the source.
- **Source Water quality:** Protection of raw drinking water sources and management of any contamination sources, including through stormwater management infrastructure, waste management, and other activities, for instance road salt impacts which have knock-on effects for aquatic life and ecosystems and human health. The Clean Water Act, 2006 recognizes/defines the drinking water quality risks of road salt activities and requires policies to manage their significant risks in the local source protection plans.

This section lists adaptation best practices applicable to water security in Ontario. Additional practices related to consideration of flooding risks and broader adaptation practices that relate to water are included in Overarching Adaptation Best Practices in Section 3.1.

Table 3-2: Water Security Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Collaborate and simplify water data capture and sharing among jurisdictions in Ontario (and beyond)</p> <p>Collaborate with municipalities, the Ontario government, and the Federal government to develop monitoring and data sharing tools and a centralized system to support decision-making and climate adaptation planning. Nationally, The Water Survey of Canada collects, interprets and disseminates standardized water resource data and information in Canada. This is in partnership with the provinces, territories and other agencies. In Ontario, provincial level data is handled by the Surface Water Monitoring Centre. The Surface Water Monitoring Centre monitors and collects data, as well as analyzes and forecast water levels for dissemination of timely messages to partners. The Centre also provides access to tools and maps, for information on flood or low water risks. Data feeds into local communication efforts by ministry district offices and conservation authorities to increase awareness and public safety.</p> <p>Water data can often difficult to amalgamate because it can be collected by many different sources, leaving the true picture fractured. In the United States of America, the U.S. Department of Energy's Water Power Technologies Office began a project to collect and categorize this data in one place to "describe the current state of accessing, using, and visualizing water data" and to "outline investigative pathways for future efforts aimed at improving the discovery, sharing, and use of water data." This yielded the identification of 14 broad categories of water data: dams; ecology; flood control; hydro climatology; hydrography; hydrology; hydropower; management landscape; migratory barriers; recreation and aesthetic importance; socioeconomic; water quality; water availability and use; weather.</p> <p>A similar approach in Canada could be beneficial in broadening the amount of accessible water data and keeping the data on a centralized platform. Simplifying water-related communications between industries, and potentially even between provinces. If developed, this information should be easily digestible and made accessible to the public.</p>	Short Term	Provincial Government, Agencies, Municipalities, Associations and Non-Government, Private Sector or Individual	[28] [354] [355] [355]
2	Projects or Programs	<p>Further develop a provincial monitoring program for drought impacts across the Province</p> <p>Enhance Ontario's Low Water Response program to provide additional monitoring for drought impacts across the Province. The Canada Drought Outlook (https://agriculture.canada.ca/en/agricultural-production/weather/canadian-drought-monitor) provides regional-level predictions for drought conditions with a 30-day future horizon; this tool could be used as the basis for an Ontario-specific drought forecasting application.</p> <p>Drought can reduce both the quantity and quality of water, which has ecological, financial, and social consequence. Consistent monitoring of water quantity and quality can better inform decision-making and planning, both reactive and future proactive action against drought impacts. Indigenous knowledge should play a role in this program. The ability to forecast drought conditions provides insight into drought risk and supports related risk management, particularly with respect to farm resilience and potential impacts to the biophysical environment, such as changes to nutrient concentrations in water bodies as a result of water quantity and the corresponding risk of contamination to soils, as well as planning to manage potential erosion and surface runoff in a heavy rain event that occurs immediately following a drought period.</p>	Short Term	Provincial Government, Agencies, Municipalities, Associations and Non-Government	[29]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Investment and Incentives	<p>Develop water storage investment programs</p> <p>Consider water storage projects, such as boosting the storage abilities of existing reservoirs, flood control, ecosystem improvement, water quality improvement, and emergency response that would directly address water security concerns in specific areas of the province.</p> <p>Guidance could be drawn from California’s Water Storage Investment Program (WSIP), which funds water storage projects across the state. Projects must meet the criteria of improve the operation of the state’s water system, be cost effective, and provide a net improvement in ecosystem and water quality conditions in the Sacramento-San Joaquin Delta to be eligible for WSIP funding.</p> <p>The public benefits from this funding can include water quality improvements, flood control benefits, emergency response, recreational opportunities, and ecosystem benefits. At least 50 percent of the total public benefits funded for a project must provide ecosystem improvements. These improvements would also be beneficial in the Ontario context.</p>	Medium Term	Provincial Government, Agencies	[30] [358]
4	Policy and Regulation	<p>Develop a collaborative approach to water policy development across borders</p> <p>Develop and strengthen cross-border water policy, given that Ontario shares its Great Lakes with other provinces and the United States. Policy generation should include Indigenous representation, in addition to other stakeholders.</p> <p>Examples of such collaborations include:</p> <ul style="list-style-type: none"> • The Ontario-Quebec Committee on Water Management, announced in 2015, which provided an opportunity for knowledge sharing and facilitation between the two provinces on water management issues for the great lakes and the St. Lawrence River. A new/updated version of this mandate is needed in the face of climate change, as is a similar agreement with Manitoba. On the international front, another example of coordination is seen in the Great Lakes Water Quality Agreement (GLWQA) between Canada and the US. This agreement explicitly states climate change as a threat in its provisions. • The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, which includes provisions specific to climate change (e.g., assessment) • The Lake of the Woods international watershed that borders Ontario, Manitoba and Minnesota, an International Joint Commission that also has a dedicated study board and publishes reports and performance indicators that include monitoring of climate change impacts. 	Medium Term	Provincial Government, Agencies	[31] [32] [33] [408]
5	Policy and Regulation Projects or Programs	<p>Create a provincial governing body to represent water management in Ontario</p> <p>Consider establishing a central body or department that could act as a resource and consultation venue for general and adaptation-specific discussions related to water in Ontario (including policy and legislation, natural resource management practices, education and knowledge sharing, etc.). A centralized water governance body could consider both water quantity and water quality, and manage water legislation with a central focus. Features of this governing body would include strong Indigenous representation, and opportunities for public review and input, where feasible.</p> <p>If the development of a centralized water governance body is not considered, create a hub or information and knowledge sharing platform to facilitate collaboration among different levels of government with respect to water management across the province. This will help to reduce potential overlap and duplication of efforts, and maintain up-to-date and accessible resources.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities	[34] [35]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Projects or Programs	<p>Develop and implement an integrated water management framework/strategy for the Province</p> <p>Develop and implement an integrated strategy for water management that would consider both water quality and water quantity, and address the needs of both elements within a single framework. For example, Conservation Ontario's 'Integrated Watershed Management – Navigating Ontario's Future – A Summary Report' discusses the need for integrated watershed management, identifies a framework for Ontario and provides an update on implementation of the framework across Conservation Authorities and in partnership with the Province.</p> <p>Another example is from the U.S. state of Oregon's Integrated Water Resources Strategy which incorporates water quantity, quality, and ecosystem needs. The purpose of the strategy is "bring various sectors and interests together to work toward the common purpose of maintaining healthy water resources to meet the needs of Oregonians and Oregon's environment for generations to come."</p>	Medium Term	Provincial Government	[36] [37]
7	Research and Development Projects or Programs Policy and Regulation	<p>Explore and apply recommended practices for managed aquifer recharge</p> <p>Conduct additional research and collaborate with municipal partners and conservation authorities to implement managed aquifer recharge more broadly across the province, a practice which refers to the planned recharge of aquifers, by taking excess surface water and storing it in an aquifer for future use. Some municipalities in Ontario have seen benefits with this practice, with increasing evidence of benefits for groundwater recharge.</p>	Short to Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[410] [411]
8	Projects or Programs	<p>Implement Policy Changes laid out in the Update of Ontario's Water Quantity Management Framework</p> <p>Implement the enhancements to Ontario's Water Quantity Management Framework as per the Province's 2021 recommendations. The process looked to increase the sustainability of the water supply by reviewing water taking policies.</p> <p>The regulatory amendments which have been approved provide an improved framework for water taking. The findings led to regulatory changes which look to increase transparency with the public surrounding water management, as well as establish priorities of water use which would be considered in water taking decisions and updated rules to reflect management challenges in high use watersheds. Legislatively, water bottling companies must have support from their local host municipality for a new or increased groundwater taking. There is therefore a responsibility for local governments to become more involved in water taking discussions and work to implement water quantity sustainability.</p>	Short Term	Municipalities, Private Sector or Individual	[395]



3.4 Energy Security

Energy security includes many elements, but can be characterized as the degree to which Ontarians have consistent access to sufficient quantities of reliable, affordable energy. Factors influencing energy security include both inputs (e.g., energy sources and generation) and outputs (e.g., distribution and consumption) in line with economic development and environmental needs. At its simplest, energy security is associated with securing reliable energy supply, including energy infrastructure, intensity, diversification, market transparency, and links with the environment and political decisions. Energy systems underpin energy security, and are comprised of the following activities that span across all Areas of Focus:

- **Energy supply:** Various energy resources that comprise Ontario's energy mix: nuclear, hydroelectricity, wind, solar, natural gas, and biomass.
- **Energy generation:** The process of generating power and electricity from sources of primary energy, including various generation facilities and their supporting energy infrastructure.
- **Energy transmission and distribution:** Any distribution technology and infrastructure, such as transmission and distribution lines, pipelines, freight, and other forms of energy transport.
- **Energy use:** Supporting infrastructure to bring energy products to market and the end use of energy in any technology, service, manufacturing, transportation, or any other form relying on energy such as inhabiting a building.

Table 3-3 lists adaptation best practices applicable to the energy system, and ultimately energy security, in Ontario.

Table 3-3: Energy Security Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs Policy and Regulation Investment and Incentives	<p>Build capacity for energy resiliency planning</p> <p>Develop and implement programs and guides to support broad capacity building in the energy sector, to support clear understanding of climate change risks, consideration of system vulnerabilities, and ways to incorporate these elements into asset management and planning.</p> <p>A key early step in achieving climate resilience is understanding the risks being faced. At the same time, and especially given the critical nature of reliable energy supply for all parts of society and economy, it is important to characterize uncertainty, including both known and unknown potential outcomes. A 2017 report commissioned by NRCan suggests that a lack of information and guidance is a key barrier to adaptation in the infrastructure sector. The following actions would support building adaptation capacity to respond to climate impacts in the energy sector:</p> <ul style="list-style-type: none"> • Implement a program similar to ICLEI’s Advancing Adaptation Project to help build knowledge and capacity on risk assessment, adaptation planning, and adaptation implementation within the energy sector (and in other sectors). An older version of this program worked with 18 municipalities across Ontario to conduct 24 community climate change vulnerability and risk assessment workshops. • Support the development of guides on how to incorporate climate change into risk management and asset planning, for example building on the adaptation guides prepared by the Canadian Electricity Association (CEA). • Develop or support the development of working groups including utilities, regulators, government officials, and experts to share information and case studies related to adaptation actions in the energy sector. • Develop or support the development of a Canadian or Ontario-specific database of adaptation initiatives with detailed information as to what the costs of implementation were, and what the outcomes were. For example, Canada has its Map of Adaptation Actions - the further development of this resource to include more case studies and more detailed case studies would be beneficial across multiple sectors. • Introduce and/or strengthen climate adaptation into regulation for the energy sector, to handle disruptions and impacts from major climate events (both acute and slow onset). <p>Utility companies can take a leadership role, with direct support from governments through incentives and/or regulations. The ‘From reliability to resilience: Confronting the challenges of extreme weather study’ (Accenture, 2017) report looked at utility providers around the world, and their levels of preparedness for extreme events. The document provides guidance for development of effective adaptation/resilience strategies within the utility sector. Recommendations include developing customer notification system (pre-event and during event restoration timelines), increased inspection frequency and access supported by technology (e.g., drones).</p> <p>Having a standard framework for assessing climate change impacts and adaptation actions would improve the ability of agencies and utilities to act on climate change. In addition, standardizing frameworks would promote transparency and interpretability of climate change impact modeling and assessments of financial risk.</p>	Short to Medium Term	Provincial Government, Agencies, Associations and Non-Government	[43] [412] [413] [414]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
2	Projects or Programs	<p>Apply an equity lens to policy decisions in the energy sector</p> <p>Ensure that an equity lens be applied to policy decisions and proposed adaptation actions for climate change, and develop support programs and regulatory lens development to ensure costs borne from adaptation actions do not unfairly impact vulnerable populations . The effects of climate change are expected to be disproportionately felt by vulnerable populations. Adapting to climate change will result in costs that may be passed on to consumers. It is important that programs be put in place to ensure that these costs do not unfairly affect those already in vulnerable situations. See for example a recent article from ICF on energy affordability and integrated utility strategies.</p> <p>For example, the City of Ottawa published an Equity & Inclusion Lens Handbook to provide guidance on consistently and coherently considering equity in municipal decision-making. The City of Toronto’s Resilience Strategy emphasizes the connection between inequality and climate impacts and discusses their own climate lens.</p>	Short to Medium Term	Provincial Government, Agencies, Associations and Non-Government	[415] [416] [417]
3	Policy and Regulation	<p>Develop policies and/or regulations to embed climate change resiliency in long-term infrastructure and energy planning</p> <p>Develop policies and regulations to align with the Ontario Energy Board (OEB) updated filing requirements for electricity distributors, which as of 2018 include an expectation that Local Distribution Companies report on climate adaptation as part of planning and risk management. The OEB has clarified that “changes in reliability performance, due to the impacts of climate change, are expected to prompt utilities to consider whether new investment or operational strategies are warranted” (OEB Implementation Plan, 2018). Effective implementation of this type of policy is likely to require additional guidance to allow utilities to evaluate cost-effective methods of integrating climate change adaptation into their planning and operations, as articulated in the Ministry of Energy’s 2017 Long Term Energy Plan.</p>	Short to Medium Term	Provincial Government, Agencies, Associations and Non-Government	[418] [419]
4	Policy and Regulation	<p>Develop regulatory mechanisms for climate adaptation funding</p> <p>Develop and implement regulatory changes that support sector organizations and utilities to direct funds towards proactive climate change adaptation actions. Significant research suggests that over time, implementing adaptation actions results in avoided costs when compared to a scenario without adaptation. The financial impacts of not adapting to climate change should be integrated into decision making, based on an evaluation of the direct and indirect costs.</p> <p>The Canadian Electricity Association has provided guidance for utility providers in its 2016 report entitled ‘Adapting to Climate Change: State of Play and Recommendations for the Electricity Sector in Canada’, which outlines both high probability and low probability scenarios and opportunities to integrate climate adaptation into investment planning. The report also offers some exploration of indirect costs in the form of health, mortality, ecosystem, and economic costs, which would be meaningful to further investigate in the Ontario context to support provincial policy for the energy sector.</p>	Short to Medium Term	Provincial Government, Agencies, Associations and Non-Government	[420]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Research and Development	<p>Convene subject matter experts to focus on critical infrastructure interdependence</p> <p>Bring together experts from different sectors, provincial and municipal governments through a working group or other collaborative arrangement, to encourage the identification of synergies and key areas in which sectors can work together to prioritize actions and prepare systemic solutions for critical infrastructure resilience. A system-wide lens is needed towards the identification of “fail-safe” and “safe-to-fail” infrastructure configurations. Fail-safe systems are built to a standard that reduces their risk of failure (e.g., increasing the tolerance to ice-loading makes an electricity line more fail-safe). Safe-to-fail systems are built to reduce consequences and promote quick recovery following a failure (e.g., ensuring ample capacity for heating and cooling centres that can operate during a power outage due to extreme weather events means much reduced consequence of a local or widespread electricity system outage).</p> <p>For example, North Bay’s Community Energy Park microgrid is able to operate in “island mode” in the event of an emergency, as the energy park operates independently from the electrical grid and provides a centrally located shelter with heat and power. For more details on the distinction between these two types of systems, see Arizona State University’s 2015 article on resilient cities.</p>	Short to Medium Term	Provincial Government, Agencies, Associations and Non-Government	[421] [422]
6	Projects or Programs	<p>Practice procedures to recover from energy failures after extreme weather events</p> <p>Participate in and review recommendations from crisis preparation programs, such as the North American Electric Reliability Corporation (NERC)’s GridEx. GridEx is the largest grid security exercise in North America, and combines physical and cybersecurity risks, and provides a platform for lessons learned and knowledge sharing among participants. Public-facing reports with recommendations from each event are released for review. More than ten government and utility representatives from Ontario participated in the November 2021 GridEx event. This event’s public report recommendations included:</p> <ul style="list-style-type: none"> • Continue to build effective communications procedures and systems to share operational information; • Continue to enhance routine and emergency operations coordination between the electricity industry and natural gas providers; • Strengthen operational coordination between the electricity industry and communications providers; and, • Continue to reinforce relationships between governments in the United States and Canada to support industry response to grid emergencies. 	Short Term	Associations and Non-Government, Private Sector or Individual	[40] [41]
7	Projects or Programs	<p>Review C40 recommendations, and identify interdependencies and collaboration opportunities</p> <p>Consider the risk of interdependencies and cascading failure across multiple energy infrastructure systems, as described in the C40 Infrastructure Interdependencies and Climate Risks Report (AECOM, 2017). The Report identifies various categories of infrastructure interdependencies, and presents a set of best practices and recommendations for municipal governments and departments to use in engagement of infrastructure organizations, to identify risks and adaptation measures, and to facilitate collective action.</p>	Short Term	Provincial Government, Agencies, Associations and Non-Government	[42]
8	Investment and Incentives Projects or Programs	<p>Develop programs to support capacity building and energy transition in remote areas</p> <p>Create and/or build upon existing programs that support capacity building regarding energy transition in remote areas (e.g., Northern Ontario). This will allow remote areas to benefit from energy innovations that are developed and tested in more urban areas.</p> <p>The Canadian government’s partnership with the International Renewable Energy Agency (IRENA) (https://www.irena.org/) can be leveraged to support this effort; as can programs like the Clean Energy for Rural and Remote Communities (https://www.nrcan.gc.ca/reducingdiesel) fund projects (e.g., Opiikapawin Services Ltd. multi-year investment in education and capacity building within 24 First Nations in Northwestern Ontario).</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[44] [45]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
9	Investment and Incentives Projects or Programs	<p>Invest in and encourage energy diversification</p> <p>Encourage diversification and consider energy sector adaptation measures for a variety of renewable energy generation infrastructure, including:</p> <ul style="list-style-type: none"> • For Hydro power: Climate change can contribute to unpredictable water levels. To mitigate risks associated with low water storage levels, consider investing in improved water management technologies, improving turbine runner capacity, or building additional storage capacity. To mitigate risks associated with high water levels consider increasing the number of facilities for debris removal. • For solar energy: Climate change will bring more variable conditions, fixed mounting angle of panels can be optimized, and tracking systems can be applied to adjust the angle for diffuse light conditions. • For offshore wind: Climate change can contribute to more variable wind patterns, thus passive technologies such as vortex generators, gurney flaps, and stall strips; and active technologies, including microtabs, flaps on turbine blades and LIDAR which allows the turbine to scan in the upwind direction, predict the wind, and reposition the rotor accordingly - can improve turbine efficiency in low wind conditions. <p>Energy generation diversification can enhance energy security, especially with renewable energy sources. Given anticipated electrification of energy services over the coming decades and the higher reliance on electricity, there is a need to understand how to keep energy systems in a changing climate. This may involve research on low- and no-emissions generation, storage, and energy network technologies such as smart grids, microgrids, and distributed energy resources (DERs).</p> <p>Incentivizing a shift to alternative energy sources includes creating and/or renewing programs and incentives to support shifts towards alternative energy source generation for all scales of businesses and governments. For example, the Northern Energy Fund, a previous program under the Northern Ontario Heritage Fund, provided funding for up to 50% of eligible costs to implement alternative energy such as solar energy. The Government of Canada “Canada Greener Homes Grant Initiative” provides a per kilowatt grant up to \$5,000 for the installation of home solar photovoltaic system (solar panels and inverter), and additional grants for batteries connected to photovoltaic systems for added resiliency. An example from the United Kingdom is the Contracts for Difference auction (https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference), currently in the fourth round; this round aims to secure 12 GW of renewable power generation, and is open to a number of renewable energy technologies, including offshore and onshore wind, solar, tidal and floating offshore wind projects, amongst others. The UK believes this will ensure a more secure and resilient energy system, and will support its transition to net zero through a greater range of energy sources.</p>	Medium Term	Provincial Government, Agencies, Associations and Non-Government, Private Sector or Individual	[46] [47] [48] [320]



3.5 Food Security

Food security is one of the most crucial challenges facing Ontario communities today, and is set to become more challenging in the years to come. Food security is achieved when “individuals have access to sufficient, safe, nutritious, and culturally appropriate food that meets their dietary needs” (Ministry of Children, Community and Social Services, 2017). It is a multi-dimensional concept that can be influenced by various sectors and is affected by impacts that cascade through food systems.

Food systems underpin food security, and are comprised of the following activities, which span across all Areas of Focus:

- **Food production:** Encompasses commercial and non-commercial agriculture, livestock, fisheries, and aquaculture production, as well as the hunting, fishing, and harvesting of traditional Indigenous foods.
- **Food processing:** The transformation of raw food inputs into retailed food products (e.g., washing, sanitizing and packaging).
- **Food distribution:** The transportation of food products to users (e.g., grocery stores, restaurants, etc.).
- **Food preparation and consumption:** Preparation and consumption of food by the consumer.

This section lists adaptation best practices applicable to food systems, and ultimately food security, in Ontario.

Table 3-4: Food Security Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	<p>Policy and Regulation</p> <p>Projects or Programs</p>	<p>Reduce food waste through modified storage and processing practices and policies</p> <p>Use food waste and by-products by converting these low-value materials into high-quality products, like livestock and poultry feed. Some food sources can be directly diverted to livestock (distiller grains and oilseed meals), while others require secondary processing. Post-harvest food loss can also result from poor storage due to lack of capacity. Where conversion to food source isn't feasible, bio-digesters can be used to generate energy.</p> <p>Improved storage capacity for food production and processing, as well as sharing food storage guidelines and strategies, can support a shift towards reduced food waste from limitations related to storage capacity. On farm storage (silos, underground storage) and warehouse storage are two commonly used methods. For on farm storage, storage containers can be pest-proofed by coating or sprinkling them with certain plant extracts. To increase warehouse storage, additional storage infrastructure may be necessary. Food processing is another method of food storage as it extends food lifetimes and allows foods to be available off-season.</p> <p>Strong food safety guidelines and regulations are essential to keep communities safe and healthy, and prepared/pre-packaged foods and fresh fruit/vegetables are key for people with disabilities to access healthy food. These goals can be met in combination with innovative ways to minimize food waste to ensure that the risk of foodborne illness is minimized, especially among vulnerable populations that may be at both an increased risk to the impacts of climate change and to the risk of morbidity and mortality from an unsafe food supply. Under climate change and increasing food insecurity, food rescue processes and policies will need to be integrated alongside food safety to develop a more resilient food system overall.</p> <p>Enhance and/or promote the direction and targets within Ontario's Food and Organic Waste Policy Statement (https://www.ontario.ca/page/food-and-organic-waste-policy-statement#section-3), which considers the rescue of surplus foods in a way that ensures safety concerns are met while surplus food is redirected. In addition, invest in education programs that promote consumer choices that reduce waste, while working directly with food producers to reduce food waste in their operations and to solidify the business case for improved storage and processing practices and encourage collaboration and partnerships that facilitate these goals.</p>	Short Term	Provincial Government, Associations and Non-Government, Private Sector or Individual	[49] [50] [51] [52]
2	<p>Investment and Incentives</p> <p>Projects or Programs</p>	<p>Support labour skills development and supply of domestic labour</p> <p>Continue to support, fund and integrate lessons learned from pilot projects coming out of programs like the Ontario Agri-Careers Support Initiative (under the Canadian Agricultural Partnership), which will fund pilot projects that attract, support and retain workers in the agri-food sector. Domestic labour supply is an important part of food security for Ontario, evidenced by the impacts to the labour market due to the COVID-19 pandemic.</p> <p>The projects funded through this program will support initiatives like childcare for workers, language skills development for workers who speak a foreign language who wish to improve their language skills, and transportation options to get workers to and from their job sites. A focus of the program can be to support and encourage Ontario families living in poverty. Supporting food producers in hiring and retaining workers to support harvesting and processing activities may also contribute to reducing food wastage (reduce risk of crops being left unharvested due to lack of labour).</p>	Short Term	Provincial Government, Associations and Non-Government	[53]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Policy and Regulation	<p>Prioritize farmland protection and sustainable growth</p> <p>Prioritize protection of prime agricultural land through land use planning, considering the efficiency of service delivery to support population growth across the province. Protection can be prioritized through improved growth management policies and policies that promote the agricultural system, food security and sustainable development. Integrated land use planning can reduce negative effects like ecosystem fragmentation and habitat deterioration, and reflect the importance of agricultural land for food production and wildlife habitat protection.</p> <p>The 2015 report 'Farmland at risk: How better land use planning could help ensure a healthy future for agriculture in the Greater Golden Horseshoe' (Ontario Federation of Agriculture, 2015) provides recommendations that can be considered. Additionally, the Ontario Federation of Agriculture (OFA) recommends creation of fixed, permanent urban boundaries as a land use planning tool to limit the loss of adjacent agricultural land surrounding urban areas (expansion beyond the fixed boundaries could occur after exhausting redevelopment of underused or vacant areas within urban boundaries).</p>	Medium Term	Provincial Government	[54] [55]
4	Projects or Programs Investment and Incentives	<p>Promote local and urban food production and circular economy principles</p> <p>Implement interventions to support food production, food retail, and food distribution to build resilience into the food system, such as those recommended by Public Health Ontario. Programs such as the Local Food Infrastructure Fund can support these initiatives in Ontario (this program is specific to community-based and not-for-profit organizations). Interventions and initiatives include:</p> <ul style="list-style-type: none"> • Urban agriculture such as community garden and edible landscaping trees • Short supply chains (consumer to grower interactions) through farmers' markets, etc. • Nutrition education related to sustainable diets <p>Our Food Future is an example of a local food production program in The County of Wellington/Guelph that uses a circular food economy model to address those that do not have enough food in the area while also reducing food waste and greenhouse gas production. Another example is the Urban Farm at Toronto Metropolitan University, which operates two rooftop farms on campus to produce and distribute food, facilitate research and engage the community through ecological rooftop farming and food justice initiatives. This includes growing foods, medicines and plants that are culturally significant to many communities.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities	[57] [58] [328] [329]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Research and Development Policy and Regulation	<p>Consider impacts from COVID-19 in development of policies related to Ontario’s food system</p> <p>Apply learnings from the pandemic to support policy development/revisions to policies related to food system in Ontario, which can build Adaptive Capacity to climate change (as well as to major disruptions like a global pandemic). COVID-19 has caused disruption to supply chains around the world, and can act as a proxy to a major climate hazard event. The Ontario Chamber of Commerce’s ‘Growing a more resilient food supply chain in Ontario’ (Kronfli, 2021) policy brief identifies six “pain points” in Ontario’s food system that were experienced during the COVID-19 pandemic, and recommendations to policy makers to reduce impacts and strengthen the food system in Ontario. These same pain points, and recommendations are applicable to food security in the face of climate change. Recommendations include:</p> <ul style="list-style-type: none"> • Support demand for local food and the shift to online sales; • Address the shortcomings with the AgriStability program; • Eliminate red tape issues for farmers; • Address labour shortages in agriculture; • Tackle food fraud (misrepresentation of food, including substitution of a product, adulterating, diluting, mislabelling, or making untrue/misleading statements); and • Take action on food insecurity, especially in Indigenous and northern communities. <p>Lessons learned from the Ontario Surplus Food Redistribution Program that supported food rescue, food security and food sovereignty efforts during the COVID-19 pandemic, at a time when food supply chains were disrupted include the importance of understanding the interconnections between food security and food sovereignty, particularly in the context of Indigenous communities.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities	[59]
6	Investment and Incentives	<p>Provide financial incentives for preservation of farmland ecosystem goods and services, soil health, and water quality</p> <p>Consider implementing financial incentives (e.g., tax benefits) for the use of idle and donated lands within rural and urban boundaries, or for the protection of soil health and high functioning agricultural lands (such as the Holland Marsh) that also provide ecosystem services for the natural environment. Incentives may include:</p> <ul style="list-style-type: none"> • Rural water quality incentives: Actions that can be incentivized include creating vegetated buffer strips along streams, controlling manure and field erosion, and planting of trees and shrubs. An example of an effective water quality program is the Rural Water Quality Program (https://www.grandriver.ca/en/our-watershed/Rural-Water-Quality-Program.aspx) (Region of Waterloo) which provides 50%-70% of project costs for best management practices identified through the Environmental Farm Plan, for those actions listed above. • Land retirement programs: Jurisdictions can motivate farmers to enhance conservation particularly in areas with valued wildlife habitats by creating farmland "set-asides". Examples include the Grassland Set-Aside Stewardship Program in British Columbia, and the Wetlands Reserve Easements through the US Department of Agriculture, as well as donations to land trusts and other environmental organizations that protect the land. • Property tax incentives: Ontario already has a farm incentive program for landowners to participate in (Farm Property Class Tax Rate Program http://omafra.gov.on.ca/english/policy/ftaxfaq.html) which provides tax exemption for eligible farmlands in agricultural production. 	Medium Term	Provincial Government	[60] [61] [62] [63]



3.6 Community Function, Human Health, Safety and Well-Being

A community is comprised of different parts that represent specialized functions, activities, or interests, each operating within specific boundaries to meet community needs. For the community to function well, each part has to effectively carry out its role, and disruptions caused by climate change can significantly undermine this. Key elements of community function that can be impacted by the changing climate are:

- **Social support and inclusion:** The strengthening of supports available to individual community members through social ties to other individuals, groups, and the larger community, and the process of improving the terms on which individuals and groups take part in society.
- **Access and infrastructure redundancy:** Available backup alternatives when other components are disrupted (e.g., due to flooding, landslides etc.).
- **Economic stability:** The absence of excessive fluctuations in economy meaning that people have the resources essential to a healthy life.
- **Emergency response management:** The management of resources and responsibilities and organization of measures and actions for dealing with the consequences of emergencies (e.g., flooding, power failure etc.) to ensure safety and security of communities and minimize damage to infrastructure and disruptions to essential services.
- **Ecological stewardship:** Responsible use and protection of the natural environment through conservation and sustainable practices.
- **Land use planning and development:** The process of regulating the use of land to promote desirable social and environmental outcomes and efficient use of resources.

Climate risks to health, safety, and well-being are complex and mediated by a range of determinants of health and other situational, behavioural, and organizational factors, including health and safety-related infrastructure. The management of climate risks and projected impacts to health, safety, and well-being requires close partnerships with officials within and outside the health sector. Climate change can impact the health, safety, and well-being of Ontarians both directly, through different climate hazards (e.g., extreme heat), and indirectly through a range of environmental, built, and economic pathways. Key impacts for Ontarians include the following:

- Spread of disease vectors and pathogens.
- Water quality and food safety concerns.
- Mental health and well-being concerns.
- Declining air quality.
- Public safety and emergency response challenges.
- Extreme temperature exposure challenges.

This section lists adaptation best practices applicable to community function and to human health, safety and well-being in Ontario.

Table 3-5: Community Function, and Human Health, Safety and Well-Being Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Support the development of community information networks</p> <p>Develop community information networks, with a platform for knowledge sharing, including traditional and community knowledge, western science, and technologies that help to monitor climate and environmental events of concern. For example, the Alaska Native Tribal Health Consortium developed the LEO Network (https://www.anthc.org/what-we-do/community-environment-and-health/leo-network/) for sharing time- and location-specific events that could impact food safety and security. Communication between communities is encouraged, to share "unusual and unique environmental events" that could impact other communities. The events are publicly posted on Google maps. Since 2012, the network has created a surveillance system and built a database of information on permafrost thaw, infrastructure damage, environmental contamination, among other impacts.</p> <p>Building on this example, Ontario could develop a set of regional community information networks that support communications within and among communities in the region, and across the province, allowing for continued learning and monitoring of climate change impacts. Monitoring and trend data can support more targeted adaptation planning, and building of Adaptive Capacity. This may be especially important in rural and remote communities.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities, Agencies	[64] [65]
2	Projects or Programs	<p>Undertake timely research in the wake of critical supply chain disruptions</p> <p>Undertake research and reporting exercises in order to evaluate system failures and document lessons learned from the COVID-19 pandemic. This exercise can be undertaken in conjunction with communities, supported by the Provincial government, to identify opportunities for Adaptive Capacity building at the community-level.</p> <p>Examples include opportunities to engage in deeper, long-term collaboration with suppliers, extending risk horizons to adapt to long-term changes and potentially begin to modify business and community service practices, and to take stock of geographic threats. The COVID-19 pandemic has brought to light weaknesses in the supply chain, as have major climate events like the flooding in British Columbia in 2021. Businesses were forced to transition to alternative service delivery methods in order to continue providing services within communities, and the outcomes of the adaptation response to the pandemic can be drawn on to develop meaningful actions to prepare for climate change as well as future pandemics.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities	[66]
3	Projects or Programs	<p>Provide consistently available and up-to-date emergency planning guidance to communities</p> <p>Generate up-to-date emergency planning guidance that is consistently available across the province, ensuring that planning is specific enough to address the different regions of Ontario. Emergency planning would include plans for transportation route disruptions (especially for remote communities). Examples and case studies from across the country can assist with developing these plans.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities	[67]
4	Investment and Incentives	<p>Reduce barriers to accessing power outage emergency kits</p> <p>Provide funding and programming to supply emergency kits to assist residents in acquiring essential items to support survival in the event of an extended power outage. Power outage emergency kits are an important resource for businesses and individual residences. The Government of Canada has a series of guidelines for dealing with outages (Public Safety Canada, 2011), including the recommendation to get an emergency kit which includes at minimum water, food, a can opener, a flashlight, a radio, and a first aid kit. For example, Saint-Laurent (a borough of Montreal) developed a subsidy to assist residents with the purchase of one emergency preparedness kit for households and one safety kit for cars, covering 50% of the cost up to \$125 before taxes. Additional funding is offered to low-income families (70% coverage to a maximum of \$175). An education and awareness program could accompany emergency kit and fund distribution programs.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[68] [69]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Research and Development Projects or Programs	<p>Continue using wastewater surveillance to track occurrences of infectious diseases</p> <p>Apply lessons learned from wastewater surveillance and wastewater-based epidemiology implemented during the COVID-19 pandemic, to provide an opportunity as a general-purpose health surveillance tool in the face of increased infectious diseases under climate change. This form of surveillance can measure the occurrence, spread, or resurgence of disease to inform a public health response.</p>	Short Term	Provincial Government, Municipalities	[70]
6	Projects or Programs	<p>Improve communications on climate change to the general public</p> <p>Improve communication from the government on the state of climate adaptation and climate action to reduce levels of climate anxiety being felt by the general public, as climate change becomes a more visible part of our lives. Resources like the 'Principle for effective communication and public engagement on climate change handbook' (Corner et al., 2018) can be useful for educating government departments on climate change communication. This handbook is designed for IPCC scientists, however the principles of communication are relevant to other leaders, and can be adapted for government officials and government scientists.</p> <p>The Ontario Biodiversity Council (2017) report, 'Communicating Biodiversity and Climate Change: A Guide for Crafting Effective Messaging', is a good resource/example for how to communicate these complex topics. Collaboration with Literacy Councils and other organizations can support the development of plain language content which is easily understood by most audiences.</p>	Short Term	Provincial Government	[71] [316]
7	Investment and Incentives Projects or Programs	<p>Develop programs to support innovation in communities</p> <p>Develop programs, funding support and/or incentives for pilot/demonstration projects of innovative practices and new technologies that build community Adaptive Capacity. An example of a program that could be expanded or used as a template is the IC-IMPACTS Innovative Technology Demonstrations Projects program. This is a joint program between India and Canada, providing funding support for projects that are relevant to safe and sustainable infrastructure, integrated water management, and public health, and is designed to encourage knowledge transfer and demonstrate the scalability of innovative technologies in the Canadian (and Indian) marketplace.</p>	Medium Term	Provincial Government, Agencies	[72]
8	Policy and Regulation	<p>Develop guidelines to support community services and businesses adapt to virtual service delivery in the event of climate disruptions</p> <p>Develop and disseminate guidelines for community services and businesses to support a transition to virtual service delivery in the event of a climate disruption. Over the course of the COVID-19 pandemic, many organizations and goods/service providers transitioned to virtual and/or home delivery of goods and services (e.g., virtual doctors' appointments by phone and video, online grocery shopping for contactless pickup or home delivery, expansion of restaurant take-out/delivery options, online schooling etc.). Similar adaptations may be needed in order to adapt to climate change related disruptions.</p> <p>The City of Calgary released guidelines based on their experiences with the pandemic, and include best practices such as:</p> <ul style="list-style-type: none"> • Identify processes, operations and functions that are critical to the organization; • Identify internal and external dependencies and what could impact the level of service delivery; • Develop plans to address these specific challenges. <p>The National Association of School Psychologists has developed similar guidelines, and include recommendations to renegotiate privacy contracts to reflect the nature of virtual meetings (reflecting the fact that the home environment may be less secure than a private office).</p>	Medium Term	Provincial Government, Private Sector or Individual	[73] [74]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
9	Policy and Regulation	<p>Include a wide breadth of stakeholders and rights holders in public policy decision making</p> <p>Integrate a more inter-disciplinary and community-based approach to decision making, in order to integrate a greater degree of awareness of potential pitfalls of policies and ways to leverage lessons learned across sectors. Public Health Ontario (2018) identifies a three-step, eight-phase policy-making process for developing public health policy in its 'Supporting the Policy-Making Process' workbook. This same process can be used to develop public policies that support climate change adaptation and builds Adaptive Capacity for communities and community function. A key aspect of the eight-step process is framing the problem from different perspectives, including community members who are experiencing the issue under consideration. A linkage between frontline staff and policy-makers is an important component of policy design for communities.</p>	Medium Term	Provincial Government, Municipalities, Agencies	[75]
10	Policy and Regulation Investment and Incentives Projects or Programs	<p>Protect and preserve green spaces in urban environments</p> <p>Develop policies, regulations, programs and/or incentives to increasing the quality and protection of green spaces in urban environments. The primary benefits are to support climate change adaptation; this has also shown co-benefits of reducing chronic illnesses and their associated risk factors. A variety of funding mechanisms exist to promote this, including taxation (such as location specific community taxes where those close to green space pay a small tax for its maintenance, levies where large employers close to green space pay an additional tax to fund the space, income-generating opportunities and loans (such as holding events in the green space that generate income), bonds, and sponsorships/naming rights which allow people or private companies to sponsor the space or a part of the space.</p>	Medium Term	Provincial Government, Municipalities, Associations and Non-Government, Private Sector or Individual	[76] [77]
11	Projects or Programs	<p>Encourage integration of climate change education in post-secondary education programs</p> <p>Post-secondary education and training curriculums that incorporate climate change education and adaptation knowledge can promote climate change action in multiple sectors, including engineering, environmental/social management, geology, biology, business and public administration, economics, etc. The University of Waterloo's Interdisciplinary Centre on Climate Change (IC3) (https://uwaterloo.ca/climate-centre/about) is an example of climate change integration at a post-secondary institute. IC3 acts as a hub, with researchers from each of the six faculties, and includes students, partner institutions (e.g., Wilfred Laurier University), and government partnerships (e.g., Environment and Climate Change Canada, Health Canada and Natural Resources Canada). These partnerships also foster innovation bringing diverse talent and expertise to the same space.</p>	Medium Term	Provincial Government, Academia	[78]
12	Projects or Programs	<p>Develop and employ citizen juries to support climate change engagement</p> <p>Convene citizen juries to provide a voice to citizens in climate change decision making processes. An example comes from the UK: the Leeds Climate Change Citizens' Jury, and the Oxford Citizens' Assembly on Climate Change (both from 2019) increased citizen engagement with respect to climate change and ensured that policies were more citizen-centred. Employing citizen juries allows for the identification of more nuanced public opinion in a fair and informed way, and would also need to ensure Indigenous representation.</p>	Medium Term	Municipalities and Indigenous Communities	[79]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
13	Investment and Incentives	<p>Build 'safety nets' to protect vulnerable populations and retain community function</p> <p>Build in 'safety nets' to support and protect vulnerable populations from climate related disruptions as a means of supporting community function in the face of climate change. A safety net is any form of program implemented to protect individuals and families from the impact of natural disasters, economic downturn, or other crises. The World Bank's Adaptive Social Protection: Building Resilience to Shocks provides a framework and recommendations for building adaptive social protection (ASP) into community planning and policy-making. ASP is a response to a demand for social protection as a tool to build Adaptive Capacity of vulnerable populations to significant shocks (like climate events). The four building blocks of ASP are: programs, finance, data & information, and institutional arrangements/partnerships. The report highlights specific priorities and investments aligned to each building block that support the design and implementation of ASP. Examples of safety nets include:</p> <ul style="list-style-type: none"> • School nutrition programs • Paid sick leave • Unemployment insurance • Emergency funding to individuals (conditional or unconditional, e.g., the Canadian Emergency Response Benefit) • Insurance coverage, including health insurance 	Long Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[80]
14	Policy and Regulation	<p>Integrate emergency and community planning standards into community and infrastructure plans</p> <p>Integrate international standards for emergency preparedness into community and infrastructure plans, to support clear decision-making and futureproofing for major climate events. There are a number of disaster risk and emergency planning standards that include climate change considerations and provide communities with the necessary decision-making supports to plan and prepare for emergency scenarios, develop resilient infrastructure and communications systems, and establish collaborations with community partners that can be leveraged in the lead-up to and during an emergency event to mitigate harm to the built environment as well as to human health and wellbeing. For instance, the Emergency Management Framework for Ontario (2021) draws on a number of international standards including the Canadian Standards Association (CSA): Z1600 Standard on Emergency and Continuity Management, and includes consideration of climate change risks in the guidance for prevention, mitigation, preparedness, response, and recovery to/from disasters or emergency events. Other standards which would be of benefit to explore depending on the scope of a given plan or policy include:</p> <ul style="list-style-type: none"> • NFPA 1300, Standard on Community Risk Assessment and Community Risk Reduction Plan Development • AS/NZS 4360:2004: risk management • NFPA 1600 (Standard on Disaster/Emergency Management and Business Continuity/Continuity of Operations Programs) 	Short to Medium Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[378]

4.0 Food & Agriculture Adaptation Practices

Ontario's food and agriculture sector plays a crucial role in the province's economy, landscape, and society, with over 700,000 employed (approximately 10.3% of provincial employment) and approximately \$45 billion in annual revenue (6.4% of total provincial GDP). The sector is multi-faceted and inextricably linked to systems within and outside of the sector, including infrastructure, economic and natural systems.

Changing climate conditions could present opportunities for agriculture in Ontario (e.g., longer growing and grazing seasons), but such benefits could be offset by negative impacts, resulting in declining productivity, crop failure, and livestock fatalities. Several commodities (e.g., cereals, corn, soybeans, apples, berries and grapes) are expected to face very high climate risks by the end of the century.

The Food and Agriculture Area of Focus has been broken down into the following Level 1 categories:

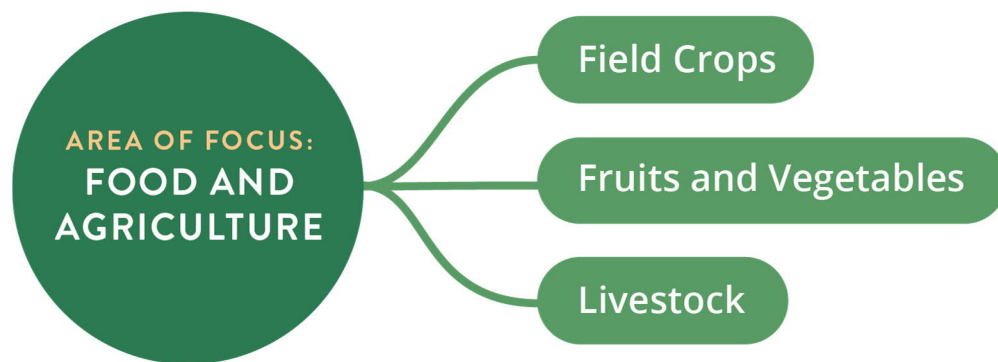


Figure 4-1: Food and Agriculture Area of Focus Level 1 Categories

All Level 1 and Level 2 industries as part of Food and Agriculture have been assessed to have a medium Adaptive Capacity, indicating some potential to undertake appropriate adaptation actions as highlighted in Table 4-1 and Table 4-2.

Table 4-1: Current Food and Agriculture Adaptation Priorities

Current Adaptation Priorities	Region	Risk Score	Adaptive Capacity
Corn	Central, Northeast	High	Medium
Soybeans	Central, Northeast	High	Medium
Apples	Central	High	Medium
Berries	Central, Northeast, Northwest	High	Medium
Field Vegetables	Central	High	Medium
Tender Fruit	Central	High	Medium

Table 4-2: Emerging Food and Agriculture Adaptation Priorities by Mid-Century (RCP8.5)

Emerging Adaptation Priorities	Region	Risk Score	Adaptive Capacity
Cereals	Central, Northeast, Northwest	High	Medium
Canola	Central, Northeast	High	Medium
Forages	Central, Northeast, Northwest	High	Medium
Greenhouse Vegetables	Central	High	Medium
Beef	Central	High	Medium
Dairy	Central	High	Medium
Poultry and eggs	Central	High	Medium
Swine	Central	High	Medium

The ABP Report provides a range of potential best practices for Food and Agriculture, as summarized in Table 4-3.

Table 4-3: Areas for Food and Agriculture Climate Adaptation

Adaptation Category	Examples of Adaptation Measures
Projects or Programs	<ul style="list-style-type: none"> ● Strengthen monitoring and surveillance programs for pest and disease management. ● Enhance emergency management planning ● Expand decision support tools for on-farm water, soil and nutrient management. ● Enable demand-driven knowledge transformation and transfer through collaboration between researchers and farmers.
Research and Development	<ul style="list-style-type: none"> ● Support and advance research on agricultural expansion opportunities under a changing climate. ● Undertake research and development efforts into new and climate-resilient varieties/species. ● Support technological research and advancements on precision agriculture, advance drainage and irrigation systems. ● Fund a knowledge transfer and sharing program for practical adaptation and best management practice sharing with Indigenous knowledge at its core.
Investment and Incentives	<ul style="list-style-type: none"> ● Increase access to financial incentives and funding programs for farmers. ● Support and advance research on agricultural expansion opportunities under a changing climate. ● Support technological research and advancements on precision agriculture, advance drainage and irrigation systems.
Policy and Regulation	<ul style="list-style-type: none"> ● Apply a climate lens to government decision-making, and ensure integration of Indigenous perspectives. ● Invest and strengthen coordination and integration of water management

The following sections present Adaptation Best Practices compiled first by overarching actions for the Food and Agriculture Area of Focus, followed by sections for each of the Level 1 categories.

4.1 Overarching – Food and Agriculture

Table 4-4: Overarching Food and Agriculture Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Strengthen monitoring and surveillance programs for pest and disease management</p> <p>Further develop and strengthen provincial monitoring initiatives, surveillance, risk assessment procedures for pests and disease (e.g., Ontario's Integrated Pest Management program and resources), for both traditional agricultural production as well as within Indigenous Communities and the urban Indigenous population. Additionally, the Province could invest in development of quantitative modelling, improved management practices, and area-wide pest management. Guidance can come from established pest monitoring programs (e.g. Saskatchewan pest monitoring program, Alberta insect pest monitoring network), that include surveillance, surveys, and crowdsourcing for monitoring. Increase coordination of early identification and monitoring for pests, diseases and weed threats and encourage on-farm best management practices for pest and disease control and management.</p> <p>Review, follow and routinely update best management practices (e.g., OMAFRA's BMP 09 - Integrated Pest Management (http://www.omafra.gov.on.ca/english/environment/bmp/ipm.htm)) for a range of known pests. The seasonality, range and number of agricultural pests is changing as temperatures warm, particularly winter temperatures. These changes are increasing the risk of pest-related damage to agricultural production and wild harvests. Agricultural pests include insects, diseases, weeds and invasive species that impact crop and livestock health.</p> <p>Disseminate information regularly, and tie this to a provincial pest monitoring program. Examples of integrated pest management practices include limiting movement of plant material and soil from field to field where some pests can spread, purchasing plant stock from reputable sources, avoiding storing potted plants alongside field edges, and continuous monitoring for pests in the planting, ripening and later growing season.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities, Academia	[155] [156] [157]
2	Research and Development	<p>Support and advance research on agricultural expansion opportunities under a changing climate</p> <p>Continue to support investigations into the viability of expansion of agriculture into non-traditional regions of the province (e.g., the Far North). This would involve monitoring temperature changes, frost trends, and changes to the growing season and precipitation patterns, in areas with agricultural potential. Some regions, such as Ontario's Clay Belt Region have been identified as opportunities for livestock expansion and are in process of being further investigated. Consideration may be made to reduce and or eliminate mono culture practices, and integrate approaches that support biodiversity in the North, as farming practices move into non-traditional regions.</p>	Short Term	Provincial Government, Academia	[158] [159] [160] [161]
3	Policy and Regulations Projects or Programs	<p>Apply a climate lens to government decision-making, and ensure integration of Indigenous perspectives</p> <p>Develop a policy and/or program to facilitate factoring climate change impacts on agriculture and the associated medium to long term implications into government decision-making and planning processes. This will support the adoption of adaptation practices, and build Adaptive Capacity into the agricultural Area of Focus. Review existing agricultural programs for Ontario's agricultural businesses to better understand how to support agricultural adaptation; evaluating programs for coordination, flexibility, consistency, transparency and inclusion of Indigenous perspectives and Traditional Knowledge. Identify and implement strategies to strengthen agricultural organizations and facilitate their participation in provincial dialogue and decision-making. Integrate agricultural adaptation considerations into land use planning policies, tools and implementation.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities	[1] [2] [3] [4] [5]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Projects or Programs	<p>Enhance emergency management planning</p> <p>Expand on existing emergency management, response and recovery planning with specific prevention and preparedness measures for agriculture production risks related to climate change impacts. Development of plans to deal with the highest risks will support Ontario's agriculture stakeholders to be more prepared and to react appropriately and quickly to new climate risks (e.g., new pests or diseases). Integrate additional supports for farm-level emergency management into OMAFRA's existing planning and programming.</p>	Short Term	Provincial Government, Private Sector or Individual, Agencies	[1] [2] [3] [5] [167]
5	Investment and Incentives	<p>Increase access to financial incentives and funding programs for farmers</p> <p>Invest in the expansion of existing financial incentive and funding programs available to Ontario farmers. Re-capitalizing or expanding these programs strategically using a climate change lens could enable broad scale implementation of adaptation practices.</p> <p>Expand funding for Business Risk Management (BRM) programs (managed by AgriCorp) to protect producers against climate risks that threaten the viability of their farms and are beyond their capacity to manage.</p>	Short Term	Provincial Government	[SME]
6	Research and Development	<p>Undertake research and development efforts into new and climate-resilient varieties/species</p> <p>Create a cross-sectoral collaboration for an updated DNA testing procedure to speed up availability of new varieties/species across the value chain. This will help to meet consumer demand for new varieties (e.g., white peaches), provide producers with a competitive advantage in the marketplace, and allow for development of more climate resilient varieties.</p> <p>Among other things, this will speed up the availability of new varieties for both local and foreign markets, recognizing the changing and increasing demand for more ethno-cultural products, and extends Ontario's relatively short growing season to increase profits and market share, which can support fruit availability in Ontario during periods of low import availability. Currently, Vineland Innovation and Research Center is in communication with the Canadian Food Inspection Agency to speed up the availability of new fruit varieties, and tender fruit marketing board is collaborating with the University of Guelph to speed up commercial production of new fruit varieties.</p> <p>Research into genetic selection for higher productivity and tolerance to adverse climate conditions (e.g., higher temperatures and humidity) for livestock can also protect against heat stress and other climate-related stressors that can reduce gains.</p>	Medium Term	Provincial Government, Private Sector or Individual, Academia	[163] [165]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	<p>Research and Development</p> <p>Projects or Programs</p>	<p>Fund a knowledge transfer and sharing program for practical adaptation and best management practice sharing with Indigenous knowledge at its core</p> <p>Develop and fund a provincial program (or programs) that supports extension staff out of universities to work on translating research results into best management practices, and engages with the farm community and Indigenous Communities to encourage adoption. This would include knowledge mobilization and lead to better implementation of adaptation practices, and higher uptake of novel technology. A program like this would support research into business risk management approaches and enable demand-driven knowledge transformation and transfer (KTT) in use through synthesis, exchange, dissemination, dialogue, collaboration and brokering among researchers, farmers and Indigenous knowledge holders.</p> <p>OMAFRA currently offers workshops, resources, tools and eLearning opportunities at no cost for the agri-food and agri-products sectors on a number of important issues including growing farm profits, biosecurity, food safety, KTT, and more. Build on existing informational tools (e.g., OMAFRA's AgriSuite tools) to expand the weather and climate information available for agricultural planning and management.</p> <p>Continue to translate weather and climate science and build on applied tools for producers, industry and other decision makers (local and regional government).</p>	Medium Term	Provincial Government, Private Sector or Individual, Municipalities and Indigenous Communities, Academia	[166] [167] [168]

4.2 Field Crops; Fruits and Vegetables

Table 4-5: Field Crops and Fruits and Vegetables Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	<p>Research and Development</p> <p>Projects or Programs</p> <p>Investments and Incentives</p>	<p>All Field Crops and Fruits and Vegetables: Provide financial and governance support for research efforts and on-farm trials for new crop types and cultivars/cropping genetics</p> <p>Support research and obtain more information on changing climate suitability and climate resilience from crop breeding programs, trials and commercial program. Incorporate research into on-farm trials for new crop types and cultivars/cropping genetics. Encourage research and diversification of crops, and the development of weather-resistant crop types. Encourage the use of resources such as NSERC's Discovery Grants program to support research efforts (e.g., climate resilient crops research is being done under this program at Thompson Rivers University). Undertake an inventory of the changing distribution of crop varieties and cultivars. Support piloting of new or transferable practices and technologies with adaptation potential. Strengthen proactive breeding and variety trial programs through incorporation of adaptation considerations. For example, test crops and varieties with enhanced resilience to projected conditions; evaluate variety trials and breeding in other jurisdictions with conditions similar to projected conditions; evaluate potential for alternate varieties and breeds to be better suited to changing conditions in Ontario.</p> <p>Some examples of research in this vein include scenario-based risk assessment decision support modelling tools for regional climate change and climate extremes, impacts and adaptation in agricultural watersheds (an OMAFRA project).</p>	Short Term	Provincial Government, Private Sector or Individual, Academia	[4] [168] [169]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
2	Investment or Incentives	<p>All Field Crops and Fruits and Vegetables: Incentivize farm-based water management opportunities</p> <p>Supporting or incentivize the development/expansion of regional and on-farm water storage, expansion of irrigation systems and capacity, uptake of on-farm tile drainage, on-farm and regional ditch and dike infrastructure, and pumping capacity. Consider establishing funding programs to support these water management activities.</p>	Short Term	Provincial Government, Private Sector or Individual	[347] [348]
3	Projects or Programs	<p>All Field Crops and Fruits and Vegetables: Expand decision support tools for on-farm water, soil and nutrient management</p> <p>Continue to develop and expand decision support tools and best management practice guidelines for effective on-farm water management and soil and nutrient management practices (e.g., cover crops, no-till/conservation tillage, crop rotation, natural pest reduction, etc.). Nutrient management plans and practices can help producers reduce the nutrient losses and run-off of nutrients into water bodies. In anticipation of increased rainfall (intensity, duration and frequency) as a result of climate change, agricultural best management practices can support farms reduce nutrient losses and better manage soil and water (which in turn can reduce GHG emissions associated with farming practices).</p>	Short Term	Provincial Government, Associations and non-Government, Private Sector or Individual	[170] [171] [172]
4	Projects or Programs	<p>All Field Crops and Fruits and Vegetables: Increase uptake of AgriCorp insurance programs</p> <p>Encourage producers to enroll in AgriCorp crop insurance to support income stabilization during extreme weather events Industry to explore opportunities for new or enhanced private sector insurance products for commodities in Ontario.</p>	Short Term	Private Sector or Individual	[173] [174] [175]
5	Projects or Programs	<p>All Field Crops and Fruits and Vegetables: Education and awareness program for on-farm adaptation practices</p> <p>Develop a stand-alone program, or enhance existing programs to continue to build awareness and encourage implementation of on-farm climate change adaptation practices, including:</p> <ul style="list-style-type: none"> • Creating production redundancy by growing crops in different geographic areas of Ontario • Selection of crop varieties with resistance and tolerance to changing conditions • Growing more than one variety to help reduce the risk of total crop failure • Tile drainage and controlled tile drainage • Crop rotation • Pasture rotation • Implementing physical barriers (e.g., wind breaks, buffer strips) • Retrofitting facilities and farm infrastructure (e.g., storage buildings) • Use of green infrastructure and protection/preservation of natural systems • Changes in planting or harvesting dates • Water storage and supply programs • Increased monitoring and new monitoring techniques • Post-harvest handling to increase crop quality, extend crop availability and reduce waste <p>Review best management practices promoted by OMAFRA (Best Management Practices Series) for additional guidance.</p>	Short Term	Provincial Government	[168] [176] [177]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Investment and Incentives Projects or Programs	<p>All Field Crops and Fruits and Vegetables: Regional forecasts and warnings programs</p> <p>Consider a provincially-funded forecasting and warning system that provides regional, community- and/or sector-based forecasts and warnings to producers, so they can be better prepared to cope with weather uncertainties (e.g., in grape-growing regions, an alert to grape growers of impending frost or extreme low winter temperatures will allow them to turn on their wind machines for better crop protection). Weather monitoring systems can be the first point of reference for farmers to accordingly shift their sowing and harvesting periods following changes in temperature and precipitation patterns.</p> <p>Alternatively, incentivize farm- or community-level installations of small-scale meteorology stations to support producers manage weather uncertainties. Encourage data-sharing among community farms.</p>	Short Term	Provincial Government	[178]
7	Investment and Incentives	<p>All Field Crops and Fruits and Vegetables: Develop incentive programs and financial tools to support on-farm planning, innovation and Adaptive Capacity</p> <p>Develop incentives and financial tools for adoption of adaptive farm practices (e.g., Agriculture Canada’s On-Farm Climate Action Fund provides funding support for farmers to adopt best management practices that store carbon and reduce GHG emissions). A similar program could be considered for climate change adaptation measures. It can provide incentives for innovation and experimentation at the farm level, and investment in on-farm adaptive practices and technologies (e.g., use business risk management supports for transitioning to more adaptive systems, such as linking premiums or payouts to incentives for investing in adaptation). Another example of a successful incentive program is from the Maine Department of Agriculture, Conservation and Forestry; the Agricultural Infrastructure Investment Program, which is designed to support farmers to improve critical infrastructure and practices that build resilience.</p> <p>An Ontario-based program could also include mechanisms to share new types of risk for farm businesses associated with climate change impacts including incremental (and compounding) impacts from more frequent small events and successive years of extreme weather event impacts.</p>	Medium Term	Provincial Government	[2] [179]
8	Projects or Programs Investment and Incentives	<p>All Field Crops and Fruits and Vegetables: Continue funding and support for risk assessments, knowledge-sharing and awareness programs</p> <p>Continue funding and supporting environmental farming coalitions and programs like the Environmental Farm Plan (EFP) and Farmland Health Check-Up program to enhance knowledge sharing among farmers/producers/Indigenous Peoples across Ontario. For example, the Ontario Farm Environmental Coalition led the development of the EFP, which provides assessment support to producers across Ontario to increase their environmental awareness, identify areas of concern, and set action plans to improve conditions. The EFP is funded by the Canadian Agricultural Partnership (federal, provincial and territorial initiative); funding support should continue and program expansion could be considered to include climate change-based risk assessment support and enhanced knowledge-sharing among farmers.</p>	Medium Term	Provincial Government	[180]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
9	Projects or Programs Investment and Incentives	<p>All Field Crops and Fruits and Vegetables: Invest and strengthen coordination and integration of water management</p> <p>Continue to provide and consider expanding technical and financial assistance to Ontario farm operations to secure water supplies or increase water use efficiency. Promote climate-smart water infrastructure (e.g., drip irrigation technologies, supporting water sources such as revegetation and canopy management to conserve moisture, storage solutions like wetlands, ponds, and other Nature Based Solutions, etc.) at the regional and/or farm level.</p> <p>Develop and promote programs focused on water conservation and efficiency solutions and innovations (e.g., Water Resource Adaptation and Management Initiative (WRAMI), an 18-month program which funded pilot-scale projects).</p> <p>Improve access to information on water resources among producers, such as through resources like OMAFRA's Canada-Ontario Environmental Farm Plan (local workshop process where farmers highlight the strengths of their farms and their limitations, and develop solutions and action plans together). Include the Indigenous perspective.</p> <p>Improve and expand on modeling of future crop water demand and regional demand relative to supply in regions across the province. An example of such a program is the BC Agriculture Water Demand Model, a GIS-based water demand model applied in 17 locations across British Columbia, and takes into account soil types/terrain, geographic extend of agricultural area, and local climatic conditions.</p>	Medium Term	Provincial Government	[57] [160] [181] [182] [183]

4.3 Fruits & Vegetables

Table 4-6: Fruits and Vegetables Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Tenderfruit: General practices for managing increased heat, rainfall and damaging frost events</p> <p>Encourage the use of shading and water-cooling techniques and technologies, to reduce extremely hot temperatures that can impact tree and tenderfruit. Deploy rain protection techniques, such as netting, helicopters, blowers, and/or pre-harvest sprays to support elimination of droplets to prevent splitting.</p> <p>Invest in frost protection techniques, like wind machines, to protect sensitive perennial crops such as grapevines and tender tree fruits from irreversible cold injury, causing malfunction or death of plant cells. Wind machines have been successful in the Niagara region since the late 1990s.</p>	Short Term	Private Sector or Individual	[2] [162] [184]
2	Projects or Programs	<p>Tenderfruit, Berries and Field Vegetables: Management practices to reduce moisture loss, erosion, and increase water infiltration</p> <p>Use grass alleys or grass cover to protect tenderfruit and berry crops. Well-managed grass cover can aid in reducing extreme temperatures, increase snow retention and increase water infiltration, as well as supporting harvesting equipment in wetter conditions and providing additional mulch for crops where suitable.</p> <p>Use mulching techniques (returning crop residue, pruned material, or other material to soil surface) to reduce moisture loss and erosion, slow runoff and improve infiltration. Consider natural mulch materials instead of artificial, as artificial/plastic mulch has a high material costs, and disposal issues must be considered.</p>	Short Term	Private Sector or Individual	[2] [162] [185] [186]

4.4 Livestock

Table 4-7: Livestock Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Research and Development Project or Program	<p>All Livestock: Adopt nutrient management best management practices to support animal health and yields</p> <p>Make changes to dietary supplementation to aid in animal health and well-being, especially during extreme heat events. This can include adjusting feeding rations, manipulating the amount of fat and fiber in diet, and adding appropriate amounts of nutrients, vitamins, synthetic aminoacids and electrolytes to diets. Adjustment of food and water schedules are also recommended (e.g., feed withdrawal to avoid high metabolic heat production in hours of extreme heat).</p>	Short Term	Private Sector or Individual	[187] [188] [189] [190]
2	Projects or Programs	<p>All Livestock: Make adjustments to treatment, handling and transportation in extreme conditions</p> <p>Encourage and educate farmers on adjustments to handling and transportation during extreme weather conditions. In cold conditions, during transport, livestock need to be protected from precipitation and wind blowing into the sides of the truck because it increases their loss of heat and can cause death from hypothermia, even at temperatures above freezing. Best practices include supplying ample bedding and insulation, avoiding overcrowding to allow animals to reposition themselves to avoid frostbite, closing nose vents in vehicles, covering bottom ventilation slats, making sure adequate ventilation exists. General treatment and handling strategies include close monitoring of animals for signs of cold stress, relocating animals to a sheltered area when needed, and providing extra nutrition and bedding where appropriate.</p> <p>In hot conditions during transportation, adequate ventilation and stocking density are necessary considerations. At all times, timely truck maintenance, careful route selection, adjusting to traffic conditions to avoid traffic jams and gradually acclimatizing indoor animals and birds to outdoor temperatures prior to catching and loading are best management practices that could be employed. General treatment and handling strategies and practices include provision of shade, avoiding peak temperatures when working cattle, feeding animals at dusk and dawn, providing adequate water supply, maintaining proper ventilation rates and space allowance and monitoring livestock for signs of heat stress. For indoor livestock, maximize air flow, using fans and opening up barns to maintain air temperatures within birds' and animals' zone of thermal comfort; provide adequate air exchange, add movable circulation fans to areas of poor airflow in the barn, and invest in tunnel ventilation systems.</p> <p>Consider installation of precision technologies and electronic alert systems to alert personnel if barn temperature falls outside of the target range.</p>	Short Term	Provincial Government, Private Sector or Individual	[191] [192] [193] [194] [195] [196] [197] [198] [199] [200] [201] [202] [203] [204] [205] [206]
3	Projects or Programs	<p>All Livestock: Support and promote emergency management training and education</p> <p>Support and promote commodity farmer groups to work with emergency animal health management organizations (e.g., Animal Health), to develop emergency management plans in the event of a major event that impacts livestock health. For instance, Emergency Management (AHM) program holds workshops and training on proactive steps to prevent disease outbreaks among animals.</p>	Short Term	Associations and Non-Government, Private Sector or Individual	[SME]
4	Projects or Programs	<p>Beef, Dairy and Sheep: Manage reproduction schedule to minimize climate impact</p> <p>Time birthing for the fall and winter months to avoid peak milk production occurring in the summer, and avoid increasingly warmer temperatures with climate change in the summer season when milk production yields are most affected. Consider the use of precision technologies to monitor reproductive activity and track estrus behaviour.</p>	Short Term	Private Sector or Individual	[187]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Projects or Programs	<p>Beef, Dairy and Sheep: Employ management-intensive grazing practices over traditional grazing</p> <p>Encourage management-intensive grazing, which refers to practices in which animals are allowed to graze only a small portion of the pasture at a time, while other areas rest and recover. This form of grazing management includes the use of time-control and shortened grazing periods, and increased animal density per paddock. As Beef and Sheep farmers manage much of Ontario's grasslands, grazing livestock can provide soil with a natural biome and bacteria that improve soil health and its ability to retain moisture and sequester carbon, and healthy grass and pasturelands provide wildlife habitats for birds currently on the Species at Risk in Ontario List and pollinators.</p>	Medium Term	Private Sector or Individual	[207] [208]

5.0 Infrastructure Adaptation Best Practices

The Infrastructure Area of Focus broadly encompasses assets that have been built, and that will be designed and constructed in the future in the province. Infrastructure is the backbone of the economy, of service delivery, and of community function. Generally, the amount of built infrastructure tends to be located where Ontarians live, with greater concentration in the most populous regions of Southwest, Central, and Eastern Ontario. Farther north, infrastructure is less concentrated but remains critically important for rural, remote and Indigenous communities in these regions.

The Infrastructure Area of Focus has been broken down into the following Level 1 categories:

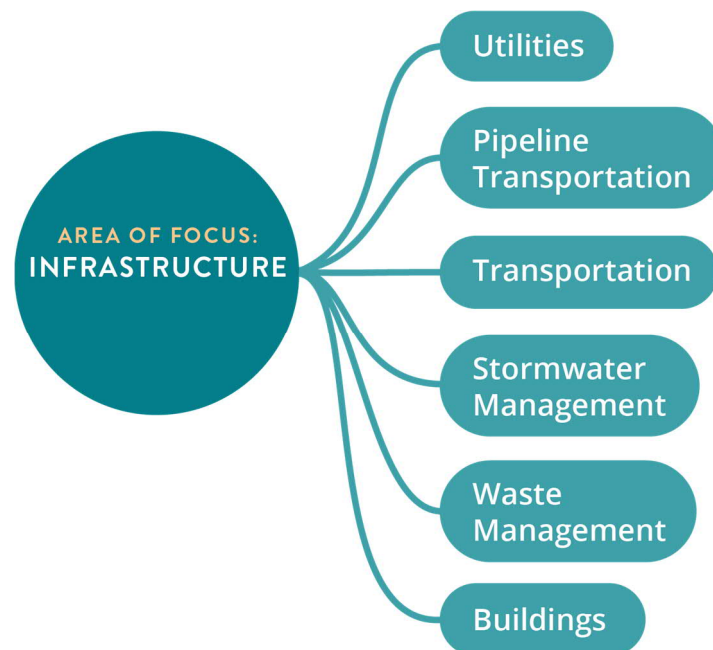


Figure 5-1: Infrastructure Area of Focus Level 1 Categories

Climate impacts on infrastructure were assessed for every region of Ontario. For each Level 1/Level 2 category, various interactions of how climate hazards could lead to impacts were documented and used to quantify how likely it would be to occur and how severe the consequences would be if it did. Consequences such as the level of disruption to services and extent of financial loss were used to inform risk profiles. This portion of the assessment only analyzed the direct impacts on Infrastructure. Indirect and cascading impacts of infrastructure disruption and damages are covered under other Areas of Focus (e.g., Business and Economy, People and Communities etc.) and under the Cross-Sectoral Theme section.

All Level 1 and Level 2 industries as part of Infrastructure have been assessed to have a medium Adaptive Capacity level compared against significant risks to a range of sectors, indicating some potential to undertake appropriate adaptation actions across regions and types of infrastructure as highlighted in Table 5-1 and Table 5-2.

Table 5-1: Current Infrastructure Adaptation Priorities

Current Priorities	Region	Risk Score	Adaptive Capacity
Electrical Power Generation	Central, Northeast, Northwest, Far North	High	Medium
Flood Mitigation Infrastructure	Central, Northeast, Northwest, Far North	High	Medium
Urban and Rural Stormwater Management Systems	Central, Northeast, Northwest, Far North	High	Medium

Table 5-2: Emerging Infrastructure Adaptation Priorities by Mid-Century (RCP8.5)

Emerging Priorities	Region	Risk Score	Adaptive Capacity
Air Transportation	Central, Northeast, Northwest	High	Medium
Electrical Transmission, Control and Distribution	Central, Northeast, Northwest, Far North	High	Medium
Housing	Far North	High	Medium
Other Buildings	Far North	High	Medium
Public Buildings	Far North	High	Medium
Rail	Central, Northeast, Northwest, Far North	High	Medium

The Adaptation Best Practices presented in this section provide a range of opportunities for action, as summarized in Table 5-3.

Table 5-3: Areas for Infrastructure Climate Adaptation

Adaptation Category	Examples of Adaptation Measures
Projects or Programs	<ul style="list-style-type: none"> ● Incorporate climate change into asset management, and specifically develop technical guidance on how to do so and at what level of detail. ● Develop programs to support communities of practice focused on each of the major infrastructure asset categories. ● Fast-track the deployment of green infrastructure by incorporating green infrastructure into designs and renewed development. ● Develop programs and/or provide funding to support a community of practice.
Research and Development	<ul style="list-style-type: none"> ● Support and encourage the release of quantitative datasets that can be used to assess risk and inform infrastructure design. ● Require that new research and modeling should factor in climate change scenarios where they inform infrastructure planning and design, such as floodplain mapping. ● Conduct further research on international impacts, integrating potential climate impacts into a broader study of future global markets for key waste products ● Develop climate resiliency design guidelines with technical specificity.
Investment and Incentives	<ul style="list-style-type: none"> ● Increase and mobilize funding for partnership research among industry, institutions, governments and Indigenous communities. ● Increase funding to support infrastructure upgrades that explicitly factor in future climate conditions and enhance climate change adaptation.
Policy and Regulation	<ul style="list-style-type: none"> ● Increase the frequency of maintenance and monitoring and develop extreme weather response plans. ● Develop policies to adopt climate risk frameworks to build sustainability and resilience principles into infrastructure projects. ● Undertake vulnerability assessments and implement standards for risk management and hazard mitigation ● Incorporate climate change into Hazard Identification Risk Assessments

The Adaptation Best Practices for the Infrastructure Area of Focus are presented in further detail as follows, organized by Level 1 category.

5.1 Overarching – Infrastructure

Table 5-4: Overarching Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Develop policies to adopt ENVISION Framework</p> <p>Consider policies that draw upon the principles of the ENVISION framework to build sustainability (including Adaptive Capacity) into new infrastructure and/or renewals projects. Similar to LEED, ENVISION consists of a guidance manual with sustainability/resilience criteria, project assessment tools etc. The framework is applicable to all types of civil infrastructure (including utilities, pipeline transportation, transportation, stormwater management, waste management, land management and buildings).</p> <p>A Grand Bend water treatment facility (Canadian Consulting Engineer, 2015) successfully employed the ENVISION framework; as well as stormwater and transportation infrastructure projects from the New York City Department of Design and Construction, Infrastructure Division (2019).</p>	Short Term	Provincial Government, Private Sector or Individual	[83] [84] [85]
2	Project or Program	<p>Incorporate climate change into Hazard Identification Risk Assessments</p> <p>Incorporate climate change vulnerability and risk analysis into the development of mandated Hazard Identification Risk Assessments (HIRAs) completed as part of Emergency Management planning as required under the Emergency Management and Civil Protection Act, R.S.O. 1990, c. E.9. The potential secondary and/or cascading effects of climate change are important to identify and understand, including the potential for disruption to downstream services and access to essential daily needs. The compounded effects of climate change alongside other major events such as an economic recession or global pandemic can also be deliberated through this framework.</p>	Short to Medium Term	Provincial Government, Municipalities and Indigenous Communities	[81] [82] [86]
3	Project or Program	<p>Incorporate climate change into asset management plans</p> <p>Consider actions that may be required to address critical vulnerabilities to municipal infrastructure assets (Ontario Regulation 588/17 – Asset Management Planning for Municipal Infrastructure). Consider the Federation of Canadian Municipalities' Guide for Integrating Climate Change Considerations into Municipal Asset Management (2020) in asset management planning. Additional guidance, tools and training to support municipalities and corporations on how to do this could be further developed.</p> <p>Integration of climate change and climate-related risks into asset management systems supports monitoring and decision-making efforts in order to arrive at the most cost-effective approach for designing and maintaining infrastructure systems. Adaptive management uses a structured, iterative process to address the uncertainties associated with climate change and the potential for extreme events. This may include increasing the frequency of maintenance and inspections of infrastructure as needed, given the increasing frequency of climate events. Consider extreme weather events when creating response plans.</p> <p>Example: Metrolinx's recommended adaptation process for 'Climate Resilient Transit Infrastructure Systems' involves obtaining flood mapping data from conservation authorities, engaging municipalities for urban flood risk estimates as well as broader climate change estimates, and conducting maintenance and monitoring of culverts, bridges, and embankments most vulnerable to climate extremes. With this information updated regularly, Metrolinx can quickly triage flooding situations and guide future development.</p>	Short to Medium Term	Provincial Government, Municipalities and Indigenous Communities	[81] [82] [86]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Project or Program	<p>Develop programs and/or provide funding to support a community of practice</p> <p>Develop programs and/or provide funding to support a “community of practice” for each of the major infrastructure asset categories. This could be developed, supported and operationalized through a central organization. A community of practice would bring together experts from different regions and levels of government and industry, focussing on critical infrastructure interdependence, identification of “fail safe” and “safe-to-fail” infrastructure configurations, lessons learned, new technologies, and green infrastructure opportunities.</p> <p>The federal Working Group on clean technology, innovation and jobs (2016) program is an example of a community of practice group that can provide recommendations to individual infrastructure sectors. One of the Working Group’s goals is to “work with Ministers responsible for municipal and urban affairs and, where appropriate, Ministers of Infrastructure to encourage municipalities to increase procurement and adoption of clean technologies and urban planning processes that support clean growth”.</p> <p>The Ontario Energy Community of Practice (2015-2016), an initiative developed between the Clean Air Partnership, is another example of a working group which focused on “providing education and capacity building for Ontario municipalities, utilities and other local stakeholders to develop and implement community energy plans, and helping connect local, regional and provincial energy planning initiatives.”</p>	Short Term	Provincial Government, Associations and Non-Government, Private Sector or Individual	[87] [88] [89]
5	Investment and Incentives Projects or Programs Research and Development	<p>Provide funding for partnership research opportunities</p> <p>Invest in programs that support partnership among industry, institutions, governments, and Indigenous Communities and organizations, to support research and development, as well as piloting and implementation of innovative adaptation solutions. Development of key performance indicators for different climate change adaptation initiatives could be made publicly available.</p> <p>For example, the US Environmental Protection Agency (EPA)’s Combined Heat and Power Partnership partners the EPA with industry (utilities, manufacturing companies, etc.) to promote Combined Heat and Power projects and support cost-effective emissions reductions in energy production.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia, Agencies	[SME]

5.2 Utilities

Table 5-5: Utilities Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Project or Program Policy and Regulation	<p>All Utilities: Fund a shared inventory and monitoring program</p> <p>Fund an inventory sharing program of key assets/components that would help expedite restoration in the event of damage, to manage risk during a natural disaster or climate disruption if the supply chain is impacted, which would limit capacity to repair or replace damaged infrastructure. A shared inventory would reduce the total number of each component needed on hand by individual utilities and offers a wider variety of components. For example, in the US, there is a group of utilities that share spare transformers.</p> <p>Additionally, utility infrastructure regulatory bodies may develop policies that require utilities to conduct close monitoring of inventory for system parts and maintenance capacity, with regularly updated inventory of spare parts.</p>	Medium Term	Provincial Government, Associations and Non-Government, Agencies	[90] [297]
2	Research and Development	<p>Electrical Generation; Transmission and Distribution; Telecommunications: Undertake post-event forensic investigations and decision-maker education</p> <p>Use methods such as post-event forensic investigations and targeted historical research to identify thresholds for failures and critical impacts. This will allow for classification of vulnerable systems and components, and provide an opportunity to make the necessary upgrades (including implementation of green infrastructure opportunities) in advance of a damaging climate event.</p> <p>Incorporation of education and capacity building for key decision-makers, using forensic investigations as evidence of critical climate impacts, may increase the potential of new infrastructure designs to include adaptation measures for climate change physical risks. Decision makers should also be advised of risks related to the transition towards a low carbon economy, and the opportunity to enable variable grid-tied renewable resources such as wind and solar.</p>	Short Term	Associations and Non-Government	[91] [92] [93]
3	Project or Program	<p>Electrical Transmission and Distribution; Telecommunications: Harden infrastructure</p> <p>Replace system components with more durable materials (e.g., concrete vs. wood poles) as part of renewal programs. Consider burying electrical lines if/where possible, as well as relocating poles and lines away from floodplains and/or falling vegetation risk. Remove fast-growing vegetation in accordance with best practices for natural environment management, install anti-galloping devices for winds, and invest in visual monitors to detect ice loading.</p>	Short to Medium Term	Associations and Non-Government	[91] [94]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Investment and Incentives	<p>Electrical Power Generation; Electrical Power Transmission and Distribution: Invest in system flexibility to accommodate changing demand</p> <p>Invest in technologies and programs that can increase flexibility in several ways, including:</p> <ul style="list-style-type: none"> • Demand side management and building energy efficiency incentive programs (e.g., New York City's Commercial and Industrial Energy Efficiency Program) • Improved equipment standards and increased energy efficiency requirements in the Building Code • Energy storage technologies • Distributed energy resources • Inter-regional transmission and communications • Smart grid technologies • Micro grid technologies <p>Increased system flexibility enables electricity systems to be more adaptable to climate change impacts and minimize service disruptions, and allows for the ability to adjust generation, transmission, and distribution systems to accommodate variable and unpredictable supply and demand in order to maintain reliable and cost-effective service. Utilities may consider setting top-down priorities, defining foundational investments, sizing and prioritizing investments, and articulating an energy plan's value. So far, utilities providers have implemented "smart metering" and "active charging management", examples of tools that can be implemented to reduce the load of utilities by allowing remote adjustments.</p> <p>The IESO incentive and investment programs are recommended to be reviewed on an intermittent basis to support integration of emerging technology and approaches that are more energy or cost efficient.</p>	Medium Term	Associations and Non-Government	[91] [95] [96]
5	Policy and Regulation	<p>Electrical Generation; Electrical Transmission and Distribution: Require climate risk planning</p> <p>Introduce new policies and/or regulations requiring utilities to account for climate change in resource and operations long-term infrastructure and energy planning. This might include conducting climate change risk assessments and updating them regularly. This increases capacity to address and to integrate climate risk considerations into planning processes. Effective implementation of this type of policy is likely to require additional guidance to allow utilities to evaluate cost-effective methods of integrating climate change adaptation into their planning and operations. Knowledge sharing between municipalities/public/private organizations and utilities, guided by the government, can ensure equal consideration of climate impacts.</p> <p>For example, the California Public Utilities Commission requires utilities to conduct climate risk assessments of assets and service delivery regularly.</p>	Medium Term	Provincial Government, Associations and Non-Government	[88] [97]
6	Policy and Regulation	<p>Telecommunications: Implement recommendations from CSA S37-18 Standard</p> <p>Implement the recommendations from new edition of CSA standard S37-18 for antennas, towers, and antenna-supporting structures, which provides updated guidance on the structural design, fabrication, and erection of new structures and the modification of existing structures. While not directly a response to climate change, this standard may be useful in the construction of new buildings to withstand the more unpredictable nature of winds brought about by changing climate conditions.</p>	Short Term	Associations and Non-Government	[SME]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	Policy and Regulation	<p>Sewage Treatment: Improve projection designs and monitoring</p> <p>Update and standardize Intensity-Duration-Frequency (IDF) curves that incorporate climate change projections to support design of sewage treatment facilities (e.g., Newfoundland and Labrador’s Standardized Updated IDF Curves). Develop policies and standard procedures to prioritize rehabilitations/repair during extreme climate events, and install insulation on walls of tanks to reduce impact from freezing events.</p>	Short Term	Provincial Government	[98]
8	Project or Program	<p>Sewage Treatment: Conduct Operator training related to climate risk management and preparedness</p> <p>Conduct new technology operator training on a regular basis to support mainstreaming of climate change knowledge and skills throughout a service provider team. Resources such as Kemira’s ‘How to treat wastewater in the climate change era’ and the results of Kirchhof and Watson’s survey ‘Are wastewater systems adapting to climate change?’ can be used as resources for training. Examples of actions for training include fabricating and installing temporary flood gates and flood proofing doors in advance of storms, and installing plugs for pump station vents to keep pump stations from flooding. Training on the benefits of green infrastructure and Nature-Based Solutions implementation and management to reduce flooding risk may also be considered.</p>	Short Term	Associations and Non-Government	[99] [100]
9	Policy and Regulation	<p>Sewage Treatment (Northern Communities): Adopt new and updated standards for Northern Region sewage treatment</p> <p>Adopt the CSA standard W203:19 which provides guidance for the planning, design, operation, and maintenance of wastewater treatment in Northern Communities using lagoon and wetland systems, and addresses effluent discharge in northern regions where it is either difficult to accomplish or not possible in colder months. This standard would be especially useful as spring thaws/runoffs become more unpredictable with climate change, as it was designed "to anticipate and accommodate climate change effects in northern Canada."</p>	Medium Term	Municipalities and Indigenous Communities, Associations and Non-Government	[101]
10	Policy and Regulation Project or Program	<p>Water Supply and Irrigation: Digitize the water sector to increase Adaptive Capacity</p> <p>Implement a digitization policy for water infrastructure, to increase Adaptive Capacity to manage increasing stresses from climate change. Digitization allows for:</p> <ul style="list-style-type: none"> • Efficient data collection for monitoring, forecasting and planning • Better management of water systems • Addressing sewage overflows • Addressing and eradicating emerging contaminants using sensors and monitoring systems • Integration of intelligent systems that can use machine learning to identify abnormalities in operational water processes <p>This technology can improve water management operations by integrating real-time data for impactful, evidence-based decision-making. Water managers can use the "Seven Stages of Digital Transformation" (adapted from the Smart Water Network Forum (SWAN) to digitally adapt water systems (including deploying sensors to advance metering infrastructure or cellular networks, collecting real-time data, and trialing new tools and solutions to improve asset planning). In addition, the WaterExe4.0 study on digitizing the water industry is ongoing in Germany and may provide guidance for implementation in Ontario. Retention of manual redundancies remains important in an increasingly digitized space.</p>	Medium Term	Provincial Government, Associations and Non-Government	[96] [102] [103]



	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
11	Policy and Regulation	<p>Water Supply and Irrigation: Decentralize water supply and irrigation systems</p> <p>Consider a decentralization policy approach for small, rural, and northern communities, to improve the ability to select and invest in updated climate resilient water systems. Guidance can be taken from the Government of Canada's Protocol for Decentralised Water and Wastewater Systems in First Nations Communities, the purpose of which is to "set minimum standards and codes that must be followed for the design, construction, operation, and maintenance of on-site water and wastewater systems that are to be funded in whole or in part by Indigenous Services Canada (formerly AANDC, Aboriginal Affairs and Northern Development Canada). The term decentralized system refers to a group or groups of band-managed (as opposed to individually-managed) on-site water or wastewater systems." This type of policy can be adapted for small and rural communities in Ontario.</p>	Medium Term to Long Term	Provincial Government, Municipalities and Indigenous Communities	[96] [104]

5.3 Pipeline Transportation

Table 5-6: Pipeline Transportation Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Pipeline Transportation: Maintenance and inspections</p> <p>Increase frequency of regular maintenance and inspections of green and engineered infrastructure. Consider extreme weather events in development of response plans.</p>	Short Term	Associations and Non-Government, Private Sector or Individual, Agencies	[81]
2	Projects or Programs	<p>Pipeline Transportation: Integrate risk management for climate-related risks</p> <p>Integrate climate-related risks into enterprise risk management categories that cover operational, financial, stakeholder and rights holders' consequences.</p>	Short Term	Associations and Non-Government, Private Sector or Individual, Agencies	[SME]

5.4 Transportation

Table 5-7: Transportation Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation Projects or Programs	<p>All Transportation: Climate risk assessment policy and guidance</p> <p>Continue to develop directives and guidance for incorporating climate resilience into engineering designs for transportation infrastructure projects, through the Ministry of Transportation. This would include support and encouragement for the development and adoption of tools and approaches that promote climate-adapted transport infrastructure and preservation of the natural environment, and into applicable professional Codes and Practices in partnership with PEO, OSPE, ESSCO, ONEIA, APGO and other stakeholders and rights holders. This would include standards and recommendations to be considered during highway, road and rail planning, design and construction.</p> <p>Example: the Province of British Columbia has published a technical circular which requires engineering design work to evaluate risk and include adaptation measures to the impacts of future climate change, weather extremes and climate-related events, as well as changes in average climate conditions. This policy applies to all new projects, as well as rehabilitation and maintenance projects.</p>	Short Term	Provincial Government, Agencies, Municipalities, Associations and Non-Government	[96] [105]
2	Projects or Programs	<p>All Transportation: Increased frequency of routine maintenance activities</p> <p>Conduct frequent routine inspections and monitoring of storm sewers and drainage capacities to evaluate and assess vulnerability of culverts and drainage systems against high flows and floods, as well as to impediments to animals/fish and degradation of natural systems. For airports in the far north, northeast and northwest regions, evaluate the capacity of wells to support fire protection loads.</p>	Short to Medium Term	Municipalities , Associations and Non-Government, Private Sector or Individual	[93] [106] [107]
3	Policy and Regulation	<p>Deep Sea, Coastal and Great Lakes: Policy to include climate change considerations in design</p> <p>Develop a Policy and Regulation that requires new marine transportation infrastructure designs and major rehabilitations to accommodate climate change projections, including a wider range of water levels and wave heights, as well as sea level change projections. Consider new technology, and green, grey and hybrid infrastructure options to help manage low and high-water events. The IPCC states, with high confidence, that “well-designed coastal protection is very effective in reducing expected damages and is cost efficient for urban and densely populated regions”.</p> <p>For example, Archimedes Screws (pumps) have been installed at several locks in Belgium, where low water events were determined to be a climate change risk. These pumps raise water levels during periods of drought/low water, and act as a bypass during periods of high water.</p>	Short to Medium Term	Provincial Government, Agencies	[108] [109] [110] [111]
4	Projects or Programs Policy and Regulation	<p>Roads and Bridges: Periodic monitoring and design criteria review</p> <p>Implement education and governance support programs to ensure structural sizing and capability are designed to handle debris during extreme precipitation events. Regulations requiring regular inspections and maintenance of culverts may be developed to monitor the stability of embankments, headwalls and wingwalls. Consider preservation of vegetation as a means of addressing embankment stability.</p> <p>For extreme temperature events on roads, a shorter service life could be considered during highway planning. For winter roads, ensure current engineering practices minimize both disturbance to the terrain and the impacts on structures. Chosen winter road locations should avoid thaw sensitive soils, and modern infrastructure should be designed to preserve thaw-sensitive permafrost, limit thaw settlement, and withstand thaw settlement where it does occur.</p>	Short to Medium Term	Provincial Government, Agencies, Municipalities, Academia	[112] [113]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Investment and Incentives	<p>Air Transportation: Funding to support infrastructure upgrades for climate change adaptation</p> <p>Expand existing funding programs or develop additional funding streams to support enhancements of air transportation infrastructure towards climate resiliency. Priorities for funding would include climate adaptation and reducing carbon emissions. An example of a successful program is the province of British Columbia's Aviation Infrastructure Funding program, which provides cost-sharing opportunities for infrastructure and environmental performance improvements. The program covers labour, materials, equipment, and signage. In addition, opportunities to leverage Federal aviation funding programs can be considered in the context of supporting local facilities that are critical for emergency response and for maintaining emergency services in the event of a major climate event. Examples of Federal programs include:</p> <ul style="list-style-type: none"> • The Transport Canada Airports Capital Assistance Program, which identifies the following key areas of focus: <ul style="list-style-type: none"> ○ improve regional airport safety ○ protect airport assets (such as equipment and runways) ○ reduce operating costs • The Transport Canada Transportation Assets Risk Assessment (TARA) Program, which specifically identifies climate adaptation and resiliency building as the core objectives of the funding stream. 	Medium Term	Provincial Government, Agencies	[114] [401] [402]
6	Projects or Programs Policy and Regulation	<p>Transportation: Adapt Northern transportation budgets to suit projected needs</p> <p>Adapt road maintenance budgets to allow for appropriate integration of climate change considerations, including winter maintenance and the managing the impact of increasing temperatures. Beyond accounting for snow clearance budgets, the long term upkeep of roads will need consideration. The design, construction, and maintenance of road infrastructure relies on historical probabilities of weather and climate risks. Historical temperature, rainfall, and snowfall records, as well as the probabilities of extreme events such as storm surges, are all included in planning for transport infrastructure. Changes in mean and extreme temperatures have been recognized as contributing to premature depreciation of transport assets. A previous study (Picketts et al. 2013) has identified four main areas of concern for transportation in Prince George: pavement surface deterioration (often attributed to increased winter freeze–thaw cycles), unsafe road conditions (particularly ice), increased salt use, and insufficient storage capacity for snow disposal sites.</p> <p>Climate warming has increasingly been recognized as a critical factor over the lifetime of major infrastructure projects in northern Canada, and has been incorporated in the engineering design and environmental impact assessments of such developments since the late 1990s. Current engineering practices, however, have the objective of minimizing both disturbance to the terrain and the impacts on structures. Locations are generally chosen to avoid thaw sensitive soils, and modern infrastructure is designed to preserve thaw-sensitive permafrost, limit thaw settlement, and withstand thaw settlement where it does occur.</p>	Medium to Long Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[324] [332] [333] [334]
7	Projects or Programs Investment and Incentives	<p>All Transportation: Diversify energy sources for traffic management signage, lighting and communications along transportation corridors and at remote facilities</p> <p>Invest in and install photovoltaic and solar energy to supply highway, interchange, and roadway illumination, signage, signals, and communications as well as for airports in remote areas, in the event of a power grid failure. Solar energy installations can also be used to provide a noise barrier along major highways, and provide redundancy to build resiliency to power-grid disruptions due to climate hazards and natural disasters.</p>	Short to Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[424]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
8	Projects or Programs Investment and Incentives	<p>Roads and Bridges: Establish roadside vegetation practices</p> <p>Implement roadside vegetation management practices to address stormwater runoff, erosion, and salt accumulation. Best practices developed for the Minnesota Department of Transportation include:</p> <ul style="list-style-type: none"> • Develop an integrated Roadside Management Plan; that includes consideration of safety, economic considerations, flexibility, environment, aesthetics, and public relations, as well as soil type, topography, and native vegetation species. • Establish sustainable vegetation using native grasses and wildflowers. • Control prohibited and restricted wild weeds • Manage living snow fences, using appropriate types of trees and crops to manage snow drift • Manage roadside vegetation for vehicle safety 	Short to Medium Term	Provincial Government, Municipalities and Indigenous Communities	[425]
9	Projects or Programs Investment and Incentives	<p>All Transportation: Invest in climate resilient communications</p> <p>Invest in communications and coordination systems that can be activated in the event of a major climate event or natural disaster. This would include:</p> <ul style="list-style-type: none"> • Making improvements to inter-agency coordination, information sharing about plans, initiatives, risks, resources, etc. (e.g., include key stakeholders in routine communications to streamline process during emergency events). • Hardening emergency telecommunications systems. • Investing in redundant communications systems. • Investing in redundant data servers. • Planning for siting and development of a disaster recovery centre. • Conducting practice exercises with coordinating agencies to develop communication protocols and emergency procedures, in order to maintain essential services e.g. paramedic and motor accident response. <p>For example, the Washington State Department of Transportation invested in improvements to wireless communications capabilities and communication redundancies between Traffic Management Centers (TMCs). The agency also filled in communication gaps to ensure continuous communication across rural areas in the event of an emergency.</p>	Short to Medium Term	Provincial Government, Municipalities and Indigenous Communities	[423]

5.5 Stormwater Management

Table 5-8: Stormwater Management Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Investment and Incentive Projects or Programs	<p>Stormwater Management: Update floodplain mapping</p> <p>Leverage available funding support to Indigenous Communities, municipalities and conservation authorities to update floodplain mapping with climate change projections, so that stormwater management calculations can be developed for projected future operating conditions. New technologies can be considered in updated mapping, including using more sophisticated models. Provide guidance in the form of updated technical documentation that outlines methodologies and tools to update flood hazard mapping studies with climate change information.</p> <p>In addition, there is an opportunity to develop a flood risk scoring system, as a collaboration among the provincial government, conservation authorities, municipal governments and Indigenous Communities, to establish flood risk scores for residential and commercial properties across the Province, based on address/postal code. A similar program exists in the United States (Risk Factor). This risk assessment and scoring tool can be used for wildfire risk and heat stress as well, and can be updated periodically based on climate change projections.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities, Academia, Agencies	[403]
2	Policy and Regulation	<p>Stormwater Management: Update design guidelines</p> <p>Update climatic load parameters in design guidelines to include consideration of climate change projections. Moving, retaining and treating water through stormwater management will see a change in type of precipitation event that needs to be accounted for in design, as the climate shifts.</p> <p>New and updated standards that can be used in design of new and renewed infrastructure include:</p> <ul style="list-style-type: none"> • CSA PLUS 4013:19 Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners (provides the reader with the ability to properly consider rainfall IDF characteristics in the planning and design of water infrastructure) • CSA W211 Management standard for stormwater systems • CSA S503:20 Community drainage system planning, design, and maintenance in northern communities 	Short Term	Provincial Government, Municipalities and Indigenous Communities	[115]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Projects or Programs	<p>Stormwater Management: Internal quality and management practices</p> <p>Associations and regulatory bodies could encourage use of new and updated guidance documents related to stormwater infrastructure management. These guidance documents consider best practice for quality management standards, and reduction of inflow and infiltration. Example actions include:</p> <ul style="list-style-type: none"> • Develop a stormwater quality management standard (QMS) in light of a changing climate (Engineers Canada, 2018) • Conduct climate risk and vulnerability assessment; integrate Climate Lens requirements into procurement documents for design and construction. • Stress test existing infrastructure to withstand future conditions (e.g., City of Ottawa’s Sewer Design Guidelines). • Consider a hierarchy of stormwater design interventions – prioritize retention and vegetated surfaces/systems (e.g., New York City’s Climate Resiliency Design Guidelines (2020)). • Use bylaws to enforce flood protection for private dwellings, including disconnection of downspouts and foundation drains to sanitary sewers (e.g., City of Thorold’s Sewer Use Bylaw (2011)). • Require monitoring plans and inspection reports to meet compliance obligations and ministry approval requirements, including CCTV inspection and reports (e.g., Halifax Regional Municipality’s Design and Construction Specification (2020)). • Conduct preventative maintenance, in addition to corrective maintenance (e.g., City of Calgary’s Stormwater Management and Design Manual (2011)). • Conduct regular internal audits to assess the system’s performance and identify opportunities for improvement (e.g. Metro Vancouver’s Integrated Liquid Waste Resources Management Plan (2010)). • Reduce the Risk of Inflow and Infiltration in New Sewer Construction (Robinson et al. (2019), developed for the Institute for Catastrophic Loss Reduction) 	Short Term	Provincial Government, Associations and Non-Government	[116] [117] [118] [119] 120] [121] [122] [123]
4	Investment and Incentives	<p>Stormwater Management: Funding and incentives for aging infrastructure retrofits</p> <p>Develop funding programs for retrofits and replacement of aging infrastructure, older communities and historic builds, to adapt their existing stormwater management infrastructure. For example, the Philadelphia government provides funding to non-residential owners to retrofit aging stormwater infrastructure that aligns with the Clean Water Act, requiring management and reduction of pollution runoff (Valderrama et al., 2012). One initiative is to discount future stormwater fees, where the savings from the discount can be used to invest in stormwater retrofits. To provide additional guidance for funding program development, the Southeast New England Program network (SNEP) is developing a Stormwater Retrofit Manual (currently in progress) to guide municipalities and consultants in retrofitting historic urban development with climate change considerations. Expand on programs like the Ontario Community Infrastructure Fund (OCIF), which provides funding for small, rural and northern communities to develop and renew their infrastructure.</p>	Medium Term	Provincial Government, Municipalities	[126] [127] [128] [317]
5	Projects or Programs	<p>Stormwater Management: Decouple drinking water and stormwater fees</p> <p>Consider decoupling municipal drinking water and stormwater fees and introducing a stormwater charge for developments. Higher permeability sites would pay less than those with lower permeability (which generate more stormwater runoff). The City of Toronto has undergone stakeholder consultation to discuss this option, and report results in the Round One Consultation Report.</p>	Medium Term	Municipalities, Private Sector or Individual	[129]



	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Policy and Regulation Project or Program	<p>Stormwater management: Land use planning for climate change</p> <p>Develop robust municipal policies requiring integration of best practices to respond to the threat of flooding and extreme precipitation. Some of the example policy actions could be to:</p> <ul style="list-style-type: none"> ● Require new developments or redevelopment projects to capture and infiltrate the first 1 or 1.5 inches of rain from any impervious portion of the development site. ● Offer fast-track development approvals to developments that meet more stringent stormwater design requirements (e.g., Province of Quebec’s approach to development approvals) and feature green infrastructure in designs. ● Adopt green and complete streets design standards. ● De-risk deployment of green infrastructure by: <ul style="list-style-type: none"> ○ Entering into community-based public-private partnerships to install and maintain green infrastructure. ○ Developing policies and/or programs that require or encourage consideration and deployment of green infrastructure assets to be incorporated in design of new and renewed developments. ● Add protection of natural flood attenuation features. Conserving Ontario’s wetlands is an important consideration as they play a key role in flood mitigation and sequestering carbon. Wetland conservation in Ontario is largely implemented through land use planning. Wetland conservation could also be integrated into watershed planning, water management and climate change mitigation and adaptation strategies. ● Modernize the measures that ensure the conservation of wetlands as it relates to the planning and integrated management of water resources, the environmental authorization scheme and natural heritage conservation measures. ● Apply Ontario’s Low Impact Development Stormwater Management Guidance Manual to inform understanding of design criteria and performance requirements (currently in draft form). ● Apply recommendations from Ontario’s Wetland Conservation Strategy <p>Additional recommendations can be found in ‘Weathering the Storm: Developing a Canadian Standard for Flood-Resilience Existing Communities’ (Moudrak and Feltmate, 2019) developed for the Intact Centre on Climate Adaptation.</p>	Medium Term	Provincial Government, Municipalities	[14] [124] [125] [126] [330] [331]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	Policy and Regulation Project or Program	<p>Flood Mitigation Infrastructure: Shoreline erosion protection</p> <p>Develop a policy and/or program to support the naturalization of shorelines for better erosion protection. This can be done with coastal, upstream and urban green infrastructure (e.g., native vegetation as erosion control), as well as combining green and grey infrastructure to maximize slope infiltration, bioengineering, and monitoring. In addition to naturalizing shorelines, explore potential infrastructure interventions for shoreline protection.</p> <p>Examples of shoreline erosion management programs include:</p> <ul style="list-style-type: none"> • The Toronto and Region Conservation Authority (TRCA) Don Mouth Naturalization and Port Lands flood protection project, where the site was a brownfield project that was naturalized with incorporated flood-protection infrastructure. • Lake Champlain case study (New York, Vermont, and Quebec) which was hit especially hard in spring 2011 by high snowmelt and intense rainfall. The Lake Champlain Basin Program developed a stormwater plan to increase the resilience of the impacted communities in two ways: <ul style="list-style-type: none"> ○ Reducing development in flood-prone areas. ○ Providing rivers with better access to their natural floodplains (by redefining "shorelines" across the region). <p>Additional resources include 'Rising Seas and Shifting Sands: Combining Natural and Grey Infrastructure to Protect Canada's Eastern and Western Coastal Communities' developed by the Intact Centre for Climate Adaptation (2021) for additional measures.</p> <p>While physical interventions tend to be the most common method of shoreline erosion control, these interventions could be coupled with policy to restrict development in shoreline areas, in alignment with international best practice.</p>	Short Term	Provincial Government, Agencies, Municipalities	[108] [130] [32] [132] [322] [323]

5.6 Waste Management

Table 5-9: Waste Management Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Waste Management: Implement recommendations from CSA R111 for northern communities</p> <p>Adopt the new standard CSA R111:21 Solid waste sites in northern communities: From planning to post-closure, which provides guidance on conducting overall risk assessments for infrastructure vulnerability and emergency response planning protocols for northern communities. Although specific to northern communities (Yukon, Northwest Territories, Nunavut, Nunavik), guidance may be useful in Northern Ontario, especially in areas underlain with permafrost.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities	[133]
2	Research and Development	<p>Conduct further research on international impacts, integrating potential climate impacts into a broader study of future global markets for key waste products</p> <p>Examine the business case for adaptation in the waste sector, and undertake vulnerability mapping to provide more detail on the current and future vulnerability of (current and planned) regulated sites to physical climate impacts.</p> <p>Conduct further research on the potential outcome of climate impacts (e.g. fire risk, changes to waste composition). Conduct an evidence review of the impact of past weather events on waste infrastructure. Conduct further research on international impacts, integrating potential climate impacts into a broader study of future global markets for key waste products. In any new waste strategy, include climate resilience alongside low carbon as two major drivers of future waste infrastructure. Conduct a policy study to review the key stakeholder relationships and procurement/service provision models.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-government, Private Sector or Individual	[325]
3	Policy and Regulation	<p>Integrate adaptation planning into Solid Waste Management Plans</p> <p>Integrate climate change adaptation planning into medium and long range waste management plans, considering the specific risks to the sector. Climate change impacts on solid waste management infrastructure and the surrounding environment may be temporary or long-lasting. Solid waste-related adaptation options include protecting critical infrastructure, reducing facility needs through recycling and demand management, and requiring waste treatment facilities to prepare adaptation plans. Key planning and policy directions could include:</p> <ul style="list-style-type: none"> ● Accommodation and Management Policy changes <ul style="list-style-type: none"> ○ Properly site landfills away from floodplains, wetlands, or areas with high water tables ○ Site landfills away from drinking water supplies ○ Develop sites large enough to accommodate projected population growth and corresponding waste generation ○ Design sites with sorting, recycling, and composting facilities to reduce waste storage needs ● Protection Policy Implementation <ul style="list-style-type: none"> ○ Update design standards to elevate and strengthen containment walls to accommodate future sea level rise and high winds ○ Design water catchment systems that can keep pace with projected rainfall patterns ○ Update equipment design standards to increase efficiency and reduce maintenance costs in changing climate, particularly for complex, HVACdependent equipment ● Retreat & Relocation <ul style="list-style-type: none"> ○ Plan for secure landfill closure and/or relocation ○ Plan for extreme event evacuation 	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-government, Private Sector or Individual	[379] [380] [381]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Policy and Regulation	<p>Integrate climate adaptation planning into Construction Operation Maintenance Program Activities</p> <p>Integrate climate change adaptation planning into the Construction, Operation, and Maintenance programs for waste management, with attention to the opportunities to achieve co-benefits between emissions reduction, environmental protection, and climate adaptation. Key policy directions and practices could include:</p> <ul style="list-style-type: none"> ● Accommodation and Management Policy changes <ul style="list-style-type: none"> ○ Increase financial and technical resources for more frequent maintenance and repairs ○ Train waste sorters and educate the public about separating recyclable and compostable material from other waste ○ Maintain collection vehicles to minimize disruptions due to mechanical failures ● Protection Policy Implementation <ul style="list-style-type: none"> ○ Prevent erosion of landfill slopes, covers, and roads into and around landfills. ○ Maintain storm water catchment systems to ensure proper function ● Retreat & Relocation <ul style="list-style-type: none"> ○ Cover threatened landfills and develop new sites in more secure locations 	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Private Sector or Individual	[379] [380] [381]



5.7 Buildings

Table 5-10: Buildings Infrastructure Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>All Buildings: Consider new and updated CSA standards in design of new buildings and major rehabilitations/renewals</p> <p>Encourage the use of new CSA standards and new editions of existing standards. Updated and new standards often incorporate climate change considerations, and could be reviewed for design of new buildings and for major rehabilitations/renewals. Examples of new editions and new standards and guidelines documents that include a climate change lens:</p> <ul style="list-style-type: none"> • CSA Z240.10.1:19 Site preparation, foundation, and installation of buildings (requirement to assess wind) • CSA S504:19 Fire resilient planning for northern communities (wildfire) • CSA S500:21 Thermosyphon foundations for buildings in permafrost regions (thawing permafrost) • CSA S501:21 Moderating the effects of permafrost degradation on existing building foundations (thawing permafrost) • CSA PLUS 4011:19 Technical guide: Infrastructure in permafrost: A guideline for climate change adaptation (thawing permafrost) • CSA S502:21 Managing changing snow load risks for buildings in Canada's North (snow loads) • CSA S505:20 Techniques for considering high winds and snow drifting and their impact on northern infrastructure (wind and snow) • CSA W204:19 Flood resilient design of new residential communities (extreme precipitation) • CSA W210 Prioritization of Flood Resilience Work in Existing Residential Communities systems <p>Additional guidance documents that hold recommendations that can also be more broadly considered for built assets include:</p> <ul style="list-style-type: none"> • Developing a method for conducting wildland/urban interface fire case study research: A foundational document (wildfire) (Institute for Catastrophic Loss Reduction, 2020) • Weathering the storm: Developing a Canadian standard for flood-resilient existing communities (extreme precipitation) (Moudrak and Feltmate, 2019) • Preventing disaster before it strikes: Developing a Canadian standard for new flood-resilient residential communities (extreme precipitation) (Moudrak and Feltmate, 2017) • Consider sustainable development initiatives such as LEED building standards and Low Impact Development (LID) as well as adaptation measures presented in Ahead of the Storm: Developing Flood-Resilience Guidance for Canada's Commercial Real Estate (Moudrak and Feltmate, 2019), related specifically to flooding risk. 	Short Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[122] [125] [134] [135] [136] [137] [138] [139] [140] [141] [92] [148] [149]
2	Project or Program	<p>All Buildings: Support for vulnerability assessments (including energy and water audits) of buildings</p> <p>Develop a program to support the development and adoption of tools and approaches for conducting climate change vulnerability assessments on new and existing buildings. Methods could be incorporated into applicable professional Codes and Practices in collaboration with stakeholders (e.g., PEO, ESSCO, ONEIA, BOMA, etc.). Several government-produced resources exist to support vulnerability assessment development for infrastructure, including the ICLR/CRI's Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol, the Infrastructure Canada's Climate Lens program, and FEMA's Resources for Climate Resilience.</p>	Short Term	Provincial Government, Agencies	[96] [142] [143] [144]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Policy and Regulation	<p>All Buildings: Promote adoption of newest editions of the National Model Codes</p> <p>Prioritize adoption and integration of the newest editions of the National Model Codes through Canada's national model codes development system, and work with building industry stakeholders to integrate understanding of the importance of a tiered code system and co-benefits of adopting a net zero emissions component to the building code regarding energy efficiency. This is being done in other jurisdictions around the world, such as New Zealand, Australia, the United States and other provinces in Canada.</p> <p>Specific examples include the Climate Resilient Buildings and Core Public Infrastructure (CRBCPI) Initiative in Canada, designed to integrate climate change resilience into infrastructure codes and standards at the federal level to ensure flood-resilient construction. In Australia, the Commonwealth Science and Industrial Research Organisation (CSIRO) is undertaking a "climate scan" of the National Construction Code (NCC) to determine where modifications are needed to ensure more resilience in future buildings.</p>	Short Term	Provincial Government	[145] [146]
4	Policy and Regulation	<p>All Buildings: Update zoning regulations</p> <p>Update municipal zoning regulations to incorporate future climate projections, for instance by modifying existing zoning restrictions to factor in the greater intensity, frequency and/or duration of certain climate hazards and minimize impacts from flooding. Zoning updates and regulations have been implemented in communities across Canada (e.g., Beaubassin-est, NB), to reduce or prohibit development in high risk zones, like flood prone areas. NRCan's Land use planning tools for local adaptation to climate change provides recommendations and case studies related to planning tools being used across Canada to help communities prepare for climate change.</p>	Short Term to Medium Term	Municipalities	[147]
5	Policy and Regulation	<p>Housing Buildings: Backup power</p> <p>Establish and implement a minimum backup power guideline in development of new housing (multi-unit residential buildings). The City of Toronto's Minimum Backup Power Guidelines for MURBs: Voluntary Performance Standards for Existing and New Buildings is an example of this.</p>	Short Term	Municipalities and Indigenous Communities	[150]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Project or Program	<p>Public Buildings: Lifecycle costing to incorporate climate change</p> <p>Consider adopting a whole lifecycle costing (LCC) approach to make or improve the business case for climate adaptation measures in infrastructure design and development. For example, capital building budgets need to consider taking on higher capital costs upfront to achieve lower operational costs over the lifecycle of the asset. Net present value (NPV) calculations for new assets should also account for the rising costs of energy, Building Code updates, etc. The LCA² initiative (Low-Carbon Asset through life cycle assessment) under the National Research Council of Canada is an example of putting this into practice (nrc.canada.ca/en/research-development/research-collaboration/programs/low-carbon-assets-through-life-cycle-assessment-initiative). The LCA "will develop important outputs that create a science-based approach to support the selection of materials and designs that offer the lowest carbon footprint while offering the lowest total cost of ownership". British Columbia also has a Climate Action Toolkit with a Life Cycle costing tool specifically designed for local government use.</p> <p>Boussabaine and Kirkham (2004) stressed the importance of performing risk analysis in construction investments when applying whole LCC. The key intent was to ensure there is improved accuracy in the assessments of effectiveness of projects over the long-term. The essence of undertaking whole-life appraisals for construction, as discussed by Flanagan, et al. (2005) entails are view of all costs that encompass the capital costs of a project, as well as the running and maintenance costs, in order to satisfy the requirements of those clients who are seeking maximum value for money. Going forward, Sterner (2000) suggests that LCC must evolve to become a holistic concept to account for 'full-cost', taking into consideration environmental and social costs as well. Indeed, the main findings of the review have provided evidence for a need to take a new direction for research.</p> <p>Building Information Modeling (BIM) could be instrumental in driving overall costs down in future since this tool is expected to change the way information is managed in the construction industry. BIM might be a vehicle for achieving value in LCC (Race, 2013). However, specific functionality with data requirements for LCC (e.g. escalated costs and present value costs, discount rates and study periods or assumed lifespans) have to be incorporated into the BIM model. This could provide cost estimators with the ability to generate the quantities, cost them and calculate the LCC. Kehily, McAuley, and Hore (2012) had produced a whole-life cost analysis tem-plate that can be built in to provide four-dimensional BIM users with the financial tools to select the most economical and sustainable building solution.</p> <p>Empirical results have shown that whole-life cost performance can be significantly affected by how users interact with the building over its lifespan (Mithraratne, Vale, & Vale, 2007; Mithraratne & Gabe, 2010). Post-occupancy empirical assessments of whole-life cost are rare in practice. Therefore, there is a strong basis for future research to develop knowledge in the area of 'sustainable living'. There is a crucial need to look beyond the design and construction phases to study what happens once the building is occupied, particularly the behaviours of users and their impact on operating costs, to trace the causes to justify revisions to the original budgetary plans.</p>	Short Term to Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia, Agencies	[151] [152]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	Policy and Regulation Project or Program	<p>Public Buildings: Building renewal policy and guidelines</p> <p>Introduce policy/guidelines that provide design guidance for rehabilitation or replacement of public buildings in order to better withstand future climate change impacts. The City of Toronto’s Tower Renewal Program is an example of a program that considers different retrofit approaches to aging buildings and building components, that include improvements for building energy use and tenant comfort. For example, the Ken Soble Tower (built in 1967) was recently improved under the Tower Renewal Program; the building’s thermal regime was flawed; the resulting impact from the renewal program was a more sustainable building that has the capacity to better adapt to climate change impacts.</p> <p>Climate Adaptive Building Shells (CABS) offer a high potential to reduce the energy demand for lighting and space conditioning. At the same time, also positive contributions to indoor air quality and thermal and visual comfort levels can be expected. (e.g. Switchable windows, which are suitable for retrofit projects, where not only the relative impact, but also the potential number of projects is high).</p> <p>Adapting buildings and cities for climate change: a 21st century survival guide (Roaf et al., 2009) outlines government actions that can be taken to improve community resilience to climate change impacts. These include Implementing risk appropriate land use planning legislation harmonized across all jurisdictions to prevent inappropriate development on land subject to inundation (e.g. no residential or commercial development should occur on land currently subject or predicted to be subject to a 1 in 50yr return period of inland flooding unless mitigation works have been carried out to maintain a 1 in 100yr risk exposure limit).</p>	Medium Term	Provincial Government, Municipalities	[153] [154] [345] [346]

6.0 Natural Environment Adaptation Practices

Ontario's natural environment consists of three distinct ecozones, based on ecology, climate and geology: Hudson Bay Lowlands, Ontario Shield, and Mixedwood Plains. Each region has unique ecosystems and pressures posed to the natural environment. For example, Southwest Ontario is in the Mixedwood Plains ecozone, has high human population density while containing one-third of the rare, threatened, and endangered species found in all of Canada.

Each of the regions across Ontario faces unique threats and challenges from the effects of climate change. Species and habitats are irreplaceable, and the services that ecosystems provide to Ontario communities are challenging and costly to replicate via engineered or technical solutions, if possible, at all. A healthy and resilient natural environment, therefore, is essential to adapt to a changing climate.

The Natural Environment is broken down into the following seven Level 1 categories, defined to cover the intrinsic value of nature and biodiversity, natural resources, and values important to humans.

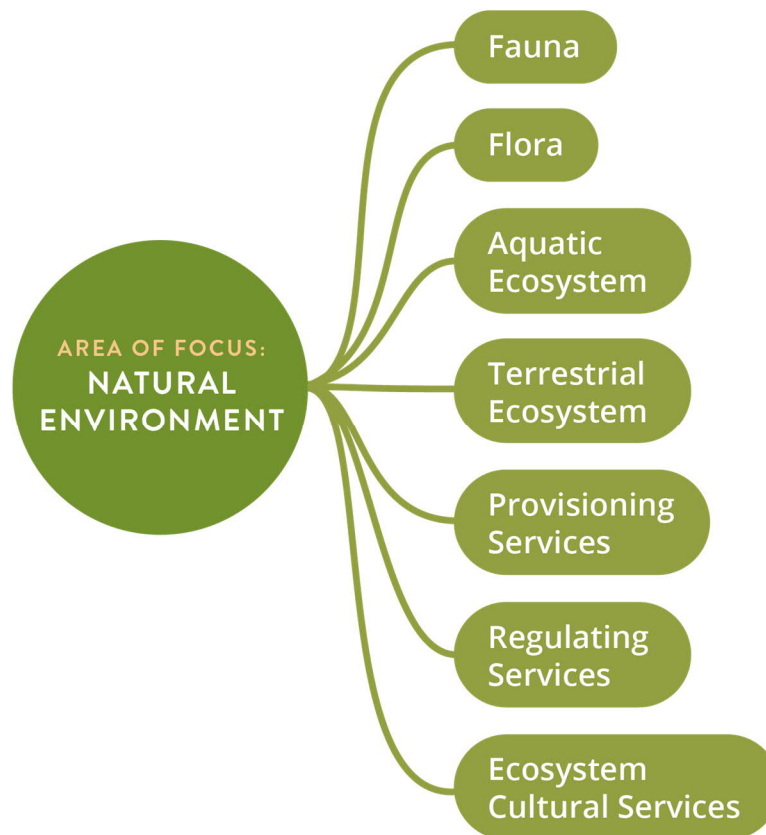


Figure 6-1: Natural Environment Area of Focus Level 1 Categories

All Level 1 and Level 2 industries as part of Natural Environment have been assessed to have a medium Adaptive Capacity level, indicating some potential to undertake appropriate adaptation actions across industries as highlighted in Table 6-1 and Table 6-2.



Table 6-1: Current Natural Environment Adaptation Priorities

Current Level 2 Priorities	Region	Risk Score	Adaptive Capacity
Fish	Central, Far North	High	Medium
Waterfowl	Central	High	Medium
Bogs	Northeast, Northwest, Far North	High	Medium
Mudflats	Far North	High	Medium
Carbon Storage	Northeast, Far North	High	Medium

Table 6-2: Emerging Natural Environment Adaptation Priorities by Mid-Century (RCP8.5)

Emerging Level 2 Priorities	Region	Risk Score	Adaptive Capacity
Birds	Central, Northeast, Northwest	High	Medium
Insect/Spider	Central, Northeast	High	Medium
Mammals	Central, Northeast, Northwest, Far North	High	Medium
Migratory songbirds	Central, Northeast, Northwest, Far North	High	Medium
Reptile	Northeast	High	Medium
Lichen	Northwest	High	Medium
Vascular plant	Central, Northeast, Northwest	High	Medium
Marsh	Central, Northeast, Far North	High	Medium
Coniferous Forest	Northeast, Northwest, Far North	High	Medium
Deciduous Forest	Central, Northeast, Northwest	High	Medium
Sand Barren and Dune	Central	High	Medium
Tallgrass Savannah	Central	High	Medium
Freshwater Provision	Central, Northeast, Northwest, Far North	High	Medium
Wood Supplies	Central	High	Medium
Carbon Storage	Central, Northwest	High	Medium
Pollination	Central	Very High	Medium
Water Flow Regulation	Central	High	Medium
Coniferous Forest	Northeast, Northwest, Far North	High	Medium
Deciduous Forest	Central, Northeast, Northwest	High	Medium
Sand Barren and Dune	Central	High	Medium
Tallgrass Savannah	Central	High	Medium
Nature-Based Recreation	Central, Northeast, Northwest	High	Medium
Recreational Fishing (Angling)	Central, Northeast, Northwest, Far North	High	Medium



The ABP Report provides a range of potential best practices for Natural Environment, as summarized in Table 6-3.

Table 6-3: Areas for Natural Environment Climate Adaptation

Adaptation Category	Examples of Adaptation Measures
Projects or Programs	<ul style="list-style-type: none"> ● Maintain, promote and enhance ecosystem connectivity. ● Ensure Indigenous Knowledge informs new and enhanced regulations and management practices. ● Develop a provincial framework to study variation in species demographics rates to track trends and conservation goals. ● Develop a policy to manage and monitor changing species ranges. ● Restore and manage ecosystems to recover biodiversity and ecosystem services, and enhance resilience. ● Develop collaborations among communities and support Indigenous-led conservation.
Research and Development	<ul style="list-style-type: none"> ● Develop education resources for forest and urban forest managers.
Investment and Incentives	<ul style="list-style-type: none"> ● Invest in research and Indigenous-led community-based monitoring and research programs. ● Prioritize ecosystem restoration, and the protection and preservation of intact or high functioning ecosystems. ● De-risk green infrastructure implementation and invest in education.
Policy and Regulation	<ul style="list-style-type: none"> ● Protect and strengthen the Conservation Authorities Act (CAA) and Environmental Assessment Act (EAA). ● Protect riparian zones along water bodies, wetlands and stream corridors. ● Develop a policy and/or related program for climate refugia protection and management. ● Conserve peatlands and other carbon-dense ecosystems as globally-important ecosystems. ● Develop provincial policy for landscape management to support assisted migration and re-establishment.

The following adaptation actions provide an overview of some key opportunities to address the highlighted risks to the natural environment in Ontario, and build Adaptive Capacity in the province.

6.1 Overarching – Natural Environment

Table 6-4: Overarching Natural Environment Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
2	Policy and Regulation	<p>Protect riparian zones along water bodies, wetlands and stream corridors</p> <p>Enhance the existing regulations (e.g., Conservation Authority Act) for the protection and management of riparian forests and wetlands through the promotion of best management practices and management of development activity with consideration of climate change. Ensure Indigenous knowledge is ingrained into new and enhanced regulations and management practices. Vegetated riparian zones help to regulate stream and lake temperatures by attenuating surface flow and providing shade; as well as increase landscape connectivity for the migration of species. Riparian wetland/stream corridors are vital points of nutrient cycling and provide important life cycle requirements for a variety of species at the intersection of aquatic and terrestrial habitats.</p> <p>Existing policy and guidance documents include the Evaluation, Classification and Management of Headwater Drainage Features (TRCA & CVC 2014), and the Living City Policies (TRCA 2014) that protect Valley and Stream Corridors and could be adapted and applied to other geographies, including the far north. In addition to various municipal Official Plan policies, the Greenbelt Plan and Oak Ridges Moraine Conservation Plan also provide protection for Key Hydrologic Features (which include intermittent watercourses), along with the Growth Plan (outside of settlement areas) and the Lake Simcoe Protection Plan which provide protection. All these policy documents recommend that the minimum vegetation protection zone shall be a minimum of 30 meters for key hydrologic features and fish habitat. Fish Habitat as defined in the Fisheries Act and that applies to these plans is: “water frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply, and migration areas”. The supporting policy Fish and Fish Habitat Protection Policy Statement identifies lakes, ponds, rivers, streams, wetlands, and associated riparian lands areas as fish habitat.</p> <p>The Natural Heritage Reference Manual (NHRM) also provides guidance to municipalities recommending vegetated buffers adjacent to key natural heritage feature such as fish habitat. In addition, on the basis of MECP’s Lakeshore Capacity Assessment Handbook, Provincial policy currently recommends that generally there be no new lot creation or other planning approvals for new or more intense residential, commercial or industrial development within 300 metres of the waterbody where it has determined a lake trout lake is at capacity for shoreline development.</p> <p>In the managed forests of Ontario, ‘The Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales’ is used by forest managers when planning and implementing operations involving harvest, renewal, tending, or the construction and use of roads and landing on crown land in Ontario. Aquatic, wetland and shoreline values, special habitat features, and habitat for species at risk are addressed through the development of area of concern prescriptions or conditions on regular operations.</p> <p>An example of management tactic to implement under this approach would be to plant native trees and shrubs in order to maintain cooler stream temperatures and stream shading. Another example focused at a landscape level could include the reforestation of riparian areas in agricultural areas to reduce erosion into adjacent water bodies and maintain cooler stream temperatures. As mentioned above, these types of tactics are being used by various agencies in Ontario; however enhanced regulations and guidance that prioritizes climate change can promote effective adaptation across the Province.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[209] [210] [321]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	<p>Policy and Regulation</p> <p>Projects or Programs</p>	<p>Develop a policy and/or related program for climate refugia protection and management</p> <p>Develop a policy and/or program within existing resource and land management frameworks, to guide the identification, protection, and management of climate refugia. There have been a number of studies supporting climate refugia as a means to support biodiversity in the 'slow lane' (Morelli et al., 2020), indicating that buffering from climate change has the potential to reduce the risks and negative impacts to native species and sensitive ecosystem with both short and long term benefits. There are a number of factors to consider in the identification of climate-change refugia, including ecological complexity, scale, and species traits, climate projections, and landscape factors.</p> <p>An Ontario-based policy or program for managing climate refugia would consider protected area systems and forest management planning and practices, drawing on established programs and available guidance for instance from the Commission for Environmental Cooperation, and research such as the review and methodology on climate refugia identification presented by Graham et al. (2020) on the boreal biome in North America.</p> <p>Develop a community of practice that allows for communication and knowledge sharing among Indigenous Peoples, forest managers, municipal governments, landowners, stakeholders and rights holders. Refugia protection and management is being done by conservation authorities, forest managers, woodlot owners, Indigenous Peoples, etc. individually – however a policy statement or policy enhancement could allow for more effective refugia protection and management across the whole province.</p> <p>Generation of meaningful policy and programs will require engagement and involvement from many stakeholders and rights holders across the Province. Examples of program inclusions are: incentives for land managers and owners, developing land trusts, using the expertise of conservation authorities and environmental NGOs and Indigenous organizations, communicating with municipal and provincial government agencies to conserve and protect important refugia opportunities, identifying priority areas that would be suitable for ecosystem restoration to support particular habitat or species health and mitigate climate risks, etc. Additionally, Traditional Ecological Knowledge (TEK) should be considered in a refugia policy/program. In particular, an integrated approach can be implemented in Federal or Provincial Parks/managed lands in conjunction with Indigenous communities.</p> <p>An important aspect of a refugia policy or program relevant to Ontario's Far North would be rooted in protection of existing climate refugia, and identification of additional areas through Community Based Land Use Planning currently being conducted in collaboration between communities and the Ministry of Natural Resources and Forestry through the Far North Act. Concerted efforts could be made to create partnerships, agreements and other mechanisms for land protection across property boundaries.</p> <p>An example from the US Forest Service's climate change refugia conservation cycle involves the following steps:</p> <ul style="list-style-type: none"> ● Define planning purpose and objectives (identify focal resources, study area, and time horizon) ● Assess climate impacts and vulnerabilities ● Review/revise conservation goals and objectives ● Identify and map key refugia features (consider scale and connectivity) ● Evaluate and prioritize refugial areas for specific management ● Identify and implement priority actions to manage climate change refugia ● Monitor the effectiveness of refugia, realign objectives accordingly 	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia	[211] [212]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	<p>Projects or Programs</p> <p>Policy and Regulation</p>	<p>Maintain, promote or enhance ecosystem connectivity</p> <p>Maintain, promote and enhance ecosystem connectivity to enable species migration across the landscape and buffer against disturbance. This will require a concerted effort to create partnerships, agreements, and other mechanisms for land protection and management across property boundaries. Coordinating forest conservation easements and certification programs, and other efforts to increase the size and connectivity of forests will foster a landscape-level response to counter the widespread effects of climate change. Establishing management agreements across boundaries of reserves and managed forests will also allow for protection of species moving across the landscape.</p> <p>There are many types of natural and semi-natural (e.g., agricultural fields/pasture) that can facilitate species' movements across a landscape. For example, riparian corridors tend to be a critical linear feature in built-up landscapes. The type of natural or semi-natural features in built-up landscapes that enable movement (in varying degrees of ease) could be identified and prioritized for such things as protection or restoration. Coordinating forest conservation easements and certification programs, and other efforts to increase the size and connectivity of forests "and other land types", will foster a landscape-level response to counter the widespread effects of climate change.</p> <p>In addition to terrestrial ecosystems, maintain, protect or enhance aquatic ecosystem connectivity (e.g. dams and barriers to movement and their removal; measures for re-establishing connectivity in aquatic ecosystems).</p> <p>Maintain, promote and or enhance ecosystem connectivity to enable species migration across the landscape and buffer against disturbance. This could include:</p> <ul style="list-style-type: none"> • A concerted effort to create creating partnerships, agreements, and other mechanisms for land protection and management across property boundaries, e.g. Coordinating forest conservation easements and certification programs, and other efforts to increase the size and connectivity of forests will foster a landscape-level response to counter the widespread effects of climate change. • Establishing management agreements across boundaries of reserves and managed forests will also allow for protection of species moving across the landscape. • Exploring opportunities throughout the province to the Far North, where the focus would be on programs to protect and preserve existing and intact ecosystems through land use planning, natural heritage systems planning, land securement and other mechanisms. These ecosystems are of high ecological and cultural integrity, and are of significant importance in this region, and for Canada as a whole. • Exploring opportunities for identifying ecological corridors, as well as for restoring connectivity in fragmented landscapes such as southern Ontario. 	Short Term	Provincial Government, Agencies, Communities, Associations and Non-Government, Private Sector or Individual	[209] [210] [219] [213]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Projects or Programs	<p>Restore and manage ecosystems to recover biodiversity and ecosystem services, and enhance resilience</p> <p>Strategically advance and invest in concerted efforts to restore ecosystems by incorporating climate considerations into ecological restoration planning. This could include drawing on the Society for Ecological Restoration (SER)'s International principles and standards for the practice of ecological restoration, which lays out a structured approach to restoration project planning and management, and is relevant for climate change adaptation and invasive species considerations. The principles provide guidelines with regards to project oversight needs in order for a project to be classified as "restorative", including the following principles:</p> <ul style="list-style-type: none"> • Engages stakeholders • Draws on many types of knowledge • Is informed by native reference ecosystems, while considering environmental change • Supports ecosystem recovery processes • Is assessed against clear goals and objectives, using measurable indicators, seeks the highest level of ecosystem recovery possible • Gains cumulative value when applied at larger scales • Is part of a continuum of restorative activities <p>Standards of practice are also included for different sectors (included protected area management, forestry, fisheries, etc.), as well as a list of global restoration initiatives (including the Convention on Biological Diversity, the Bonn Challenge, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, etc.)</p>	Short Term	Provincial Government, Agencies	[214]
6	Policy and Regulation	<p>Conserve peatlands and other carbon-dense ecosystems as globally-important ecosystems</p> <p>Develop policies and/or regulations for the conservation of peatlands in northern Ontario. Conservation of these ecosystems is a critical nature-based solution for climate change, particularly given the role of peatlands as critical carbon sinks, as only 10% of Ontario's peatlands are currently protected and existing peatlands are in some cases under threat from mining and other extractive activities. Policy would focus on avoidance of disturbance, with a focus on Indigenous stewardship and identification of peatland areas that are suitable for greater protection as an important mechanism for managing impacts from human activity (Wildlife Conservation Society Canada, 2019).</p> <p>Review the Far North Advisory Panel's Science for a Changing Far North report, containing recommended protection actions, as well as Smart Prosperity Institute's 2021 Policy Brief on Protecting Northern Peatlands.</p>	Short to Medium Term	Provincial Government, Agencies, Communities, Academia	[217] [376] [377]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	<p>Policy and Regulation</p> <p>Projects or Programs</p>	<p>Promote well managed protected areas</p> <p>Support strategically placed and managed protected areas to increase important ecosystem functions such as connectivity, habitat for climate refugia, protection of riparian zones, protection of carbon-dense ecosystems, sustaining dwindling populations of flora and fauna, and improving ecosystem services such as improved watershed quality and the improvement of human health and culture. Managed effectively, protected areas can play a role in climate change mitigation and adaptation. Targeting the conservation of ecosystems which are carbon dense may allow for sequestered carbon to remain stored and prevent future emissions from being emitted into the atmosphere.</p> <p>Many protected areas in Canada, and throughout North America, have been managed in a way that views humans as separate from the natural environment and sees any form of human action within a protected area as negative, and much of the activity outside of this area as widely acceptable. Often, protected areas managed using this “fortress conservation” method have come short of reaching conservation goals.</p> <p>Therefore, it is important to ensure that land stewardship is approached from a holistic perspective, such that traditional and Indigenous relationships with the land are preserved, and that stewardship extends outside the bounds of established protected areas. Protected areas are defined by geographically-defined areas which are recognised as being protected, and their permanence and tailored management present a significant advantage over unrecognized areas. Protected areas can have a sizable benefit for both the mitigation of and adaptation to climate change.</p>	Medium Term	Provincial Government, Agencies, Communities	[339][340]

6.2 Flora and Fauna

Table 6-5: Flora and Fauna Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	<p>Projects or Programs</p> <p>Policy and Regulation</p>	<p>Coldwater and Coolwater Fish: Integrate climate impacts into fisheries management and policy, including using climate-informed water temperature models to help prioritize restoration and conservation and to manage fish species and populations</p> <p>Consider the development and use of species-specific water temperature models and decision support tools to support prioritization of conservation efforts and management techniques for coldwater fish and their habitat, including refugia. This will help to invest resources on coldwater restoration/protection in areas that have a high likelihood of success and support modifications to management techniques in a changing climate. Water temperature models were successfully used in Fourchue River, Quebec, where summer temperature was modelled under climate change scenarios, in order to determine when cold water releases would be necessary to keep temperatures under Upper Incipient Lethal Temperature (UILT).</p> <p>The models are a tool to achieve integration of climate change into managing fish and fish habitat, to be supplemented with policies to inform restoration and conservation efforts.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government	[218] [219] [220]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
2	Projects or Programs	<p>Mammals: Develop/expand upon a provincial framework to study variation in demographic rates to identify trends and conservation goals</p> <p>Develop a provincial framework or adopt an existing one for population monitoring of fauna populations across the Province, prioritizing species at risk. Modeling impacts of species shifts and other climate impacts will strengthen the ability to develop successful management practices. For example, the North American Bat Monitoring Program (NABat) can be used as a Canadian/Ontarian sampling framework for bats, specifically. It may be able to be adapted to other fauna and/or flora as well. Review existing programs for usefulness and expansion capacity such as the Ontario Biodiversity Council's Monitoring and Reporting Indicator. Ensure TEK is included in the provincial framework development.</p> <p>Resource managers should understand the variation in demographic rates (survival, fecundity) to identify trends and shifts in populations, which will help to identify conservation and management goals. Understanding demographics and trends (e.g., south to north) will also support management of populations through disease and other impacts that are projected with climate change. Incorporation of TEK will support these efforts.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government	[215] [221] [222] [318]
3	Projects or Programs	<p>Mammals: Adapt/ expand on a provincial management and monitoring program for Caribou</p> <p>Adapt existing management and monitoring programs for Caribou in the north. This program would include effective harvest monitoring, predator control management, and land use planning recommendations and/or regulation to protect remaining herds – and would be developed with inclusion of Indigenous Knowledge. Engagement with the public and local communities (Indigenous and non-Indigenous) and governments could be planned, in order to support collaborative decision-making regarding territory impact (e.g., forestry, hydrocarbon exploration, motorized winter recreation, unsustainable harvest, etc.). The distribution and abundance of predators, alternate prey, and parasites or diseases will likely be impacted by climate change. Effective monitoring can identify trends and support management and decision-making changes.</p> <p>Management approaches based on the best available science, TEK and augmented by precautionary assumptions should underlay the program. These approaches should be integrated across the disciplines of forestry, wildlife management, and sociology. A comprehensive ecosystem-based approach to management of the forest landscape may be essential for the survival of both caribou and the forest industry.</p> <p>Guidance can be taken from the collaborative caribou monitoring project led by the Dene Tha' First Nation in Northern Alberta.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[18] [223] [224]
4	Policy and Regulation	<p>Mammals: Develop or expand a policy to manage species ranges</p> <p>Develop a policy framework to manage changes to species ranges (range expansion or range decline) due to a changing climate, specifically where competition between species may become more common. An extension of Ontario's White-tailed Deer Management Policy that prioritizes range shifts under climate change is an option for a policy expansion. For example, climate change is modifying deer and moose populations in the favour of deer, as elevated deer populations put stress on moose populations due warming temperatures and elevated disease risk. An updated or expanded policy framework would allow for the management of deer populations in Cervid ecological zones that are supposed to support moose populations, including removing deer heavily on the northern expanding edge of their range to reduce the risk of disease spread to moose populations, and to reduce the risk of deer supporting higher wolf populations in moose range.</p>	Medium Term	Provincial Government, Agencies, Indigenous Communities	[225]
5	Projects or Programs	<p>Expand the existing Broad-Scale Monitoring Program to include rivers and streams and develop an Ontario Rivers and Streams Climate Change Database</p> <p>Look into developing a provincial rivers and streams monitoring program, similar to the Ministry of Natural Resources and Forestry (MNRF)'s existing Broad-Scale Monitoring program that supports management of Ontario's inland fisheries, as well as the development of an associated database to support future planning, alongside ongoing monitoring and reporting.</p>	Medium Term	Provincial Government, Agencies, Indigenous Communities	[SME]

6.3 Aquatic and Terrestrial Ecosystems

Table 6-6: Aquatic and Terrestrial Ecosystems Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	<p>Projects and Programs</p> <p>Research and Development</p>	<p>Wetlands: Prioritize ecosystem restoration, and/or protection and preservation, including monitoring and evaluation</p> <p>Restore wetlands ecosystems to expand areas that provide protection from climate change impacts, and monitor changes to the hydrologic cycle, including drought and invasive species, which are stressors on these systems. Consider implementing a province-wide monitoring program to better understand the state of wetlands (including bogs and mudflats) across the Province, and to establish a baseline for prioritization of restoration and/or protection.</p> <p>The Proper Functioning Condition (PFC) methodology provides a standard checklist to assess wetland function; this methodology can be used in conjunction with TEK (e.g., PFC and Traditional Knowledge – Working Together for Tribal Sustainability). Financial analysis of wetland function can be considered in protection, preservation and restoration pursuits, e.g., as described in The Intact Centre on Climate Adaptation 2022 report 'Getting Nature on the Balance Sheet'.</p> <p>Large-scale medium and long-range planning efforts can be considered for implementation, such as the Monitoring of Lake Ontario coastal wetland habitat in support of Adaptive Management program, in conjunction with existing public education programs implemented by conservation authorities across Ontario. This can be supported through funding such as the Government of Canada's Nature Smart Climate Solutions fund (e.g., Conservation Ontario is currently managing \$9 million in funding for conservation authorities across Ontario, through the Nature Smart program).</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government	[216] [226] [228]
2	<p>Research and Development</p> <p>Investment and Incentive</p>	<p>Deciduous and Coniferous forests; Carbon Storage: Invest in research and education for forest managers and decision-makers</p> <p>Invest in research and education to better inform forest management practices and decision-making based on future rather than past climate information; ensure urban Indigenous Communities are engaged and involved. Climate-informed management decisions and practices can increase forest sector carbon while reducing potential impacts of climate change. Implementing such strategies in the short term will not only help mitigate climate change but also expand markets for a forest industry presently facing economic challenges.</p> <p>The US Department of Agriculture's 'Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada' report presents a series of mitigation and adaptation recommendations based on observed and projected changes in the forest environment. Adaptation recommendations include:</p> <ul style="list-style-type: none"> • Increasing boundary of protected areas (to reduce fragmentation and help maintain ecosystem function) • Conserving 'stepping stones, corridors, and refugia' (stepping stones and corridors both connect larger protected areas together, while refugia provide the necessary conditions for species to persist despite climate change hazards) • Reducing other stresses on forests (e.g., species invasion, resource extraction, etc.) <p>Additionally, seasonal timing decisions for management, recreational and subsistence activities, such as prescribed burns, waterfowl hunting, etc., would account for changing temperatures and precipitation patterns.</p>	Short Term	Provincial Government, Agencies, Associations and Non-Government, Municipalities and Indigenous Communities, Private Sector or Individual	[229] [230] [231] [233]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Projects or Programs	<p>Deciduous and Coniferous Forests: Pest management guidelines</p> <p>Develop and disseminate guidelines for integrated pest management in forest ecosystems. Guidelines would include best practices currently in use, including emphasizing early detection and rapid response to new infestations, and use of equipment and practices during site preparation or harvesting that minimize transmission or disease/transportation of pests, reducing the density of a host species and increasing the vigor of the remaining trees. The Invasive Species Centre’s Best Management Practices database provides a helpful starting point for development of such guidelines (www.invasivespeciescentre.ca/invasive-species/invasive-species-resources/best-management-practices-database).</p>	Short Term	Provincial Government, Agencies, Associations and Non-Government	[209] [300]
4	Research and Development Investment and Incentive	<p>Deciduous and Coniferous forests (urban): Invest in research and development of education tools/resources for urban forest managers</p> <p>Invest in research, as well as education programs, tools and resources for urban forest managers, to inform decision making and better understand how climate change projections will alter the suitability of commonly used urban tree species and urban forest management practices. Ensure urban Indigenous Communities are engaged and involved in research and development of education tools.</p> <p>Under projected climate shifts the commonly relied upon non-native tree species may soon be less suitable. New cultivars of native species present a possible solution for urban forests. Consider guidance from other jurisdictions further south. For example, the Washington DC Climate Change Vulnerability of Urban Trees resource offers a guide to suitable urban trees based on climate change projections for the region for two climate change scenarios (RCP4.5 and RCP8.5).</p> <p>The US Forest Service also maintains a Tree Atlas that models suitable habitats for 125 tree species in the eastern part of the country. This could be used for the planning in Ontario’s southwest region, and can act as a model for a potential Ontario-based atlas, with consideration of culturally significant species.</p>	Medium Term	Provincial Government, Agencies, Municipalities, Associations and Non-Government, Private Sector or Individual	[230] [232]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Policy and Regulation Projects or Programs	<p>Terrestrial and Aquatic Ecosystems: Regulate protection of shorelines to reduce nutrient and pollution impact to aquatic ecosystems</p> <p>Enhance and update regulations for the protection of shorelines from erosion, and limit nutrient run-off from land-based activities to aquatic ecosystems. With an expected increase in frequency of extreme precipitation events, natural or re-naturalized shorelines, using green infrastructure and nature-based solutions, will support natural capacity to filter nutrients and pathogens that enter waterways.</p> <p>Develop a program that identifies and regulates shoreline resiliency priority zones, with integration of Indigenous Knowledge. Significant threats from climate change can include high water levels, stronger wind/wave energy, sudden spring thaws, and ice jams – all of which can accelerate erosion and impact nutrient transport. Areas of high vulnerability should be identified and protection measures funded, including green infrastructure (native vegetation as erosion control and to slow down surface runoff), combining green and grey infrastructure to maximize slope infiltration, bioengineering (to restore eroding shorelines), and monitoring; these tactics can be used to keep nutrients (as well as pollutants) on the shoreline out of the receiving water bodies. The program may include reviewing and updating the Ontario Lakeshore Capacity Assessment Handbook: Protecting Water Quality in Inland Lakes, to provide guidance on shoreline development and protection on all lakes.</p> <p>For example, the Canada-Ontario Lake Erie Action Plan released in 2018 is a joint effort between the Federal and Ontario Provincial government, with support from organizations like Conservation Ontario and Ontario Agri-Business Association. The plan includes cost-effective and high-impact actions to reduce phosphorus loading to Lake Erie. Another example is Michigan's Great Lakes Sediment and Nutrient Reduction Program, which provided grants to local governments and not for profit organizations to implement erosion and sediment control measure projects. Under this program, Sheboygan County (Wisconsin) was able to reduce phosphorus entry into Elkhart Lake through the installation of a sand/iron filter bed, which treats agricultural drainage before it is discharged using a subsurface drain tile system. In Muskegon County, a grant allowed for the construction of a 10-acre wetland to increase the hydrologic stability of the area, and aid in stormwater retention, nutrient sequestration, and sediment removal (sediments and nutrients which would otherwise flow into Lake Michigan due to the degradation of the watershed).</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government	[130] [235] [236] [407]
6	Policy and Regulation Projects or Programs	<p>Terrestrial Aquatic Ecosystems: Maintain and restore hydrology</p> <p>Implement a policy that requires consideration of maintenance and restoration of hydrology in development planning; and to protect or conserve hydrological connectivity in un-fragmented watersheds. This is important for both terrestrial ecosystems (e.g., forest health) and aquatic ecosystems (e.g., fish migration).</p> <p>In order to maintain appropriate hydrologic regimes within systems, existing infrastructure that diverts water or otherwise alters hydrology can be re-evaluated to compensate for changes in water levels or flows. Modifications that maintain or improve hydrology at one site may result in negative impact hydrology at adjacent sites. Adaptation tactics under this approach can include minimizing road networks, considering impacts to hydrology when considering dam construction, adjusting culvert size requirements for changes in peak flow, repairing perched culverts, and planning for seasonal limitations on heavy equipment.</p> <p>Review opportunities to restore hydrological connectivity in fragmented watersheds/developed areas. This may involve site inspection efforts to review on-site conditions at culverts and dams, for example.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[209] [349]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
7	<p>Projects or Programs</p> <p>Investment and Incentives</p>	<p>Terrestrial Ecosystems; Carbon Storage: Implement forest management techniques to reduce wildfire impact and risk</p> <p>Identify the factors for wildfire management and response at multiple spatial and temporal scales, to allow better prediction of their occurrence and mitigation of their impacts. Prediction and mitigation are particularly important in the North American boreal forest, where rapid and widespread development and climatic changes are likely to be accelerated in the coming decades. Wildfire management would include strong collaboration, resource sharing, investments to develop decision support tools, and increased focus on prevention, especially to understand the benefits and potential consequences of certain strategies.</p> <p>A wildfire management practice employed in northern Wisconsin is to reduce the density of balsam fir (a ladder fuel) in wildland-urban interface areas or near power lines to reduce the spread of fire, acting as a fuelbreak. A fuelbreak is defined as a physical barrier to the spread of fire (e.g., a road, body of water, etc.); it can also be defined as a change in composition and density of a forest at its edges to reduce fuels. Fuelbreaks can be created to reduce fire spread and intensity. Using this approach may be successful for mitigating fire risk, but may also increase forest fragmentation, which should be considered. Another common wildfire management technique is prescribed burning. A region-wide survey in the Southern United States of 523 fire use practitioners, working on both public and private lands found that a 1–2 year prescribed fire interval was consistently viewed as effective in decreasing wildfire ignitions, behaviour, and severity, as well as reducing suppression resources needed where wildfire occurred.</p> <p>Studies have identified innovative wildfire mitigation measures in the two British Columbia municipalities of Logan Lake and Kamloops. These innovative mitigation measures included: structural changes to buildings, vegetation management, ecological interventions, and collaborative efforts between various stakeholders.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[209] [237] [342] [343] [344]
8	Policy and Regulation	<p>Terrestrial and Aquatic Ecosystems: Enhanced stewardship and protection for intermittent rivers and ephemeral streams</p> <p>Enhance protection regulation for Intermittent rivers and ephemeral streams (IRES) within the Ontario Water Resources Act, going beyond discharge of pollutants. Intermittent rivers and ephemeral streams (IRES) have an important ecological purpose, regulating the input of sediment, water, nutrients, etc. to downstream ecosystems. However, because they do not flow year-round, management regulations can be lacking. The Ontario Water Resources Act of 1990 prohibits the discharge of pollutants in waters it protects, which does include IRES.</p> <p>For example, the EPA has now included "Seasonal streams (intermittent)" and "rain-dependent streams (ephemeral)" into section 404 of the Clean Water Act, ensuring that they receive the same protections as the larger water bodies they feed. With enhanced protection status, IRES could also be incorporated into local water biomonitoring programs.</p> <p>Another example approach is the State of Michigan Water Withdrawal Assessment Tool, which provides an initial, screening-level assessment of the impact of a potential water withdrawal on local stream and river ecosystems to support issuing of permits. The fish ecology model determines how a reduction in stream flow is likely to impact the types and abundance of fish that live there.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[238]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
9	Projects or Programs	<p>Terrestrial and Aquatic Ecosystems: Improve and promote Indigenous-led community-based monitoring and research program</p> <p>Improve and/or promote existing Indigenous-led funding and monitoring programs to encourage and enhance monitoring of regional climate shifts, biodiversity, forest health, etc. Examples of existing programs include CIRNAC's Indigenous Community-Based Climate Monitoring Program which "provides funding for long-term climate monitoring programs for Indigenous communities", with a budget of six million dollars per year. Funded activities include development of monitoring plans, monitoring key climate indicators, purchasing/renting monitoring equipment, etc. These programs would feed into and/or lead other programs and efforts, rather than acting as a stand-alone program.</p> <p>Additionally, the provincial government could formally support the establishment of the National Indigenous Guardians Network (NIGN) within Ontario. The NIGN is designed as a stewardship program, building on the success of the Indigenous Guardians teams operating across Canada. The network will focus on monitoring and protecting biodiversity and maintaining healthy forests.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[239] [240]
10	Projects or Programs	<p>Marsh: Restore and preserve vulnerable marsh ecosystems in advance of climate change impact</p> <p>Take a holistic approach that restores watershed resiliency and water retention for marshes that will be reduced or eliminated due to drought, as this could be of a significant benefit for sensitive marshes. The approach may include ensuring that watersheds are vegetated, and that restoration methods are used which prioritize water retention such as increasing tree cover over streams or restoring meadows and pastures and buffer strips in agriculture.</p> <p>A marsh's ability to maintain itself depends largely on conserving its source, therefore viewing the marsh system holistically and introducing regulations to different land use types accordingly can have significant impact on marsh ecosystems. The implementation of a province-wide monitoring effort to understand the state of marshes and how different methods may be affecting them could be beneficial, particularly for those which are primarily filled by meltwater runoff. Large-scale medium and long-range planning efforts can be considered for implementation, such as ensuring that marshes and their tributaries are recognized as special management zones or conservation areas, in conjunction with existing public education programs implemented by conservation authorities across Ontario. This can be achieved through funding such as the Government of Canada's Nature Smart Climate Solutions fund.</p> <p>Marsh restoration and preservation may also be supported through the removal of invasive species, which can displace native flora and fauna by creating a monoculture. An example of successful and ongoing invasive management is the removal of phragmites from the Long Point and Rondeau coastal marshes.</p>	Medium Term	Provincial Government, Agencies	[216] [226] [227] [356]



6.4 Provisioning Services, Regulating Services, and Ecosystem Cultural Services

Table 6-7: Provisioning Services, Regulating Services and Ecosystem Cultural Services Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Develop provincial policy and bylaws for landscape management to support assisted migration and re-establishment</p> <p>Develop provincial policies and local bylaws, with support of conservation authorities, communities and other stakeholders and rights holders, to support landscape management to protect habitat and create a connected habitat corridor to facilitate species migration. Policy can be developed for both flora and fauna.</p> <p>Considerations during policy development may include:</p> <ul style="list-style-type: none"> • Habitat management in areas where climate-driven species losses are concentrated could slow range losses. • Avoiding the introduction of novel genotypes of pathogens to new areas, and to avoid creating non-analog ecological communities. • Identify areas of overlap between species' projected range shifts across climate scenarios, and target these areas for assisted colonization. • Review of resources such as the Ontario Tree Seed Transfer Policy • Natural migration versus human-assisted colonization to more climatically suitable habitats 	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government	[212] [351]
2	Projects or Programs	<p>Cultural Ecosystem Services: Develop a provincial parks and conservation reserves climate adaptation strategy</p> <p>Provide a policy focus on environmental protection in parks planning and climate adaptation policies, as longer recreation seasons have the potential to make maintenance of protected ecological resources more challenging. In order to attend to the Adaptive Capacity gaps that may make adaptation planning challenging (Lemieux & Scott, 2011), consider convening a working group or other mechanism for collaboration among stakeholders and Indigenous knowledge keepers, to support integration of Traditional Environmental Knowledge and provide a platform for training and capacity building.</p> <p>The International Union for Conservation of Nature (IUCN) report on 'Adapting to Climate Change; Guidance for protected area managers and planners' provides an overview of key steps in the adaptation planning process, including:</p> <ul style="list-style-type: none"> • Building capacity for climate adaptation, through involvement of partners and communities and stressing the urgency for action • Assessing climate change vulnerability and risk, and identifying appropriate actions that link to risks • Developing adaptation options and evaluating them • Implementing adaptation, and monitoring and evaluating the results • Understanding and designing resilient conservation landscapes and seascapes • Mainstreaming of protected areas as a Nature Based Solution to climate change <p>Parks Canada has also released a strategy (Departmental Sustainable Development Strategy 2020 to 2023) which includes a goal to develop "measures to reduce climate change risks to assets, services and operations" such as impact assessment, adjusting policies and programs, addressing research gaps, etc., which help to ensure environmental protection in Canada's national parks. Ontario can draw on this strategy to help shape the development of similar guidance for provincial parks and reserves.</p>	Medium Term	Provincial Government, Indigenous Communities, Associations and Non-Government	[232] [241]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Projects or Program Research and Development	<p>Regulating Services: Improve awareness and adoption of green infrastructure</p> <p>Invest in improving awareness and adoption of green infrastructure, so that ecosystem services like groundwater recharge can be strengthened, and co-benefits can be realized including helping communities become better adapted to extreme weather events. Facilitate access to academic research on latest technological advances in support of improved efficiency and reduced climate change burden. Support academic researchers to partner with industry leaders to explore and demonstrate economic feasibility for latest advances with green infrastructure.</p> <p>'An Economic Impact Assessment of the Green Infrastructure Sector in Ontario' Report (Green Infrastructure Ontario Coalition, 2020) provides economic impact data in support of green infrastructure. Additional examples of green infrastructure options are included in the International Institute for Sustainable Development's report Advancing the Climate Resilience of Canadian Infrastructure: A review of literature to inform the way forward.</p>	Long Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Private Sector or Individual, Academia	[234] [243] [244]
4	Policy and Regulation Investment and Incentive	<p>Terrestrial Ecosystems; Carbon Storage: Management policies and funding programs to support protection/preservation and restoration of carbon sinks</p> <p>Develop management guidelines and policies for focused management and protection, preservation and restoration of carbon sinks in Ontario (including peatlands, forests, and grasslands). Focused funding and incentive program efforts can support this endeavour. An example is Germany's International Climate Initiative (IKI): Preserving and restoring natural carbon sinks funding program. Participation in initiatives like the Bonn Challenge, a global challenge to restore degraded and deforested landscapes, may garner buy-in and catalyze action.</p>	Medium Term	Provincial Government, Agencies	[227]
5	Projects or Program	<p>Facilitate the creation of pollinator gardens within urban environments</p> <p>Develop pollinator garden networks within communities to encourage native pollinator and flora resilience. Consider programs such as the Garden Habitat Certification through the Canadian Wildlife Federation.</p>	Short Term	Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[350] [351]



7.0 People & Communities Adaptation Practices

Climate change and related impacts will increase risks to Ontario's people and communities. Ontario's rapidly changing climate threatens the health and well-being, livelihoods, service access, and cultural practices of Ontarians and their communities in a myriad of ways, both direct and indirect. While the physical impacts to property and infrastructure often receive the greatest focus and have consequential impacts for people, the impacts on human health and the systems that people across the province rely on for their well-being have also been significant.

Vulnerability is not distributed evenly across Ontario, with climate change disproportionately impacting individuals and communities facing systemic inequities, such as marginalized and racialized groups. It is therefore critical to apply an equity lens when analysing climate impacts on Ontario's people and communities. Socially vulnerable people, and women and people with disabilities in particular, are disproportionately affected by global climate change because of their geographic location and gendered socioeconomic roles, yet they are least equipped to deal with its impacts due to their disadvantaged economic and political position. Unhoused populations experience impacts from climate events more so than most of the general population, both due to a lack of adequate shelter and a higher likelihood of compromised physical and/or mental health. Resulting impacts from climate hazards for unhoused populations include illness, injury, and death with the greatest impacts felt by those most marginalized.

A key way to build Adaptive Capacity among marginalized groups is to understand the interconnections between climate change risk and other social and economic issues, including access to housing, disability rights, poverty, immigration status, language or cultural barriers, and environmental justice more broadly, and work in tandem across levels of government and society to build Adaptive Capacity through access to resources.

The People and Communities Area of Focus is broken down into the following Level 1 categories, developed based on an understanding of the need to parse climate change impacts and not overlap with the considerations and analysis of the other Areas of Focus.

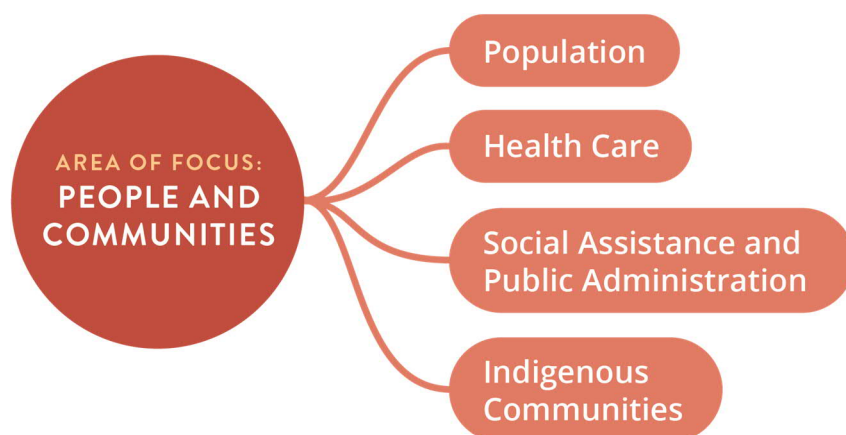


Figure 7-1: People and Communities Area of Focus Level 1 Categories



All Level 1 and Level 2 industries as part of Infrastructure have been assessed to have a low or medium Adaptive Capacity level, indicating several areas challenged by shortfalls in technology, resource availability, or governance, along with significant sector complexity as highlighted in Table 7-1 and Table 7-2.

Table 7-1: Current People and Communities Adaptation Priorities

Current Adaptation Priorities	Region	Risk Score	Combined Adaptive Capacity Rating
Health Care	Central	High	Medium
Unhoused Population	Central, Far North, Northeast, Northwest	High	Lower
	Eastern, Southwest,	High	Medium
Indigenous Population	Northeast	High	Lower
	Eastern, Southwest	High	Medium
Indigenous Cultural Services	Central, Far North, Northeast, Northwest	High	Lower
	Eastern, Southwest	High	Medium
Indigenous Health Care	Central, Northeast, Northwest	High	Lower
	Eastern, Southwest	High	Medium

Table 7-2: Emerging People and Communities Adaptation Priorities By Mid-Century (RCP8.5)

Emerging Adaptation Priorities	Region	Risk Score	Combined Adaptive Capacity Rating
General Population	Central, Northeast, Northwest	High	Lower
	Eastern, Southwest	High	Medium
Health Care	Northeast, Northwest, Far North	High	Medium
Social Assistance and Public Administration	Central, Northeast, Northwest, Far North	High	Lower
	Eastern, Southwest	High	Medium
Indigenous Population	Central, Northwest, Far North	High	Lower
Indigenous Social Assistance	Eastern, Southwest	Very High	Medium
	Central	Very High	Lower
	Northeast, Northwest, Far North	High	Lower



The ABP Report provides a range of potential avenues for building climate resiliency among People and Communities in Ontario, as summarized in Table 7-3.

Table 7-3: Areas for People and Communities Climate Adaptation

Adaptation Category	Examples of Adaptation Measures
Projects or Programs	<ul style="list-style-type: none"> • Provide funding and programming support for development of heat event response planning for municipalities. • Promote Indigenous-led adaptation projects and programs. • Provide consistently available and up-to-date emergency planning guidance to communities. • Encourage the use of innovative technology to increase capacity to respond to climate-related health crises (e.g. emergency response planning scenarios).
Research and Development	<ul style="list-style-type: none"> • Advance research to fill remaining knowledge gaps on climate changes impacts to people and communities in Ontario.
Investment and Incentives	<ul style="list-style-type: none"> • Invest in early warning systems for climate hazard events. • Invest in the establishment and enhancement of extreme heat impact reduction strategies. • Adapt food resource management in the face of climate change and provide funding for resurfacing of Traditional Ecological Knowledge.
Policy and Regulation	<ul style="list-style-type: none"> • Develop policies and tools to support respectful and meaningful incorporation of Traditional Ecological Knowledge in community adaptation planning. • Reframe adaptation policies to be culturally appropriate for Indigenous communities. • Include a wide breadth of rights holders and stakeholders in public policy development and decision-making.

The following adaptation best practices have been compiled and presented first by adaptation best practices that apply to the whole People and Communities Area of Focus (overarching), followed by more specific actions by Level 1 category.

7.1 Overarching – People and Communities

Table 7-4: Overarching Adaptation Best Practices for People and Communities

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Provide funding and programming support for development of heat event response planning for municipalities</p> <p>Implement funding programs to ensure access to in-home cooling as well as cooling centres for unhoused community members. Extreme heat events are expected to increase in frequency and intensity with climate change. With government support, individuals, property owners and managers, and communities can take action to reduce the risks. The following recommendations draw on the Province of British Columbia's Report to the Chief Coroner: Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. (2022), as well as the Ontario Human Rights Commission (OHRC)'s statement on human rights, extreme heat waves and air conditioning (August 19, 2022).</p> <ul style="list-style-type: none"> • Develop a Province-wide coordinated response for municipal planning, building on with existing municipal and public health office level efforts and recommended guidance. Actions that can be implemented draw on the Intact Centre's report 'Irreversible Extreme Heat: Protecting Canadians and Communities from a Lethal Future', which outlines steps individuals can take, the importance of green and grey infrastructure, and opportunities for property managers to take action. In addition, The British Columbia Centre for Disease Control's 'Developing a Municipal Heat Response Plan: A Guide for Medium-sized Municipalities' report offers guidance to municipalities in developing heat response plans. • Undertake communications and outreach to improve the awareness and compliance of the legal requirement to have air conditioning in certain high-risk buildings, such as schools and long-term care homes, and establish a monitoring and reporting program to ensure that cooling is installed and effectively operating. • Develop housing provider regulations related to extreme heat, including instituting a provincial maximum temperature for indoor spaces, preventing landlords from imposing restrictions to prohibit tenants from installing portable or other air conditioning units, and passive and active cooling design to reduce heat stress for both outdoor and indoor environments. 	Short Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[245] [246] [370]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
2	Policy and Regulation Projects and Programs	<p>Develop policies and tools to support respectful and meaningful incorporation of Traditional Ecological Knowledge in community adaptation planning</p> <p>Develop policies to support meaningful incorporation of Traditional Ecological Knowledge (TEK) in adaptation decisions for non-Indigenous and Indigenous communities. This would include meaningful collaboration, recognizing and appreciating the ability of TEK to provide specific and otherwise inaccessible information about climate change and natural interactions/impacts. For example, TEK was applied to determine that there was a temporal relationship between extreme climatic events in the summer of 2005, and fish die-offs in the Albany River (Northern Ontario). TEK was also used to examine a potential shift in subsistence fish species distribution due to climate change.</p> <p>Policy considerations would include:</p> <ul style="list-style-type: none"> • Protection of TEK, and protection of privacy and rights of individuals and groups who share their knowledge. For example, the USDA Farm Bill protected TEK by including a "statement limiting the need to disclose information related to traditional site and resource uses among tribes". • Specific funding and or prioritization of climate change initiatives that incorporate TEK. An example is the "Climate Change Adaptation Initiative" of the US's Department of the Interior which specifically supports the integration of TEK into adaptation strategies. • Continual involvement and communication. • Inclusion of TEK in ongoing climate change research and management through working groups and committees. A case study example comes from a community-based approach to health research with Anishinabek communities in northern Ontario (Tobias et al., 2013), and demonstrates how a collaborative approach to respectful and reciprocal research can be achieved, including some of the challenges they faced in adopting this approach. • Consider the principles of Ownership, Control, Access and Possession (OCAP). <p>Consider using the Tribal Climate Adaptation Menu (2019) developed by the Great Lakes Indian Fish and Wildlife Commission in Odanah, Wisconsin as a resource to develop adaptation planning tools tailored to Ontario Indigenous communities. The Menu was developed by the tribal, academic, intertribal and government entities in Minnesota, Wisconsin and Michigan, in recognition that many adaptation planning tools do not adequately address the needs, values and cultures of Indigenous communities; and was intentionally designed to be adaptable to other Indigenous communities, allowing for the incorporation of their language, knowledge and culture.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[247] [248] [249] [250] [251]
3	Projects or Programs	<p>Develop a program to support knowledge sharing among smaller and more remote municipalities and Indigenous Communities across Ontario</p> <p>Develop a program and framework for partnership and knowledge sharing among these communities, to address capacity gaps in sharing knowledge, lessons learned and best practices, especially among small, remote and northern communities. For example, the Northwest Territories Association of Communities (NWTAC) organized a forum designed in an interactive format with communities, government and other partners to develop a climate change agenda. The forum encouraged networking, learning and co-creation of climate change solutions, and resulted in a strategy and adaptation plan as well as an agreement for increased dialogue among participants. This project was funded by a grant from the Municipalities for Climate Innovation Program, local government, sponsorship, as well as registration fees from participants.</p>	Medium Term	Municipalities and Indigenous Communities, Agencies, Associations and Non-Government	[252]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Investment and Incentive Projects or Programs	<p>Expand on existing early warning systems for climate hazard events</p> <p>Expand on and integrate a province-wide approach to early warning systems and heat alerts issued by municipalities and public health officials, clearly identifying risks along with resources available and accessible information to build public understanding of how heat stress can create both short and long term health effects. Invest in and introduce forecast-based warning and intervention programs that provide information to the public related to health risks (such as from extreme heat, cold, wildfire, disease vectors, etc.). Warnings provided before these events occur can reduce their associated health and economic burdens. Ensure that warnings are accessible to all populations, and are communicated clearly and with consistent messaging.</p> <p>Health Canada's Heat Alert and Response Systems to Protect Health: Best Practices Guidebook (2019) lays out a clear approach to developing a Heat Alert Response, including challenges with reaching specific vulnerable groups and ways to overcome these with example case studies.</p> <p>In another example, in North Carolina, researchers have modelled a forecasting system that shows potential to reduce exposure risks to forest fires. The National Weather Service (United States) has developed a weather warning system which provides extreme weather notifications/warnings to polygon areas instead of counties (known as "Storm-based Warnings"), which reduces the amount of false alarm warnings, improving warning accuracy. Syndromic surveillance (originally a tool used for anti-terrorism efforts) is another tool that has been applied in the context of heat-related illness detection and monitoring of medical needs after severe weather, where data is used to build capacity for public health preparedness and response (applied for monitoring after Superstorm Sandy in New York).</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Private Sector or Individual	[253] [254] [255]
5	Investment and Incentive Projects or Programs	<p>Invest in the establishment and enhancement of extreme heat impact reduction strategies for vulnerable populations</p> <p>Support the enhancement and/or development of extreme heat impact reduction strategies, targeted towards those at highest risk of health impacts from heat stress, such as people with disabilities, older adults, people with a chronic illness, and who are inadequately housed. Work with municipalities to identify funding gaps for air conditioning for low-income residents and those at highest risk due to disability, age, or other conditions, and provide rebates or funding mechanisms for portable air conditioning units to be purchased and/or distributed in advance of a heat wave.</p> <p>Provide funding for cooling centres in communities vulnerable to extreme heat events, with backup power in the event of a heat wave during a blackout. Cooling centres benefit those who are experiencing homelessness and well as the broader population that is vulnerable to extreme heat. These centres can be staffed by volunteers and municipal employees, located in air-conditioned buildings. Cooling centres need to be located in such that vulnerable residents (including those with mobility concerns) can make use of them. Priority considerations would include improving accessibility and addressing barriers to the utilization of these spaces as well as considering backup power in the event of a heat wave during a blackout. Many successful examples of cooling centres exist, including in Portland, Oregon, Los Angeles, California, as well as Toronto's Emergency Cooling Centres that open when Heat Alerts are issues in the region.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government	[256] [257] [258] [370]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Projects or Programs	<p>Develop and implement a targeted health-focused climate communications campaign</p> <p>Develop and implement a regional or provincial based health-focused climate communications campaign. Based on public opinion research, a health-focused climate communication campaign can increase awareness and engage new audiences, including public health partners, in collaboration on actions to reduce climate-related health impacts for current and future generations. Incorporate health communication and promotion programs/strategies to reduce the risk of the negative direct and indirect health impacts of climate change (including those related to extreme temperature, extreme weather, air quality, vector-borne disease, food and water quality and safety, and ultraviolet radiation).</p> <p>An example of a coordinated response approach is the Simcoe Muskoka Emergency Plan for Vulnerable Populations. This multi-stakeholder approach utilizes existing social networks to identify pathways to improve communications to vulnerable or at risk populations who may be at risk from climate related hazards (e.g. extreme heat) or other incidents/emergencies.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[259]
7	Policy and Regulation Projects and Programs	<p>Integrate a gender lens into climate change adaptation and capacity building</p> <p>Apply a gender lens in the planning and implementation of climate change adaptation, recognized the disproportionate impact of climate change on women. Community-based education and organizing are fundamental to creating the conditions for local knowledge to be shared and utilized, through equitable democratic participation. Building inclusive governance structures and strengthening the role of civil society, especially women, in climate change governance are essential components for addressing vulnerability and fostering resilience and sustainability in urban centres as well as rural areas. According to the Intergovernmental Panel on Climate Change, “adaptation is shown to be successful and sustainable when linked to effective governance systems, civil and political rights and literacy” (Parry et al., 2007).</p> <p>Engaging women is fundamentally important for durable climate change adaptation, particularly during environmental crises. Community-based, ‘people-centred’ approaches to climate change are needed in order to develop adaptation strategies which address social and gender inequalities and allow women to serve as active agents of change in their communities.</p>	Short to Medium Term	Provincial Government, Municipalities, Associations and Non-Government, Private Sector or Individual	[385] [386]
8	Policy and Regulation Projects and Programs	<p>Collaborate with Indigenous communities on Indigenous-led fire stewardship</p> <p>Implement the calls to action in ‘The right to burn: barriers and opportunities for Indigenous-led fire stewardship in Canada’ (Hoffman et al., 2022), towards enhancing ecosystem diversity and providing a mechanism for knowledge sharing from Indigenous fire stewards and knowledge keepers on cultural burning practices. These actions include:</p> <ul style="list-style-type: none"> • Establish a National Indigenous Wildfire Stewardship working group, which includes regional hubs of Indigenous fire practitioners and resource managers across provinces and territories – Support the sharing of knowledge and relationship building to better understand cultural burning and integrate Indigenous Traditional Knowledge into wildfire management practices province-wide. • Introduce governance processes that equally prioritize Indigenous knowledge systems to correct power imbalances – including early and often engagement with Indigenous fire stewards, and more flexible burn permits that allow wider burn periods when the risk is low such as in the early spring and late fall. • Reduce wildfire science and management gate-keeping by opening up prescribed fire training and accreditation outside of wildfire management agencies. • Develop a network of Indigenous and non-Indigenous fire practitioners and researchers within each province and territory to identify key policy barriers for reintroducing cultural burning, including (but not limited to) jurisdiction, liability, and land governance. • Increase financial support for Indigenous fire stewardship that preventatively and economically reduces wildfire risk within community interface areas and across territories. 	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[409]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
9	Policy and Regulation Projects and Programs	<p>Adopt a disability justice-oriented approach to developing climate change response and planning policies</p> <p>Support the development of municipal and Provincial policy led by people with disabilities and in collaboration with organizations working to address the disproportionate impact of climate change on marginalized communities. People with disabilities represent approximately 20% of the Canadian population, and are the group most likely to experience severe and long lasting health impacts and loss of life in a severe weather event.</p> <p>Ensure that a disability lens is integrated into the development of policies and plans for climate adaptation as well as emergency response, drawing on the knowledge and experience of people with a diverse range of disabilities and chronic illnesses, and recognizing the specific challenges faced by those with multiple intersecting identities or circumstances that present greater vulnerability to climate change impacts, such as poverty, gender, race, and language fluency. Work with various levels of government as well as community-based groups to address the root causes of social vulnerability and build resilience to climate change through evidence based approaches and clear representation of disability rights in policy and planning.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[428] [429] [430]

7.2 Population

Table 7-5: Population Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Population: Develop a set of policies to manage flood and other climate hazard risks for communities</p> <p>Develop policies to better manage flood and other climate hazard risks to communities across Ontario. These include policies to ensure emergency preparedness plans include climate change considerations, that transparent and timely updates are made by governments (including early warning systems and communications during events), and there is provision of guidance for responsible media coverage to support government and community action.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[SME]
2	Projects or Programs	<p>Population: Facilitate opportunities for volunteers to train in disaster management</p> <p>Facilitate development of opportunities for community volunteers to train and receive guidance on how to safely provide vital services to people affected by an emergency or disaster. This includes learning how to provide practical and emotional support to people who have suddenly found themselves without a home. Encourage volunteers to take training programs offered through national organizations like the Canadian Red Cross. Ongoing education and awareness campaigns are recommended to encourage active participation.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Private Sector or Individual	[261]
3	Investment and Incentive	<p>Population: Invest in funding programs and research partnerships for municipal climate change cost education</p> <p>Provide funding and leverage research from the Insurance Bureau of Canada (IBC) to develop climate change adaptation education programs and work with municipalities, Indigenous Communities, academia and other organizations. Programs would educate executive financial operators in communities on climate change costs and insurance. Programs such as the Federation of Canadian Municipality (FCM)'s Municipalities for Climate Innovation Program provide funding, resources, and training to help develop responses to climate change to protect residents, environments, and economies.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government	[262]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Investment and Incentive Projects or Programs	<p>Population: Continue to develop and disseminate “fire smart” guidance; initiate a community resilience investment program</p> <p>Continue to develop and disseminate “fire smart” guidance documents for homeowners and businesses in areas at greater risk of wildfire. The Intact Centre on Climate Adaptation has produced an infographic document and best practice checklists for home protection; the Government of British Columbia’s Fire Smart Begins at Home manual is another example of existing documentation.</p> <p>Consider the development of a community resiliency investment program, similar to what was created by the British Columbia provincial government in 2018. This program is a collaboration among the BC Wildfire Service and a number of stakeholders across the province, to offer guidance and incentives for fire risk mitigation activities. A similar program can be initiated in Ontario, in regions where wildfire is of greatest concern.</p> <p>Consider the need to create and disseminate this information in multiple ways, as some methods may not work for some communities/individuals. Consider the inclusion of TEK in development of new guidance.</p>	Medium to Long Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[263] [264] [265] [266]
5	Policies or Regulation	<p>Unhoused Population: Develop Government policy to maintain affordable housing markets in Ontario</p> <p>Implement policies and programs to support social and affordable housing through government intervention, which is needed to maintain an accessible housing market in Ontario. Policies can be implemented that support these efforts, such as:</p> <ul style="list-style-type: none"> • Reducing the construction cost of housing (supply measures) • Inclusionary zoning which ensures that a certain percentage of new homes are affordable • Loans (low-cost and forgivable) for building affordable housing shelter/supportive housing • Shared equity mortgages to help people purchase homes • Influencing the price of existing rental housing (rent controls and encouraging transfers in the ownership from private-for-profit owners to not-for-profit owners) • Disposing of surplus government realty to return vacant buildings and land into productive use; surplus properties could be upcycled through the new Centre of Realty Excellence (CORE), once fully established. 	Medium Term	Provincial Government, Agencies, Municipalities, Private Sector or Individual	[267] [268] [269] [270] [271]



	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	<p>Projects or Programs</p> <p>Investment and Incentive</p>	<p>Unhoused Population: Fund and support the development of programs to prevent people from becoming unhoused</p> <p>Consider funding to support start-ups and programs like Unhoused.org, focused on using technology to help the unhoused. Unhoused.org develops technology solutions to help the homeless crisis in the UK and internationally, with innovations such as sustainable, self-cleaning clothing, and an innovative model for donating fresh supplies.</p> <p>Consider funding and/or developing pilot projects to house the unhoused. An example of a pilot is the 'Hey Neighbour' project, which is repurposing 30 shipping containers into tiny homes for people as they await more stable, permanent housing. Another example is a modular housing project for residents of Durham Region who are experiencing homelessness, with ten residential units. The homes will offer transitional housing with access to various health and social supports, including financial assistance, employment services, mental health and addictions and the teaching of life skills.</p> <p>Consider reviewing the outcomes of and potential to continue or expand programs such as the Social Services Relief Fund (made available in response to the COVID-19 pandemic, 2020) which was used to acquire motel and hotel spaces to support shelter residents (and encourage physical distancing), hire more shelter staff, and purchase cleaning supplies.</p> <p>Consider allocating funding for rent and utility banks to help prevent more people from becoming homeless (e.g., Toronto Rent Bank, Ontario Energy Board's Low-income Energy Assistance Program, etc.).</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[272] [273]

7.3 Health Care

Table 7-6: Health Care Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Project emergency department visits and associated costs to prepare for climate change impacts to emergency healthcare</p> <p>Develop a program and/or policy to encourage and fund hospitals to model/project emergency department visits and associated costs, under population growth and climate change scenarios. Integrate data sharing mechanisms and agreements to allow for collation of Province-wide data. As health care costs are expected to rise under climate change scenarios, preparing for projected cost increases and increased emergency room visits can reduce hallway medicine practices and other impacts to the emergency healthcare sector.</p>	Short Term	Provincial Government, Associations and Non-Government, Academia	[274] [275]
2	Projects or Programs	<p>Encourage climate change vulnerability assessments for health care facilities</p> <p>Incentivize and encourage the development of climate change vulnerability assessments for health care facilities across the province. The Canadian Coalition for Green Health Care's Health Care Facility Climate Change Resiliency Toolkit provides an example of a guidance document that can be repurposed, enhanced, or simply redistributed for use by Ontario health care facilities.</p>	Short Term	Provincial Government, Agencies	[276]
3	Projects or Programs	<p>Invest in mental health training for healthcare workers</p> <p>Invest in training for health care professionals to identify the risks of acute psychological stress and potential chronic mental health challenges related to climate change, to allow for early identification, intervention, and referral to community services. This training can provide nursing staff, nurse practitioners, physician assistants and physicians the capacity to identify and recognize the human health impacts (mental and physical) of climate-related events (e.g., injuries and fatalities associated with severe weather, increased levels of asthma or cardiovascular challenges associated with reduce air quality, increases in vector-borne disease, reduced access to clean water under drought conditions, etc.), all of which can result in anxiety and depression.</p>	Short Term	Provincial Government, Indigenous Communities, Associations and Non-Government, Academia	[277]
4	Projects or Programs Research and Development	<p>Encourage the use of technology to increase capacity to respond to climate-related health crises</p> <p>Encourage the use of innovative technologies to increase opportunities for training, capacity building and on-the-ground response to climate-related health crises, especially when accessibility is a concern. For instance, the use of game techniques as the core of simulated or virtual training tools opens new ways for training and learning for emergency scenarios. For untrained volunteer responders, telemedicine supported by augmented reality may present an opportunity for emergency medical attention.</p> <p>Drones have shown to be a promising solution for the delivery of medical supplies (e.g., medicine, vaccine, and AED) to patients in a timely manner, and can assist ambulance services, especially for harder-to-reach patients. Other ways drones can support emergency personnel is through taking on-scene images and sending information back to emergency medical services operation centers, which would improve the decision-making process in ambulance dispatching and other emergency management circumstances.</p> <p>Indoor air filtration is another key area for technology and adaptation that provides co-benefits in managing the transmission of communicable diseases, through high-efficiency particulate absorbing (HEPA) filters and improved ventilation.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia	[278] [279]

7.4 Social Assistance and Public Administration

Table 7-7: Social Assistance and Public Administration Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Develop and/or promote personal emergency preparedness guidance</p> <p>Develop programming to support individuals, families and vulnerable communities to create personal emergency preparedness plans. An educational campaigns with associated guidelines can be made available to individuals and caregivers to support this effort. The Government of Canada's Emergency Preparedness Guide for People with Disabilities/Special Needs is an example of a guidance document that can be tailored to a community, region or for the Province.</p> <p>Of additional importance is consideration to individuals/communities with specific needs. For instance, individuals with diabetes should put together a diabetes care kit as well.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual	[280] [281] [282]
2	Projects or Programs	<p>Develop mental health support kits</p> <p>Develop mental health support kits/resources, tailored to individual communities (with consideration of spiritual needs), regions or for the Province of Ontario. Climate events can cause devastating physical impacts that affect people at multiple scales (community and individual). As climate change continues to evolve, and climate impacts become more frequent, the mental health of community members may be impacted, especially during and immediately after an event. The Canadian Mental Health Association's Coping with natural disaster stress offers resources to help individuals cope through potentially traumatic events.</p> <p>Studying the impact of these changes on individuals and communities, researchers and public health officials have largely focused on physical health. However, climate change also exacerbates many social and environmental risk factors for mental health and psychosocial problems, and can lead to emotional distress, the development of new mental health conditions and a worsening situation for people already living with these conditions. Therefore, in preparing for and responding to this growing emergency, there is an increasing need for the provision of mental health and psychosocial support (MHPSS). Certain groups will be disproportionately at risk due to climate change, depending on existing vulnerabilities and inequalities.</p> <p>Establish integrated monitoring systems that allow the collection and analysis of data on environmental hazards, socioeconomic factors and mental health outcomes (e.g. drought or heat stress management). Revising and enforcing regulations on key environmental determinants of mental health and psychosocial wellbeing (e.g. air quality and safety of housing).</p> <p>Address the large gaps that exist in funding both for mental health and for responding to the health impacts of climate change. Estimates show that mental health receives less than 1% of international aid for health. Moreover, governments spend just 2.1% of their health budgets on mental health. However, the costs of mental health impacts are very large. Lost productivity resulting from depression and anxiety alone, two of the most common mental disorders, costs the global economy approximately US\$ 1 trillion each year.</p>	Short Term	Provincial Government, Municipalities and Indigenous Communities	[261] [283]
3	Projects or Programs Investments and Incentives	<p>Renew the Ontario basic income pilot project</p> <p>Review, modify and consider re-implementation of the Ontario Basic Income project (pilot ended in 2019) across the province, recognizing that poverty reduction is key to improving health and increasing Adaptive Capacity to climate change (and other hazards). Evidence for the success of basic income projects can be seen through the reduced rates of suicide during the pandemic, which is associated with the provision of CERB and other social support programs.</p>	Medium Term	Provincial Government	[284] [296]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Policy and Regulation Projects or Programs	<p>Develop climate resiliency for the education sector</p> <p>Collaborate with education sector administrators, educators, planners, and students to build capacity to assess and adequately plan for climate change risks. Continuity of education access in light of severe and ongoing climate change is a key element of community services that families and students across the province rely upon. The Victoria State Government in Australia has developed an education sector adaptation plan, which includes the following key recommendations:</p> <ul style="list-style-type: none"> ● Build sector capacity to assess climate change risks and identify potential impacts to services and operational safety ● Strengthen the resilience of built assets to maintain the safety of all occupants ● Support the participation of students and teachers/trainers in the development of adaptation and mitigation responses to climate change ● Incorporate climate change considerations into decision making and planning, particularly related to emergency response, prioritizing the health and wellbeing of all those affected and understanding how to protect the most vulnerable members of a school or education facility community ● Engage with Indigenous communities and knowledge keepers on planning for climate change adaptation ● Build towards net-zero, climate resilient communities <p>Other key considerations for the education sector particularly in rural and remote communities would include:</p> <ul style="list-style-type: none"> ● Planning in tandem with municipalities and community organizations to support emergency shelter and community services in the event of a climate disaster or extreme weather event ● Developing energy resiliency and redundancy to be able to maintain indoor environmental comfort for all occupants in the event of a power grip failure or major disruption to electricity supply ● Installing air filtration and ventilation to manage the spread of communicable diseases 	Short to Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Academia, Private Sector or Individual	[430] [431]

7.5 Indigenous Communities

Table 7-8: Indigenous Communities Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Reframe adaptation policy to be Indigenous-led and culturally appropriate for Indigenous communities</p> <p>Assess climate change risks and impacts through the lens of Indigenous culture, perspective, worldview and language. Integrate Indigenous Elders and knowledge-keepers into climate change planning teams to ensure that Indigenous histories and traditional knowledge are centered, recognizing the importance of place and that the relationship to land has been impacted by a legacy of colonization, and the disproportionate impact of climate change on Indigenous communities both on and off-reserves. The word “adaptation” linked to climate change is associated with European colonization; Indigenous populations have been adapting for millennia.</p> <p>Changes to natural landscapes are affecting mobility and traditional activities such as hunting and fishing, as well as the delivery of essential community supplies, medicines and teachings. Food security and health impacts present significant challenges to Indigenous ways of being and community resiliency.</p> <p>Approach adaptation planning to support Indigenous self-determination, and in consideration of the United Nations Declaration on the Rights of Indigenous Peoples, with attention to human rights (food, shelter, clean water, healthcare, and sanitation) as well as free, prior and informed consent incorporated into decisions surrounding adaptation to climate impacts.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[286] [287]
2	Policy and Regulation	<p>Indigenous: Adapt food resource management in the face of climate change and provide funding for resurfacing of Traditional Ecological Knowledge</p> <p>Provide funding to Indigenous Communities to identify and resurface TEK that can be used to adapt to shifting resources, recognizing that climate change is shifting the demographic structures and locations of fauna populations. For the food resource populations, shift hunt quotas and use other management techniques to manage the security of the resources. For example, the community of Arctic Bay, NU has shifted a portion of its narwhal quota from spring to summer hunts to reduce risks associated with ice break-up conditions, and to increase chances of hunting success. Communities in Northern Ontario can use similar strategies.</p>	Short Term	Provincial Government, Indigenous Communities	[288]
3	Projects or Programs	<p>Indigenous: Funding for on-reserve adaptation action</p> <p>Leverage and consider an Ontario-based expansion of the First Nation Adapt, Indigenous Guardians, and Natural Smart Climate Solutions Fund – Indigenous Partnerships Stream programs for Indigenous Communities, to fund assessment and response to climate change impacts on community infrastructure and disaster risk reduction. Examples of funded climate change adaptation initiatives during the 2020-2021 funding period included a flood risk assessment in Eel River Bar First Nation, an archaeological heritage of waterways assessment in the context of climate change for Waban-Aki Nation, and a prescribed burn adaptation and management plan for Alderville First Nation.</p>	Medium Term	Provincial Government, Indigenous Communities	[SME]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Projects or Programs	<p>Indigenous: Develop programs to support Inuit, as well as Métis communities and First Nations in Ontario</p> <p>Establish programs to support wellness, strength, and cultural continuity for Inuit, Métis, and First Nations in Ontario, in order to also support Adaptive Capacity building for climate change impacts. Ontario has the third highest population of Inuit in Canada after Nunavut; however, this population is not often specifically considered in policy. Develop or encourage development of programs that support hands-on knowledge transfer, enhancement or creation of new relationships between youth and elders, and the promotion of cultural preservations. Examples of existing programs like this include the Aullak, Sangilivallianginnatuk (Going Off, Growing Strong), which brings youth together with experienced harvesters to support food security; and the IlikKuset-Ilingannet (Culture-Connect!) program which unites youth with adult mentors to teach skills such as trapping, carving, snowshoe-making, etc.), show promise as strategies to support cultural sustainability and improve Adaptive Capacity to climate change.</p>	Medium Term	Provincial Government, Indigenous Communities	[289]

8.0 Business & Economy Adaptation Practices

Ontario's businesses and their economic contribution is significant, contributing almost 39% of Canada's overall gross domestic product (GDP) in 2021. Climate change impacts are fueling more extreme weather, impacting local economies, driving up costs and challenging economic growth. Climate impacts, and the associated economic shocks and the ability to recover from these impacts, will not be uniform across Ontario. Now is the time for to build strong local, resilient economies that support in reducing greenhouse gas emissions as well as fostering innovative business practices. A resilient Ontario economy has a competitive advantage and can enable businesses at all scales and across industries to thrive in the face of an uncertain and extreme future.

The Business and Economy Area of Focus is broken down into the following Level 1 categories:



Figure 8-1: Business and Economy Area of Focus Level 1 Categories

As Ontario's Financial Accountability Office reports, following the sharp job loss caused by the COVID-19 pandemic shutdowns, Ontario employment rebounded strongly in 2021, with jobs increasing by 4.9 per cent rise compared to 2020 (FAO, 2022). The province's annual unemployment rate declined to 8.0% in 2021, down from 9.6% in 2020. It currently sits at 5.1% as of November 2022 (Ontario Ministry of Labour, Immigration, Training and Skills Development, 2022). Despite this progress, the unemployment rate in 2021 was well above the pre-pandemic rate, as a larger number of job seekers entered the labour market looking for work. While some sectors saw job growth, others have seen an increase in demand for workers with a shortage of workers. These trends can be attributed to a range of factors, including an aging workforce and a reduction in the female working population (Greenspon, 2022).

Adaptation planning across the spectrum of business and economic sectors in Ontario therefore requires an understanding of how climate change is interconnected with other ongoing stresses, and the ways in which climate resiliency is intertwined with broader social and economic trends and pressures.

All Level 1 and Level 2 industries as part of Business and Economy have been assessed to have a medium or high Adaptive Capacity (see Section 1.3 for an explanation of the assessment). In other words, no industry is considered to have a low Adaptive Capacity based upon technology, resource availability, governance, and sector complexity. Thus, climate adaptation priorities for current and future timeframes can be considered a reflection of those with the highest risk profiles (see Table 8-1 and Table 8-2).

Table 8-1: Current Business and Economy Priorities

Current Adaptation Priorities	Region	Risk Score	Adaptive Capacity
Arts, Entertainment and Recreation	Central	High	Medium
Fishing, Hunting and Trapping	Central, Northeast, Northwest, Far North	High	Medium
Forestry and Logging	Central, Northeast, Northwest, Far North	High	Medium
Deep Sea, Coastal and Great Lakes	Central, Northeast, Northwest, Far North	High	Medium

Table 8-2: Emerging Business and Economy Priorities by Mid-Century 2050s (RCP8.5)

Emerging Adaptation Priorities	Region	Risk Score	Adaptive Capacity
Arts, Entertainment and Recreation	Northeast, Northwest, Far North	High	Medium
Rail	Central, Northeast, Northwest	High	Medium

The benefits of taking action to address climate risk via planned adaptation generally outweigh the costs, over the medium to long term. The areas for building climate resilience comprise both actions that can be undertaken at the industry and firm-level, as well as actions that can be implemented by government to establish enabling conditions/incentives for adaptation.

The PCCIA Adaptation Best Practices Report categorizes adaptation options for industries within the Business and Economy Area of Focus. Ontario has the solutions and knowledge to act and lessen or avoid many climate risks that industries face. A high-level summary is provided in Table 8-3, with industry-specific adaptation options available in the PCCIA Adaptation Best Practices Report.

Table 8-3: Areas for Business and Economy Climate Adaptation

Adaptation Category	Examples of Adaptation Measures
Projects or Programs	<ul style="list-style-type: none"> ● Integrate climate change into financial valuation, natural environment impacts, and business continuity planning. ● Facilitate development of knowledge sharing networks, and encourage participation in the United Nations Office for Disaster Risk Reduction (UNDRR) ARISE program. ● Support the use of public-private partnerships to reduce climate risk impacts to businesses.
Research and Development	<ul style="list-style-type: none"> ● Review and mobilize case studies across businesses, such as Environment and Climate Change Canada's map of adaptation actions. ● Undertake industry-specific climate change risk assessments that factor in interdependencies and supply chain impacts. ● Support innovative research at the industry-specific level that achieves low carbon resilience in operations and business activities.
Investment and Incentives	<ul style="list-style-type: none"> ● Develop financial instruments to promote investment in climate resilience. ● Develop financial instruments to promote investment in climate resilience. ● Develop a grant or loan program to support industry-specific activities that support regional economic employment (e.g., resource-based recreation and tourism industries).
Policy and Regulation	<ul style="list-style-type: none"> ● Provide government support and leadership for climate change adaptation action in the private sector. ● Integrate climate change adaptation measures into early construction processes. ● Implement regulatory obligations on critical infrastructure to incorporate and disclose climate change risks.

Adaptation best practices for the Business and Economy Area of Focus have been compiled by Level 1 category, or adaptation best practices that apply to the whole Area of Focus (overarching).

8.1 Overarching – Business and Economy

Table 8-4: Overarching Business and Economy Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Integrate climate change into financial valuation, natural environment impacts, and business continuity planning</p> <p>Integrate climate change considerations in financial valuations, natural environment impacts, and business continuity planning. An example of guidance for financial valuation includes the University of Waterloo and Intact Centre on Climate Adaptation's Factoring Climate Risk into Financial Valuation guidelines.</p> <p>An example of existing guidance for business continuity planning includes the British Standards Institution (BSI)'s Adapting to Climate Change using your Business Continuity Management System provides recommendations for business continuity planning for climate change. Manitoba's Climate Resilience Training program also offers a recorded webinar on Business Continuity Planning and Climate Change.</p> <p>An example displaying the importance of business continuity planning, including reducing supply chain disruptions in the case of a climate change event, comes from British Columbia in the wake of the 2021 flooding. Aliya's Foods imports chicken from British Columbia; they proactively conduct planning for hypothetical disasters and disruptions annually, and therefore already had a plan for their disrupted supply chain.</p>	Short to Medium Term	Provincial Government, Private Sector or Individual	[94] [291] [292] [293]
2	Projects or Programs	<p>Facilitate development of knowledge sharing networks, and encourage participation in UNDRR'S ARISE program</p> <p>Develop a series of knowledge sharing networks dedicated to the assessment of climate change impacts and adaptation challenges, and solutions. The coordinating agency could include other levels of government, the private sector, academia, and Indigenous organizations and Communities.</p> <p>Additionally, encourage businesses to join the UN Office for Disaster Risk Reduction's ARISE program. ARISE supports national networks across the globe, supporting members with tools, case studies, and good practices to support four key priorities:</p> <ul style="list-style-type: none"> • Enhancing resilience of small and medium enterprises • Integrating disaster and climate risk into investment decisions • Incentivizing disaster risk reduction and enhanced data for risk-informed decision-making through engagement with the insurance industry as global risk manager • Supporting resilient infrastructure development 	Short Term	Provincial Government, Municipalities and Indigenous Communities, Private Sector or Individual, Academia	[294]
3	Research and Development	<p>Review and explore ECCC's Map of Adaptation Actions</p> <p>Explore Environment and Climate Change Canada's Map of Adaptation Actions, which identifies case studies from across Canada, to inform and inspire businesses and individuals on actions they can take to increase Adaptive Capacity to climate change. Review sector-specific actions (e.g., transportation, natural resources, energy, etc.); types of actions include policies, laws and regulations, practice and behaviour, etc.).</p>	Short to Medium Term	Private Sector or Individual	[295]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Investment and Incentives	<p>Develop financial instruments to promote investment in climate resilience</p> <p>Develop financing programs using financial instruments (such as grants, loans, equity, co-financing agreements, etc.), to support the private sector in climate change adaptation advancement and reduced environmental footprint, especially for small and medium enterprises (SMEs). A financing program could include support for purchase of new technologies, implementation of adaptation actions, and research and development. A number of climate change adaptation financing programs exist, offered through organizations like the World Bank and the United Nations. An Ontario-based financing program could be considered to support the most vulnerable businesses and sectors.</p> <p>Additionally, funding support can be considered for northern businesses (e.g., fishing and hunting outfitters) and Indigenous organizations/Communities to implement green energy infrastructure as well as to set up mechanisms to reduce wildfire and flooding risks (e.g., sprinkler systems, water barriers), in a program similar to the Northern Ontario Recovery Program for COVID-19, which provided grants up to \$25,000 for businesses to implement health and safety measures.</p>	Short Term	Provincial Government, Agencies, Municipalities and Indigenous Communities	[11] [12] [296] [297] [298]



5	<p>Policy and Regulation</p> <p>Investment and Incentives</p> <p>Projects or Programs</p>	<p>Provide government support and leadership for climate change adaptation action in the private sector</p> <p>Since 2019, employment gains have been concentrated in positions that usually require a university education (8.3%) while losses were observed in occupations that usually require less education. Within specific occupations that saw strong job growth since 2019, the importance of “softer skills” such as active learning, reading comprehension, writing, complex problem solving, as well as specialized technical skills like programming and operations analysis increased. A shift in demand for these skills could put Ontarians with lower education levels or fewer resources to upgrade their skills at a higher risk of job displacement.</p> <p>Government support and leadership (through regulations and policies, knowledge sharing, financial incentives and funding programs, etc.) for alternative production, activities and/or relocations in the private sector could be considered. Governments can provide leadership through ensuring that regulations and policies do not distort the market or provide disincentives for adaptation, and by providing support to ensure market failures are addressed. A careful balance needs to be struck, between the use of market-based financial tools (which could potentially cause maladaptation) and direct government intervention (which could dissuade the private sector if it results in increased transaction costs).</p> <p>An example of a set of tools and resources developed for climate change adaptation for businesses is the Manitoba Climate Resilience Training program for Northern Business, offering webinar courses and tools that cover the basics of climate change, climate change impacts to northern businesses, climate change risk assessment for northern business, business continuity planning, and introduction to costs and benefits of climate change adaptation action for northern business.</p> <p>Private sector actors are diverse and multi-faceted, and, as such, they have a variety of motivations for engaging in climate change adaptation. For some, adaptation action may be motivated by the search for profit and new markets or by the desire to reduce business risks; for others, it may be in response to policies, regulations, or signals from investors. Different actors will have different risk and capacity profiles that affect their willingness and ability to invest their own funds in developing new markets or tools that support climate adaptation (UNEP, 2016). The following key practices would support capacity building and climate resiliency in the private sector:</p> <ul style="list-style-type: none"> ● Awareness-raising and engagement with relevant actors, including domestic enterprises, financiers, multinational corporations, and Micro, small and medium-sizes enterprises. This is often best done through business associations, cooperatives, or chambers. These institutions are often a more efficient way of reaching a broad audience with knowledge products, climate information, or training. ● Enhancing resilience of Private sector infrastructure, activities and services through: <ul style="list-style-type: none"> ○ Information Sharing on climate vulnerability, risks, and adaptation options, communicated strategically and in a way that makes a clear business case for investments in climate change adaptation. ○ Financing incentives to motivate private sector actors to invest in new products or markets that support adaptation, such as tax breaks, risk guarantees, government procurement contracts that help to secure demand for new climate-resilient products and services, and favourable conditions set by export credit agencies to encourage investments in climate change adaptation. Mechanisms like taxes, levies, fees, and royalties can also be used to generate government revenues in support of climate risk assessments, extension services, and start-up or seed financing for new products and services. Exploring ways of de-risking investments—particularly for large-scale infrastructure investments—will also help to make these investments attractive to private investment and building resiliency. ○ Capacity Building in the use of techniques, technologies, and equipment needed to adapt or capacities to develop the business models needed to commercialize adaptation products and services. Private sector actors may not understand how to implement business strategies that can reduce their exposure to climate risk or may need help in identifying and seeking out appropriate financing for adaptation investments. With support from development partners, business service providers focusing on adaptation, labour unions, and international actors like the World Business Council on Sustainable Development, governments should work to strengthen these capacities in order to create an environment in which businesses and financiers are able to understand and act on current and forecasted climate change information. 	Short to Medium Term	Provincial Government, Private Sector or Individual	[9] [11] [299]
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	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
6	Policy and Regulation Research and Development	<p>Take steps to minimize supply chain disruption across Ontario</p> <p>Develop collaborative partnerships among government, private sector and supply chain management experts to support emergency preparedness and recovery plan development.</p> <p>Steps that can be taken to avoid supply chain disruption during large scale climate hazards, as developed by researchers at the University of Calgary, include:</p> <ul style="list-style-type: none"> • Push for more responsible media coverage to avoid/limit panic-buying; this can be done through retail policies limiting the number of items per household that can be purchased. • The government could provide timely and transparent updates for all stakeholders in the supply chain (including the public); when the public has been provided with regular updates, information about possible shortages, estimated shortage timeframes, and information about how the government is addressing the shortages, the impact of panic-inducing media coverage and resulting panic-buying can be lessened. • Manage risk through distribution of risk; this can be done through diversification of suppliers (e.g., using more local suppliers), reinforcing transportation networks, creating alternative delivery routes and using alternative modes of transportation. <p>Additional steps within the private sector may include:</p> <ul style="list-style-type: none"> • Strategic increase of priority inventory, both finished product and/or raw materials (with consideration given to the financial and operational risk of overstocking); • Train workers and offer competitive wages to strengthen the supply chain workforce; and, • Invest in regular proactive supply chain risk analyses. 	Medium Term	Provincial Government, Agencies, Private Sector or Individual	[301] [360] [361]

8.2 Accommodation and Food Services

Table 8-5: Accommodation and Food Services Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Invest in sustainable building improvements</p> <p>Buildings within the hospitality sector present a key opportunity to integrate climate resiliency, by improving indoor comfort in extreme heat and cold weather and integrating features to manage energy and water use. Design features could include:</p> <ul style="list-style-type: none"> • Increased thermal resistance of walls and roofs • Cool walls/roofs with higher solar reflectivity • Solar shading of windows • Improved natural ventilation and air filtration • High efficiency mechanical cooling • Chillers with heat recovery • Solar collectors for Domestic Hot Water • Water and energy conservation • Photovoltaics installed on southwest facades and roofs 	Short to Medium Term	Associations and Non-Government, Private Sector or Individual	[426]
2	Projects or Programs	<p>Conduct site risk assessments to support continuity planning</p> <p>Undertake assessment of site-level physical risks, to be reviewed on an ongoing basis and inform emergency plans. This would include a review of how climate hazards could interact with the site characteristics, access points and routes for emergency evacuation or access for emergency services, ways to improve outdoor comfort and climate controls for outdoor spaces, and emergency energy and water supplies.</p>	Short to Medium Term	Associations and Non-Government, Private Sector or Individual	[427]
3	Projects or Programs Research and Development	<p>Conduct supply chain risk assessments</p> <p>Undertake supply chain risk assessments to identify sustainability risks and inform business continuity procedures in the event of a major disruption. Some of the actions to mitigate supply chain risk could include:</p> <ul style="list-style-type: none"> • Supplier training and investment to develop climate-resilient crops and improve yields • Improving water management practices and investing in drought response and preparedness infrastructure • Partnering with community based organizations to finance a range of smaller scale and independent suppliers, diversifying the chain and supporting local entrepreneurship and economic resiliency 	Short to Medium Term	Associations and Non-Government, Private Sector or Individual	[427]

8.3 Arts, Entertainment and Recreation; Information and Cultural Industries

Table 8-6: Arts, Entertainment and Recreation; Information and Cultural Industries

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Investment and Incentives	<p>Develop a grant/loan program to support the resource-based recreation, culture, and tourism industries</p> <p>Consider developing a grant and/or loan program, potentially under the Northern Ontario Heritage Fund Corporation (NOHFC) to assist resource-based tourism operators to become more climate resilient (e.g., to install sprinkler systems to reduce wildfire damage to buildings, flood management through shoreline modifications, research and development, supply chain modifications, etc.), and to adapt or modify operations to respond to a changed environment (e.g., modifications to infrastructure due to changing water levels, diversification of recreation services offered, additional maintenance operations, modifying seasonal schedules, etc.)</p> <p>An example of a tourism company making climate-informed changes is Frontiers North Adventures in Northern Manitoba. This company made changes to their operations due to changing operating conditions (Arctic ice conditions); they also modified their supply networks by switching to local suppliers in order to become less reliant on rail deliveries which were becoming inconsistent due to changes in permafrost.</p>	Medium Term	Provincial Government, Private Sector or Individual	[297] [302] [352]
2	Projects and Programs	<p>Develop strategic partnerships to guide sustainability strategies and climate adaptation efforts and to distribute best-practice guidance</p> <p>Leverage resource and information sharing partnerships, as these are particularly relevant to the tourism, sport and recreation sector in understanding and responding to climate change.</p> <p>Build on the Northern Ontario Heritage Fund Corporation (NOHFC)'s programs as the organization has a regional mandate to support businesses and communities in the districts of Parry Sound and Nipissing and areas further north of these communities. Additional partnerships with local communities, private sector organizations, and even academia are needed to inform, design, and develop a stand-alone program that could be delivered by government and sector associations in order to advance the goals of guiding climate adaptation for the tourism, culture and sport sectors, sharing lessons learned, and supporting innovation.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia	[397]

8.4 Construction

Table 8-7: Construction Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Enhance the use of green technology in construction</p> <p>Continue to build and enhance the use of “green technology” in construction, with the intention of building more sustainable and climate-adapted buildings. Green technologies can reduce energy consumption and GHG emissions associated with construction and operations, as well as create infrastructure that requires less energy to operate, reducing reliance on the grid, and creating more livable/healthy indoor spaces.</p> <p>In addition, there are opportunities to expand on climate adapted pavement applications that rely on rehabilitation technologies, reducing costs while offering more long lasting options for paving.</p>	Short Term	Provincial Government	[398] [399] [400]
2	Policy and Regulation Projects or Programs Investment and Incentives	<p>Integrate climate change adaptation measures into early construction processes</p> <p>Support the construction sector to build new projects that are more resilient to climate change. Leaders in the construction sector can consider integrating climate change adaptation measures into the planning and design processes. This can be encouraged through policy and regulation, education, and incentives. This can include strategic planning to maintain natural features where possible, and implementation of green infrastructure.</p> <p>An example of successful inclusion of climate adaptation comes from the design and construction of the Confederation Bridge, which connects Prince Edward Island to the Canadian mainland. Planning for the bridge began in 1985; the bridge was designed to accommodate the needs of travelers and ocean vessels over the next 100 years, and climate change and rising sea levels were considered from the beginning. The structure, completed in 1997, can accommodate a one metre rise in sea levels that could have otherwise undermined the integrity and structure of the bridge.</p>	Short Term	Provincial Government, Private Sector or Individual	[367]
3	Investment and Incentives Projects or Programs	<p>Develop and manage partnerships between government and the construction industry, incentivize innovation and adaptation through procurement</p> <p>Develop collaborative and sustained partnerships between different levels of government and the construction industry, to ensure that largescale infrastructure built today will withstand the future operating environment.</p> <p>Governments (national, provincial and municipal) can consider modifying procurement practices for long-term infrastructure investments, drawing on evaluations of Green Performance Contracting practices. Specifically, the tendency to select the lowest bid may not be the optimal model upon which to allocate funds. Instead, a strong evaluation consideration could be placed upon the use of innovative materials and concepts, adaptation measures, and strong environmental considerations, even if they cost more. An increase in investment dollars today to prepare for future impact, may be able to offset the level of investment needed for repairs and replacement of infrastructure devastated by future climate events. For instance, in the case of highway construction, additional factors for consideration could include emission reduction potential, financial consideration, technological maturity, organizational readiness, industrial and public acceptance, risk, and impact on project performance, as identified by University of Maryland researchers.</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual, Academia	[371]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
4	Projects or Programs	<p>Adopt Canadian Construction industry recommendations for accelerating progress towards resilient infrastructure</p> <p>Adopt the Canadian Construction Association (CCA, 2021) published 'Strength, resilience, sustainability – Canada's construction sector recommendations on adapting to climate change', with the following key recommendations:</p> <ul style="list-style-type: none"> • Establish a national vision for resilient infrastructure • Enable continuous development • Align procurement and project design with the national vision • Invest in the future today <p>Although these are national recommendations, it provides a useful roadmap for provincial and municipal governments to support the transition towards more resilient infrastructure. There can be an emphasis, as well, upon the preservation of natural systems, and reestablishment of these ecosystem functions where possible (e.g., through green infrastructure implementation).</p>	Medium Term	Provincial Government, Municipalities and Indigenous Communities	[303]

8.5 Financial and Insurance

Table 8-8: Financial and Insurance Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Develop a program to educate insurance brokers, in collaboration with insurance companies across Ontario</p> <p>Develop a climate change adaptation education and awareness program for insurance brokers, recognizing that this group will act as an efficient access point for up to 95% of the businesses operating in Ontario today, encouraging them to adapt and save, or risk insurance availability issues. The majority of commercial insurance is sold through insurance brokers in Ontario. Insurance brokers have a key role to play in consumer education and risk management techniques, and will play a key role in risk management education and a key human resource to help communicate the message and drive positive change.</p>	Short Term	Private Sector or Individual, Academia	[305] [306] [307]
2	Projects or Programs	<p>Insurance: Support the use of public-private partnerships to reduce climate risk impacts to businesses</p> <p>Invest in public-private partnerships, specifically with the insurance industry, to support climate adaptation and assure economic continuity for businesses across the province. Priority would be given to insurance and financial risk management products that transfer climate-related risks, while incentivizing risk reduction actions.</p> <p>A Canadian example is the partnership and funding of the University of Waterloo's Intact Centre on Climate Adaptation, by the Intact Financial Corporation. The Intact Centre is an applied research centre that works with homeowners, communities, governments and businesses to identify, and reduce, the impacts of extreme weather and climate change.</p> <p>Other examples come from Asia. For instance, Swiss Re has provided reinsurance capacity to the Thai national rice insurance scheme since 2011. It now includes other crops and protection for more than two million people, with financial relief if the crop is damaged before harvest.</p> <p>In China, the insurance sector offers farms and companies affordable weather insurance policies that manage risk against the financial consequences of extreme weather conditions. They can do because the insurance industry partnered with local governments and institutions to prepare. In cooperation with the China Meteorological Administration (CMA), a detailed analysis of the climate situation in China was considered, with analysis of the legal and general regulatory frameworks for index-based weather insurance policies. Weather vulnerabilities for production sectors such as agriculture, industry and services were determined in two pilot provinces, and demand potential was identified. In cooperation with CMA, reinsurers and insurance companies could then evaluate historical weather data and continuously improve infrastructure, and indices were drawn up for the situations to be insured. This particular project focuses on insurance product development, as well as on improving dialogue between key stakeholders through workshops, seminars and conferences.</p>	Medium Term	Provincial Government, Private Sector or Individual	[308]

8.6 Forestry, Fishing and Hunting Economies

Table 8-9: Forestry, Fishing and Hunting Economies Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Forestry: Modify extraction methodologies and timing</p> <p>Consider modifying extraction methods within the forestry industry to account for, or based on impacts of, increased extreme rainfall or wildfire risk under climate change conditions. For example, some forestry companies have started using high-flotation tires on their vehicles to help navigate wet or washed-out conditions, allowing them to work in a wider range of weather conditions.</p> <p>Considerations can also be made to the timing of extraction, to support forest management practices that have been modified or implemented for adaptation to climate change (and natural resource management). Engagement with forest managers and other stakeholders and rights holders could take place to better plan for timber extraction.</p>	Short to Medium Term	Private Sector or Individual	[304]
2	Investment and Incentive Projects or Programs	<p>Forestry, Fishing and Hunting: Incentive and funding programs to support adaptation in the North</p> <p>Develop and invest in a funding and incentive program (loans and grants) that would allow northern businesses to implement green energy infrastructure as well as to set up mechanisms to reduce wildfire and flooding risks. The Northern Ontario Heritage Fund Corporation (NOHFC), as an example, offers funding and grants for businesses (and public-private partnerships) in the areas north of, and including, the districts of Parry Sound and Nipissing. This could act as a template for more broadly applicable climate adaptation funding programs.</p> <p>In addition, alignment with Ontario's Forest Sector Strategy (2020) is recommended, as the Strategy outlines targeted actions for Northern Ontario communities, including: energy alternatives to make use of waste products from forestry operations; establishing and strengthening connections with Indigenous peoples; and support for innovation related to climate change action within the sector.</p>	Medium Term	Provincial Government, Agencies, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[297] [368]
3	Project or Programs Research and Development	<p>Fishing: Review feasibility of sustainable expansion of Ontario aquaculture industry</p> <p>Undertake additional study to confirm appropriate directions for expanding aquaculture practices in the province. While Ontario aquaculture remains a small fraction of Canada's total output, aquaculture is in a period of high market growth. Inland aquaculture is dominant in Ontario; adapting to climate change risks may include netting to protect from product loss during floods and high rainfalls, and increasing dike height and depth to protect from extreme heat and storm surges. Inland aquaculture can be highly dependent on stable electricity source, therefore establishing a connection to a stable power supply and provisions for backup power may be beneficial in adding resiliency to aquaculture systems. Fish are highly temperature-sensitive, and additional design considerations may be required to control for or protect from extreme temperatures. Research into species ability to survive in Ontario's changing climate may change the dominant species farmed in the aquaculture industry.</p>	Long Term	Private Sector or Individual, Academia	[357] [358] [359]

8.7 Manufacturing

Table 8-10: Manufacturing Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects and Programs	<p>Manufacturing: Regulate source water protection planning</p> <p>Leverage opportunities with source protection authorities to ensure that water takings (e.g. water-heavy manufacturing companies) remain considered in assessing the vulnerability of drinking water sources to climate change and development of any related policies that require actions to protect sources of drinking water from depletion or contamination in the local source protection plans.</p> <p>Additional consideration could be made to special taxes for heavy-water users, in which tax revenue is used for programming, educational campaigns, and incentives for water conservation.</p>	Medium Term	Provincial Government	[SME]
2	Policy and Regulation	<p>Manufacturing: Food labeling policy development</p> <p>Create a food labeling policy, in collaboration with the Federal government, in which commodities are labelled to show their origin, seasonality (if applicable), and carbon footprint. This may promote local food supply chains, reducing risk from supply chain disruptions across a wider geography and strengthening local economies. Examples from food manufacturers include Maple Leaf Foods adding new labels to declare carbon neutral products, and Quorn Foods listing their products' carbon footprints directly on their packaging, with the carbon footprint data certified by the Carbon Trust.</p>	Medium Term	Provincial Government, Private Sector or Individual	[309] [310]

8.8 Mining, Quarrying, and Oil and Gas Extraction

Table 8-11: Mining, Quarrying, and Oil and Gas Extraction Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Mining: Incorporate climate change hazard and risk planning into Mining management</p> <p>Incorporate climate change considerations into risk management planning and operations across the mining sector. Climate change is already affecting the mining industry and projected changes to key climate variables such as temperature and rainfall have the potential to impact all aspects of the mining sector in the future. Mine owners already have established processes in place to manage risks. Climate change acts as a modifier of these risks that could have physical, social, reputational, and economic impacts on the mining sector. The incorporation of climate change considerations and the management of climate change-related liability is increasingly becoming a requirement by regulators. In parallel, there is a growing expectation from investors, lenders, insurers, and communities of interest (COI) that companies demonstrate how climate change-related risks are being managed. There is growing investor interest in the disclosure of the physical risks and opportunities posed by climate change, the potential operational, regulatory, financial, and reputational impacts, and corporate governance processes related to climate change adaptation.</p> <p>Approaches to increase the resilience of mines, reducing the potential for impacts and the need for more costly adaptation measures later in the life cycle needs to be considered. Additionally, mine owners need to take advantage of climate change opportunities for improved mine management, such as longer growing seasons that can help enhance revegetation and reclamation activities.</p>	Short to Medium Term	Associations and Non-Government, Private Sector or Individual	[382] [383] [384]
2	Policy and Regulation Investments and Incentives Projects or Programs	<p>Mining and Quarrying: Take action on decarbonization to improve energy security</p> <p>Large capital investments are required for mines and quarrying operations to fully decarbonize, but certain measures, such as adopting renewables, electrification, and operational efficiency, are economical today for many within the sector. Future regulatory and technological developments may change the viability of certain decarbonization actions. To effectively respond to the impact of climate change, mining executives can implement a range of actions, such as:</p> <ul style="list-style-type: none"> • Perform an end-to-end diagnostic of climate change's effects on the business to understand which assets to protect from physical climate change and which stand to gain or lose from decarbonization. • Mobilize the C-suite and the board to set ambitious climate targets that come from the top. • Shift to renewables, which can lower the mine's electricity costs and reduce volatility. • Introduce "climate intelligence" to decision-making processes, such as capital allocation. • Engage through reporting, partnerships, and other proactive measures, such as climate risk disclosures, which will become more important as climate expectations mature. 	Medium Term	Provincial Government, Associations and Non-Government, Private Sector or Individual	[382] [383] [384]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
3	Investment and Incentive Projects or Programs	<p>Develop community-based partnerships to support climate resiliency and mitigate the environmental impacts from mining operations</p> <p>Leverage opportunities to develop partnerships and opportunities with local communities towards reducing environmental impacts and building resiliency to climate impacts. Beyond energy, fuel and process efficiency, member companies of the Mining Association of Canada (MAC), are also engaged in numerous projects with local communities that relate to climate change, either directly or indirectly. Below is a broad sample of MAC member projects that support addressing climate change and its impacts, and the communities where they operate.</p> <ul style="list-style-type: none"> ● Renewables: <ul style="list-style-type: none"> ○ Rio Tinto’s wind farm at the remote Diavik Diamond Mine in the Northwest Territories, the first large-scale wind farm in the territory, has reduced the operation’s diesel consumption by 10% annually. ○ In 2014, IAMGOLD worked alongside five communities and a local workforce of 150 people to construct a large-scale 5-megawatt solar energy farm near its Rosebel Gold Mine in Suriname—the first in the country. The solar farm has returned a significant amount of power to the national grid, has reduced emissions, and has inspired IAMGOLD to invest in solar-powered community projects. The company’s Essakane Mine in Burkina Faso, winner of the 2019 TSM Excellence Award, is currently the world’s largest hybrid solar/thermal plant and is ensuring that IAMGOLD can lower costs, improve safety and improve its sustainability practices over the long-term. ● Reclamation <ul style="list-style-type: none"> ○ Eldorado Gold is undertaking one of the largest reclamation projects in Greece at the company’s Olympias site in the Halkidiki Peninsula. Mining activities by the previous project owners left behind more than 2.4 million tonnes of tailings. Eldorado has been rehabilitating 26.5 hectares of land, an area almost three times the size of Parliament Hill. Eldorado has removed the old tailings and reprocessed them and restored the soil so that it can support vegetation. The aim is to eventually return the Olympias valley to a green area. ● Fuel Diversification <ul style="list-style-type: none"> ○ A number of Teck’s coal mines have increased their use of natural gas in the place of coal over the last decade, reducing more than 250,000 tonnes of CO2e annually. ● Energy Efficiency <ul style="list-style-type: none"> ○ At the project development stage, Avalon Advanced Materials has successfully reduced energy use and GHG generation well in advance of construction activities through adopting a hybrid solar-diesel power generation system. ○ Dominion Diamond Corporation installed an in-vessel composter at the Ekati Diamond Mine in the Northwest Territories—the first mine in Canada’s North to do so. By the end of 2016, more than 67,000 kilograms of organic waste has been diverted, reducing GHG emissions by 210 tonnes CO2 equivalent and diesel consumption by 74,000 litres. This project was recognized with the 2017 TSM Environmental Excellence Award. 	Long Term	Provincial Government, Municipalities and Indigenous Communities, Associations and Non-Government, Private Sector or Individual	[382] [383] [384]



8.9 Retail Trade

Table 8-12: Retail Trade Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Projects or Programs	<p>Retail Trade: Integrate weather forecasting into inventory and asset management</p> <p>Apply available weather forecasting tools, as well as Indigenous and Traditional Ecological Knowledge, to integrate climate change (shifting weather patterns) into inventory and asset management systems. This will allow for the prediction and early response to potential sales and supply chain impacts. This may also allow for assessment of how products “in transit” may be impacted by climate-related disturbances.</p> <p>Mountain Equipment Company's (previously Mountain Equipment Co-operative) integrated system is an example of this in practice, as described in CPA's Adaptation Case Study #3. They track the weather and mirror this against sales to make medium- to long-term decisions about how to manage inventory and supply chain, and additionally use climate data such as flood zone mapping to inform infrastructure (e.g., distribution centre) location selection.</p>	Short Term	Private Sector or Individual	[311]

8.10 Transportation Economy

Table 8-13: Transportation Economy Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>Long Haul and Local Freight Trucking and Delivery Services: Develop regulations and/or provide incentives for gas station backup power supplies</p> <p>Develop regulations and/or incentives for retail gas stations along key transportation routes and evacuation corridors to be required to have backup power supplies in the case of power outages. For example, in Florida and Louisiana, specific service stations are required to maintain an alternative power source allowing them to continue supplying fuel. The Florida law stipulates power must be provided for a minimum of 72 hours, and details requirements based on population. In California in 2010, a proposed bill tax would have offered credits for the purchase and installation of emergency generators at service stations for the provision of power during power outages (that meet a certification standard for energy efficient or low emissions).</p>	Medium Term	Provincial Government, Private Sector or Individual	[366] [367]
2	Projects or Programs	<p>All Transportation: Climate risk assessment policy and guidance</p> <p>Integrate directives and guidance for incorporating climate resilience into engineering designs for transportation infrastructure projects. This would include adoption of tools and approaches that promote climate-adapted transport infrastructure.</p> <p>A Canadian example is the Province of British Columbia's technical circular which requires engineering design work to evaluate risk and include adaptation measures to the impacts of future climate change, weather extremes and climate-related events, as well as changes in average climate conditions.</p>	Short Term	Provincial Government, Private Sector or Individual	[96] [105]
3	Projects or Programs	<p>All Transportation: Routine and increased frequency of maintenance activities</p> <p>Conduct routine inspections and monitoring of storm sewers and drainage capacities as well as road and rail infrastructure at a higher frequency based on an increase in the rate of severe weather events and temperature fluctuations, to evaluate and assess vulnerability of culverts and drainage systems against high flows and floods.</p> <p>For airports in the far north, northeast and northwest regions, evaluate the capacity of wells to support fire protection loads.</p>	Short Term	Provincial Government, Private Sector or Individual	[107]

8.11 Utility Services

Table 8-14: Utility Services Adaptation Best Practices

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
1	Policy and Regulation	<p>All Utilities: Implement regulatory obligations on critical infrastructure to incorporate and disclose climate change risks</p> <p>Implement regulatory obligations on operators of critical infrastructure, like utilities, to incorporate and, where necessary, disclose climate change risks and opportunities in their strategic and operational plans. These disclosures would include supply and demand forecasts, Integrated Resource Management Plans, and recommendations from the Task Force on Climate-related Financial Disclosures.</p>	Medium Term	Provincial Government, Associations and Non-Government, Private Sector or Individual	[312] [313]
2	Projects or Programs	<p>All Utilities: Undertake full cost accounting, including externalities</p> <p>Expand cost accounting and pricing practices in water and energy utilities, to reflect the true lifecycle costs of the impacts of more extreme weather and climate change on water, energy management and services. Incentivize increased efficiency, reduced consumption and improved Adaptive Capacity.</p>	Short Term	Associations and Non-Government, Private Sector or Individual	[8] [9] [10] [11] [299] [302] [305] [311] [314][315]
3	Investments and Incentives Projects or Programs	<p>All Utilities: Provide funding and a platform for research on the lifecycle costs and benefits of adaptation actions</p> <p>Provide funding and create a knowledge sharing platform for research on the lifecycle costs and benefits of adaptation actions, particularly for the energy sector, in which a large proportion of social and indirect costs are associated with inaction. Research can focus on new low- and no-emissions generation and storage technologies for the energy sector. The platform can include development of guidelines on incorporation of risk management and asset planning, development of working groups including utility providers, regulators, government officials, and experts to share information and case studies, and development of a Canadian or Ontario specific database of energy adaptation initiatives.</p>	Long Term	Provincial Government	[SME]
4	Policy and Regulation	<p>Electrical Power Generation; Electrical Power Transmission and Distribution: Undertake climate risk planning</p> <p>Introduce new policies and/or regulations requiring utilities to account for climate change in resource and operations long-term infrastructure and energy planning. This might include conducting climate change risk assessments and updating them regularly. This increases capacity to address, and to integrate climate risk considerations into planning processes. Effective implementation of this type of policy is likely to require additional guidance to allow utilities to evaluate cost-effective methods of integrating climate change adaptation into their planning and operations. Knowledge sharing between municipalities/public/private organizations and utilities, guided by the government, can ensure equal consideration of climate impacts.</p> <p>For example, the California Public Utilities Commission requires utilities to conduct climate risk assessments of assets and service delivery regularly.</p>	Medium Term	Provincial Government, Associations and Non-Government	[311]

	Type of Adaptation Best Practices	Description of Adaptation Best Practices	Timeframe for Implementation	Implementation Responsibility and Partners	References
5	Investment and Incentive Projects or Programs	<p>Electrical Power Generation; Electrical Power Transmission and Distribution: Invest in infrastructure renewals and upgrades, and reduced regulatory barriers</p> <p>Develop incentive and funding programs, including removal of regulatory barriers (e.g., fast-tracked development permits for infrastructure designed for climate change and with minimal environmental impact), and mechanisms to accelerate code changes, to increase the speed of adoption of climate change adaptive practices. Given the current transition towards net zero emissions, which will increase electrification of transportation, buildings, industry, etc., investments need to be made for newer infrastructure and existing/aging infrastructure to be modernized and upgraded to support increased demand. The speed at which the program development and investment occurs needs to match or outpace the electrification pressure to avoid system strain and/or failure.</p>	Medium Term	Provincial Government	[301]
6	Research and Development	<p>Electrical Power Generation; Electrical Power Transmission and Distribution; Telecommunications: Undertake post-event forensic investigations and decision-maker education</p> <p>Apply tools such as post-event forensic investigations and targeted historical research to identify thresholds for failures and critical impacts. This will allow for classification of vulnerable systems and components, and provide an opportunity to make the necessary upgrades in advance of a damaging climate event.</p> <p>Education and capacity building of key decision-makers, using forensic investigations as evidence of critical climate impacts, could be used to increase the potential of new infrastructure designs to include climate change considerations (physical risk). Decision makers would also be advised of risks related to the transition towards a low carbon economy, and the opportunity to enable variable grid-tied renewable resources such as wind and solar.</p>	Short Term	Associations and Non-Government	[301] [307]



9.0 Closure

The PCCIA focused on identifying climate impacts and Adaptive Capacity across five Areas of Focus, namely Business and Economy, Food and Agriculture, Infrastructure, Natural Environment, and People and Communities. In addition, five cross sectoral areas were identified, namely Water Security, Energy Security, Food Security, Community Function, and Human Health, Safety and Well-being.

The report presents a series of adaptation practices that are overarching across the province, for each Cross Sectoral theme, and for each Area of Focus studied within the PCCIA, and identifies practices that may reduce risks and build Adaptive Capacity.

The identified practices are measures that have been implemented (either in Ontario or in other jurisdictions), researched and peer-reviewed, and/or recommended by subject matter experts (both through consultation with external participants, and in collaboration with internal consulting team specialists). This report is intended to provide a starting point for discussion, and support the development of targeted climate change adaptation action and implementation plans across Ontario.

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