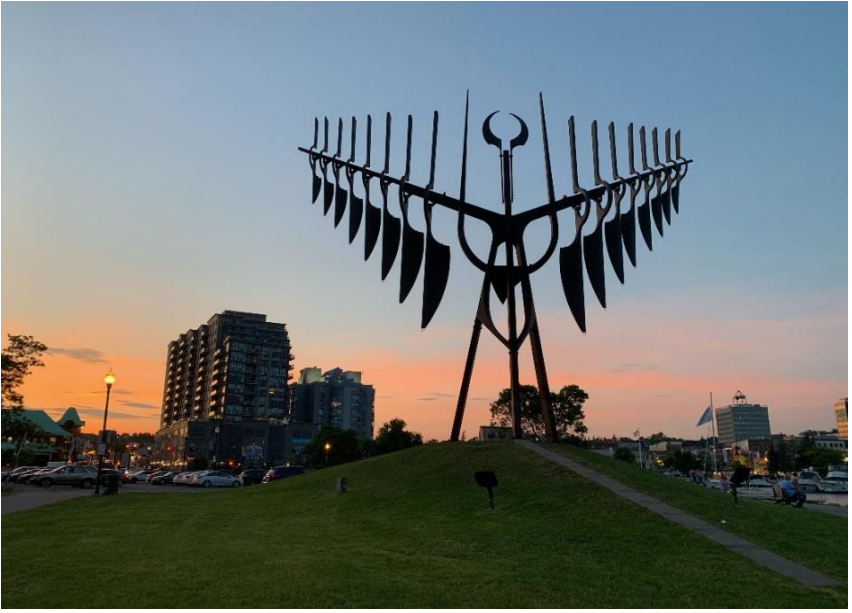


Ontario Provincial Climate Change Impact Assessment

Summary Report

January 2023

Table of Contents

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.

Project Team: Climate Risk Institute (CRI), Dillion Consulting Limited, ESSA Technologies Limited, Kennedy Consulting, and VIRIDI Global.

Acknowledgements

We gratefully acknowledge the Ontario Ministry of the Environment, Conservation and Parks (MECP), the Impact Assessment Inter-Ministry Committee (IAIC), and the Peer Review Panel for the guidance, support, and input throughout the project.

The following ministries comprised IAIC:

Ontario Ministry of Agriculture, Food and Rural Affairs

Ontario Ministry of Citizenship and Multiculturalism

Ontario Ministry of Economic Development, Job Creation and Trade

Ontario Ministry of Energy

Ontario Ministry of Environment, Conservation and Parks

Ontario Ministry of Finance

Ontario Ministry of Health

Ontario Ministry of Infrastructure

Ontario Ministry of Labour, Immigration, Training and Skills Development

Ontario Ministry of Mines

Ontario Ministry of Municipal Affairs and Housing

Ontario Ministry of Natural Resources and Forestry

Ontario Ministry of Northern Development

Ontario Ministry of Public and Business Service Delivery

Ontario Ministry of Solicitor General

Ontario Ministry of Tourism, Culture and Sport

Ontario Ministry of Transportation

Ontario Ministry of Treasury Board Secretariat

Infrastructure Ontario

This report could not have been possible without the input of the following individuals serving as part of the Peer Review Panel:

Kerry Ann Charles, Cambium Indigenous Professional Services (CIPS)

Amber Crawford, Association of Municipalities of Ontario (AMO)

Mark Fisher, Council of the Great Lakes Region (CGLR)

Kathryn Bakos, Intact Centre on Climate Adaptation

Jo-Anne Rzadki, Conservation Ontario (CO)

Michael Brooks, Real Property Association of Canada (REALPAC)

Gordon McBean, Institute for Catastrophic Loss Reduction (ICLR)

Drew Spoelstra, Ontario Federation of Agriculture (OFA)

Andrew Graham, Ontario Soil and Crop Improvement Association (OSCIA)

Cheryl Chetkiewicz, Ontario Association for Impact Assessment (OAIA)

Introduction and context

The climate has changed. Between 1948 and 2016, average temperatures have risen 1.3°C and total precipitation has increased by 9.7% in Ontario[i]. Observation and climate model data indicate increasingly frequent, variable, and severe extreme weather events, with impacts reflected in rising damages and losses tracked by organizations across Ontario and Canada.

Ontario has already experienced significant climate impacts from flooding, wildfires, heat waves, ice storms and many other events. Flooding in particular has been a significant driver of damages and costs to both public and private sectors.

The climate will continue to change. In fact, we are locked into climate impacts over the next half century, with impacts expected to become more frequent and more extreme.

There is an urgent need to act, to prepare and to invest. The impacts associated with a changing climate have become more apparent in daily life, increasing risks to social, economic, cultural and ecological systems.

A climate change impact assessment was undertaken across Ontario to better understand the risks Ontario's residents, communities, systems, and sectors face. Information produced from this assessment can help to prioritize investments, policy making and decision-making focused on adaptation.

What was assessed?

Food and Agriculture

Natural Environment

Business and Economy

Infrastructure

People and Communities

While significant work has been done, and Ontario's capacity to adapt is considered relatively high because of institutional, technological, human, and financial resources, **Adaptive Capacity has not yet been mobilized widely nor sufficiently to build climate resilience.**

How to read this summary report

Welcome! This Summary Report is designed to help you navigate across the vast range of results from Ontario's Provincial Climate Change Impact Assessment (PCCIA), with key results presented by Area of Focus, Cross-Sectoral Theme and Region.

What are you interested in? Click on the buttons below to navigate to the appropriate section in this Summary Report. At the end of each section a link back to this landing page will be provided.

I want to understand:

- Key Takeaways from the Assessment
- What Climate Conditions are Driving the Highest Risks
- What was Assessed
- What are the Limitations
- Where Climate Impacts were Assessed
- Are there any Opportunities
- How Climate Impacts were Assessed
- Ontario's Capacity to Adapt

Areas of Focus Results

- Food and Agriculture
- Infrastructure
- Natural Environment
- People and Communities
- Business and Economy

Cross-Sectoral Theme Results

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

Key Takeaways from the Climate Change Impact Assessment

Headline Statements

1. The climate has changed, is changing and will continue to change across all regions of Ontario. Climate change impacts are being observed across numerous sectors, ecosystems, communities and industries.
2. The degree of future climate change risk in Ontario is dependent on the extent to which greenhouse gas (GHG) emissions are reduced, the extent to which Adaptive Capacity is further enhanced and marked increases in the scale of adaptation.
3. No matter how quickly GHG emissions are reduced, momentum in the climate system will drive climate change and impacts for many years.
4. Ontario has a relatively high capacity to adapt to climate change, but the capacity is unevenly distributed across the province and has not been mobilized widely or sufficiently to effectively build climate resilience.
5. Literature, data and observations of climate change underpin this provincial impact assessment. Sustained research and monitoring builds further understanding of climate drivers, the nature of impacts on ecological and human systems, and the success of adaptation choices.
6. Many risk scenarios and scores were developed as part of the Provincial Climate Change Impact Assessment (PCCIA) and provide a foundation for decision-makers to investigate, invest, and accelerate implementation of adaptation measures.
7. While opportunities in the face of a changing climate are not widespread, they do exist in some regions and for certain sectors. For example, warmer average annual air temperatures may conditionally contribute to opportunities for some plant and animal species through expansion.
8. The time to act is now. There is an urgent need to act, to prepare, and to invest in adaptation across Ontario.
9. Although not explicitly part of this assessment, the business case is strong and there is ample evidence that points to high direct and indirect returns on climate change adaptation investment[ii].
10. The health and well-being of future generations of Ontarians is dependent on improved climate-resilient infrastructure standards and significant actions to conserve, protect and enhance our natural systems in a changing climate.

Areas of Focus

Food and Agriculture

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

12. In addition to direct impacts to crop and livestock productivity, Ontario's agriculture is vulnerable to indirect impacts caused by climate interactions with pests and diseases, soil and water conditions, and infrastructure that is critical for agricultural production. With proactive adaptation by the agri-food industry, Ontario producers may experience more stability, lower economic losses from climate-related impacts and stronger competitive advantage.

Infrastructure

13. Almost all infrastructure across Ontario is at risk from climate change. Not a single asset included in this assessment is considered to have a risk profile less than 'medium' under current climate conditions. In many regions, and for certain asset classes, this risk is expected to rise in the future.

14. Existing infrastructure condition pressures combined with a changing climate will drive mid- to long-term challenges in managing Ontario's infrastructure. Climate-sensitive upgrades, renewal, and new builds that seize recently developed codes and standards for climate change will improve asset longevity and ensure service level stability for Ontarians.

Natural Environment

15. Climate change is already a threat to Ontario's natural environment and is expected to continue to intensify risks to species, habitats, and ecosystems into the future. In tandem with significant human development pressures, risk profiles across almost all natural systems that were assessed are rising to 'high' by mid-century. By the end of the century, one quarter of climate risks to the natural environment are expected to be 'very high'.

16. Species and habitats are irreplaceable, and ecosystem services and functions that benefit society are difficult and costly to replicate via engineered technical substitutes. A healthy and resilient natural environment in Ontario is the essential foundation to adapting to a changing climate.

People and Communities

17. Climate risks are highest among Ontario's most vulnerable populations, including Indigenous Communities and Populations with underlying health and social inequities, exacerbating existing disparities and injustices.

18. Climate change has already had significant impacts on individuals, communities, and associated services in Ontario, and without coordinated and inclusive adaptation efforts, it will continue to drive risks into the future.

Business and Economy

19. Most Ontario businesses will face increased risks due to the physical impacts of climate change. Declining ecological integrity and health, driven in part by climate change, will also negatively affect natural resource businesses and regional economies.

20. Climate-resilient businesses are key to a resilient economy. Through investment in adaptation and capacity building, this can become a competitive advantage and lead to climate-sensitive prosperity for businesses and improved quality of life for Ontarians.

Cross-Sectoral Themes

Food Security

21. With elements of productivity, processing, transportation, distribution and large retail, the agri-food system in Ontario is complex and has many points of interaction with weather and climate. System-wide resilience with a focus on areas that are known to be vulnerable to climate change and regions that are more food insecure, will improve system resilience.

Energy Security

22. Energy is already unaffordable for many Ontarians, and energy insecurity disproportionately impacts Indigenous, rural, and remote communities across Ontario. Energy infrastructure investments will help meet emission reduction targets and ensure a resilient, equitable and affordable energy system for all.

Water Security

23. The high complexity and interconnectedness of the water sector in Ontario underlines the importance of collaboration, efficient and timely decision-making and policy alignment. Consideration of climate change within this complex environment is crucial but can increase the complexity and underscore the need for robust and flexible decision-making systems.

Human Health, Safety and Well-Being

24. Existing human health inequities across Ontario will be worsened by climate change. Health-related adaptation requires involvement from both inside and outside of the health sector, as well as coordination across levels of government and Indigenous Organizations and Communities. Prioritizing adaptation actions to address existing health inequities and vulnerability will minimize negative climate-related outcomes for the health, safety, and well-being of Ontarians.

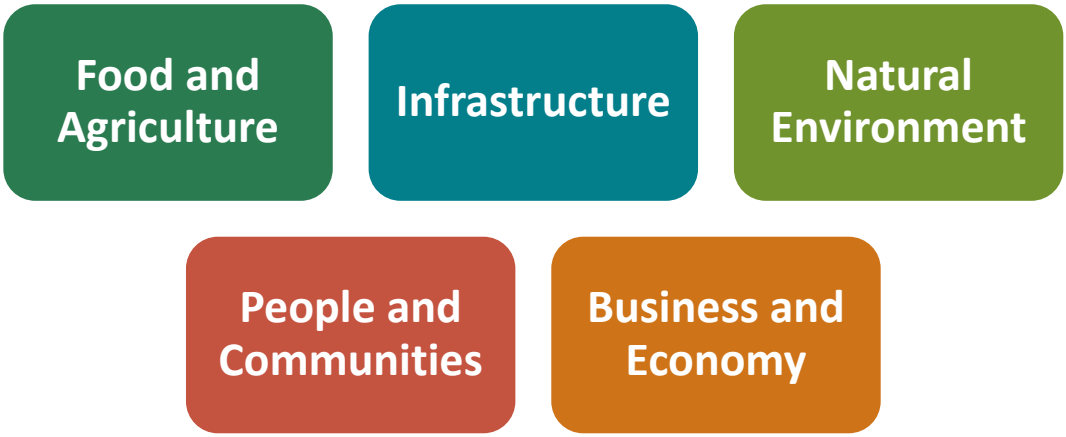
Community Function

25. Climate change impacts community function both directly, through different climate and weather events (e.g. extreme precipitation or wildfire), and indirectly, through a range of environmental, infrastructure, and economic pathways. Community-level adaptation planning and response should seek to address social inequities and similarly, investments to address social inequity will lead to greater climate resilience.

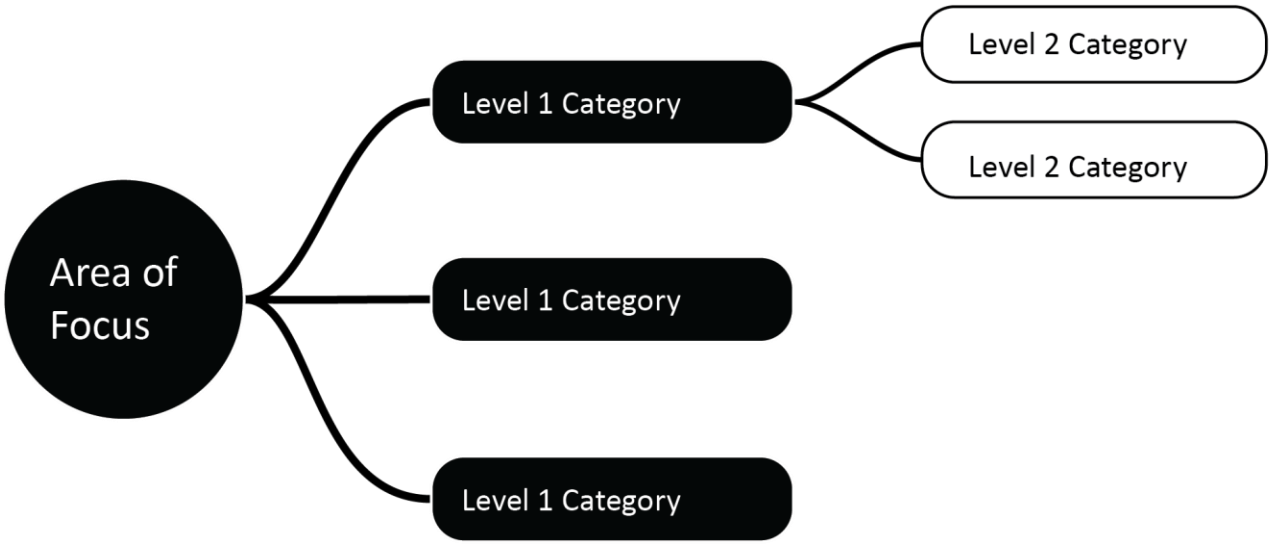
What sectors and systems were assessed?

Ontario's PCCIA focused on Areas of Focus and Cross-Sectoral Themes for analysis. Each of these sectors and systems broadly represent the diversity of ecological, social, and business systems in Ontario.

Areas of Focus



In each Area of Focus, a series of categories called 'Level 1' and 'Level 2' were used to guide the development of risk scenarios for assessment. Each Level 1 category represents key components or sectors under each Area of Focus. Some of these categories are further delineated to include sub-categories, labeled as Level 2 categories, and provide additional details for certain subsectors and industries.



Wondering where a particular commodity, species, asset, or potential category is located?

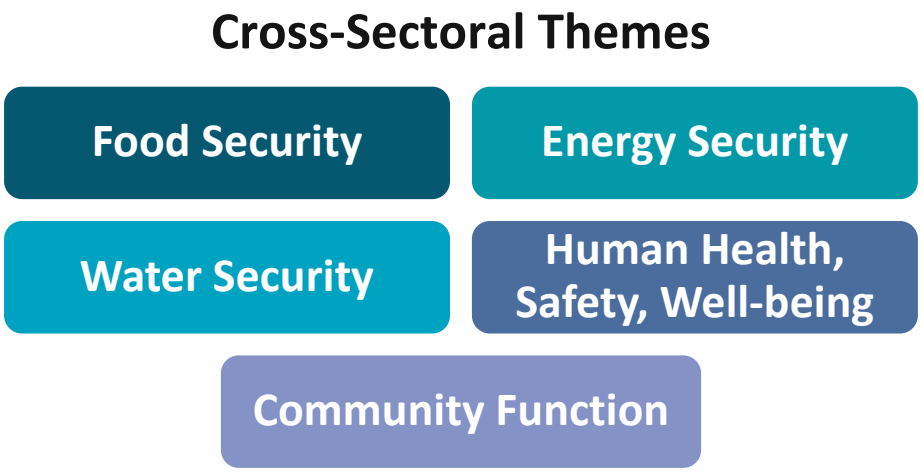
If it is not displayed within the Area of Focus categories, it may have been considered but not evaluated quantitatively as part of the assessment. Many areas have been qualitatively assessed and are contained within other PCCIA products.

What about impacts that span multiple Areas of Focus?

To represent the inherent connectedness of systems in society, and complex interactions between Areas of Focus, cross-sectoral analyses were conducted. These 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
5. Community Function

The cross-sectoral analysis centered around human populations and impacts were viewed through an equity lens which highlighted unique factors or populations that may be disproportionately impacted.



Where were climate change impacts assessed?

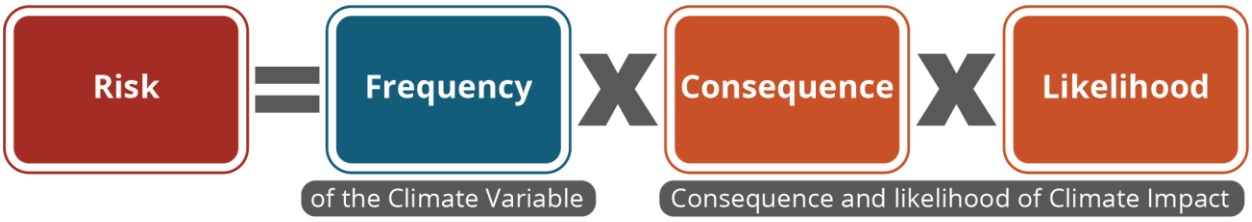
The assessment was conducted across six Geographic Regions. The Regions aligned with Census Canada Divisions except for the Far North Region, which aligns with the Far North boundary as defined by the Ontario Ministry of Natural Resources and Forestry (MNRF). As a result, certain areas of Kenora, Cochrane and Thunder Bay appear in two distinct Regions.

Each Region was explicitly considered, and risk scenarios and risk scores developed for each. Ontario is geographically unique, and each Region is anticipated to have different systems, sectors, and levels of risk to climate change. For example, in some Regions, highly important ecosystem components are more prevalent and thus contribute to both what is at risk, and what drives risk in a particular Region of Ontario. In other Regions, infrastructure systems or agricultural operations may be present and play a bigger role, changing the risk context and contributing to regional perspectives.

Regional Profiles

How were climate impacts assessed?

Climate risks were evaluated as a function of the **frequency of the climate variable**, the **consequences of an impact**, and the **likelihood of that impact occurring**.



Climate variables for the PCCIA refer to individual and separate aspects of climate and weather that have changed, are going to change from current to future (2050s or 2080s) and have widespread impacts on Areas of Focus. Climate variables were treated as discrete and independent elements that feed into the impact assessment process.

The **frequency** of each climate variable was characterized by the amount of change from baseline (current) conditions to the 2050s and 2080s time periods, with the direction of change indicating potential for increased risk or opportunity.

Consequence of impact was assessed based on consideration of one or more of the following categories:

1. Impacts on Human Health and Safety
2. Environmental Damage
3. Disruption of Services
4. Financial Loss

The **likelihood of impacts** associated with consequence was characterized as the annual probability or percent chance of an impact occurring, categorized as 'improbable', 'remote', 'occasional', 'probable', and 'frequent'.

Projections of demographic, social, economic and financial change, known as socio-economic projections, were developed for future time periods. These projections explain how society could evolve into the future and form the backdrop against which climate change impacts are evaluated. The socio-economic projections were used to inform changes to the severity of consequence and/or likelihood of impact within each Region and Area of Focus.

To calculate total risk scores, the impact assessment was conducted in steps. First, risk scores for each unique interaction (e.g. one climate variable and its associated effect on a particular Level 2 category in one Region of Ontario) were combined to produce a representative risk profile for a Level 2 category, then further summed to produce scores for a Level 1 category. Scores were then summed and rolled up for each Area of Focus and Geographic Region.

Risk scores were assigned for current, mid-century (2050s) and end of the century (2080s) time periods. Current climate impacts were assessed using a baseline period of 1981 to 2010. Then, using climate projections the same impacts were assessed in future time horizons for the 2050s (representing the period from 2041 to 2070) and the 2080s (representing the period from 2071 to 2100).

How were consequences assessed?

When evaluating the consequences, ratings of 'very low', 'low', 'medium', 'high', and 'very high' were used. Depending on the Area of Focus, different themes or combinations of themes were used to assess impact consequences in relation to a single risk scenario.

Impacts on **Human Health and Safety** were considered for People and Communities Area of Focus and assessed as a proportion of the population that experiences an adverse effect in relation to each risk scenario.

Environmental Damage was considered for Natural Environment Area of Focus, using two sets of criteria. One focused on the ability to recover from climate impacts and was applied to risk scenarios associated with species and ecosystems. The second criterion focused on the ability of natural assets, such as wetlands and forests, to deliver ecosystem services despite climate threats and was applied to risk scenarios for ecosystem services.

Disruption of Services was considered for Business and Economy Area of Focus. The severity of impact for each risk scenario was assessed by quantifying the degree to which an asset or service would no longer function at normal levels, measured as a percent of loss of function of an asset or service.

Financial Losses were considered for Food and Agriculture, Infrastructure, and Business and Economy Areas of Focus. The respective severity of impact for each risk scenario was assessed by quantifying the extent of yield loss for crop and livestock products, cost of infrastructure asset damage or replacement, and the amount of business loss as a percent of company annual revenue.

Which climate variables were used in the assessment?

Historical and projected future climate data were a fundamental component of the PCCIA. Ultimately, 15 climate variables were selected for the PCCIA and categorized into eight main climate groupings[iii]. The selected variables are defined in the table below.

Climate Grouping	Climate Variable	Brief Description
High and Extreme Temperature	Extreme Hot Days (> 30°C)	A count of the average number of days per year where the maximum temperature exceeds 30°C.
	Cooling Degree Days (18°C)	The annual accumulation of mean temperature over 18°C as an indication of cooling demand.
Low Temperature	Degree Days < 0°C	The annual accumulation of cold conditions in a year where the daily mean temperature is less than zero.
	Cold Days < -25°C	A count of the average number of days per year where the minimum temperature is less than -25°C.

Climate Grouping	Climate Variable	Brief Description
Temperature	Growing degree Days (5°C)	The seasonal accumulation of heat where the mean temperature is greater than 5°C.
	Growing Season Length	The length of the growing season in days is determined by spring temperature and autumn temperature thresholds.
Precipitation	Spring Precipitation	Total spring precipitation (rain and snow).
	Summer Precipitation	Total summer precipitation (rain and snow).
	Autumn Precipitation	Total autumn precipitation (rain and snow).
Winter Precipitation	Winter Rain Percentage (Rain to Snow Ratio)	The proportion of winter precipitation falling as snow using a daily mean temperature threshold of less than 0°C.
	Winter Precipitation	Total winter precipitation (rain and snow).
Extreme Precipitation Events	Extreme Precipitation (Short Duration)	The average annual maximum one day precipitation amount.
	Extreme Precipitation (Long Duration)	The average annual maximum three-day accumulated precipitation amount.
Drought	Moisture Deficit	The difference between annual precipitation and annual evapotranspiration.
Wildfire	Wildfire Index	Wildfire return period is the average time between fire events.

How were risks categorized?

The PCCIA classifies risks into four broad categories, 'low', 'medium', 'high' and 'very high' across the three time periods (current, 2050s, and 2080s). The results presented in this report are operating under a high-emissions scenario (RCP8.5). The risk scores are reflective of only direct impacts associated with climate change, and do not include indirect or cascading impacts. These impacts are explored qualitatively throughout each Area of Focus and Cross-Sectoral Theme.

A Representative Concentration Pathway or RCP represents concentrations of future greenhouse gas concentrations in the atmosphere. The pathways are dependent on several societal factors (e.g. population growth, energy mix) and are used in climate modeling to develop future climate states.

RCP 8.5 represents a 'business-as-usual' or high emissions trajectory.

Climate conditions driving Ontario's most significant climate risks

'High' and 'very high' risks were present in every Area of Focus across each Region of Ontario, but climate variables and events driving the highest risks differ depending on:

1. How far into the future the risks are evaluated for (e.g. current vs. 2050s vs. 2080s)
2. What Area of Focus the risks are for (e.g. Infrastructure has different major drivers than Natural Environment)
3. What Region of Ontario the risks are evaluated for

If we had to summarize it briefly:

High and extreme temperatures, extreme precipitation events and changes in seasonal temperatures are the main drivers of highest risks across Ontario.

However, wildfire, drought and changes in seasonal precipitation are also especially impactful for certain Regions and Areas of Focus.

Some Areas of Focus have a much more diverse suite of climate conditions and events driving the highest risks. This could reflect how many possible impacts or interactions a particular sector or system is exposed to (e.g. food and agriculture commodities and natural environment systems).

What are the limitations of this assessment?

Uncertainty is inherent in any type of climate change impact assessment, particularly in relation to future climate and socio-economic conditions. Coupled with the degree of uncertainty, the scope and scale of a provincial-level assessment establishes a coarse lens to evaluating climate change impacts across Ontario. Consequently, many of the impacts and associated risks identified throughout this assessment may look different for individual communities or sectors.

In addition, the risk scores from this assessment reflect only the direct physical impacts of climate change. Indirect impacts are ones that occur secondarily (trickle down) or are presented when combined with other climate variables. Due to their complexity and in trying to manage the scope of the PCCIA, indirect impacts and those associated with cascading events were assessed qualitatively and do not factor into individual or total risk scores. Further details on limitations specific to each Area of Focus are included throughout the report.

Are there any opportunities?

The impact assessment found that while there may be some opportunities associated with a changing climate, in most cases the risks outweigh the potential opportunities. By enhancing Adaptive Capacity and implementing adaptations noted in this report, Ontario may see some positive impacts stemming from climate change. The PCCIA found that some opportunities exist for some animal and plant species (e.g. certain reptiles species), which may be able to shift and expand their ranges. In addition, warmer average annual and seasonal temperatures may conditionally contribute to opportunities for agriculture through higher production levels and through commodity and regional expansion.

Assessing Ontario's Adaptive Capacity

When assessing the impacts that climate change will have on Ontario, it is important to not only look at risk, but also the province's 'Adaptive Capacity'. **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**' [iv].

This PCCIA analyzed five main categories of adaptive capacity:

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

Find a summary of Ontario's Adaptive Capacity and current adaptation priorities identified throughout the PCCIA by navigating to the sections below.

Ontario's Capacity to Adapt | **Adaptation Priorities for Ontario**

Navigate back to the Launch Page

Areas of Focus

Food and Agriculture

What are they key findings for Food and Agriculture?

Ontario's food and agriculture systems are sensitive to regional climatic conditions, with changing temperature and precipitation patterns directly influencing productivity and other facets of the sector. While changing climate conditions may present potential opportunities for agriculture in Ontario (e.g. longer growing and grazing seasons), such benefits will likely be offset by negative impacts, resulting in declining productivity, crop failure, and livestock fatalities. Several field crops and fruit and vegetable commodities (e.g. corn, cereals, soybeans, grapes, field vegetables) are expected to face 'very high' climate risk by the end of the century.

Several commodities are expected to face very high climate risks by the end of the century.

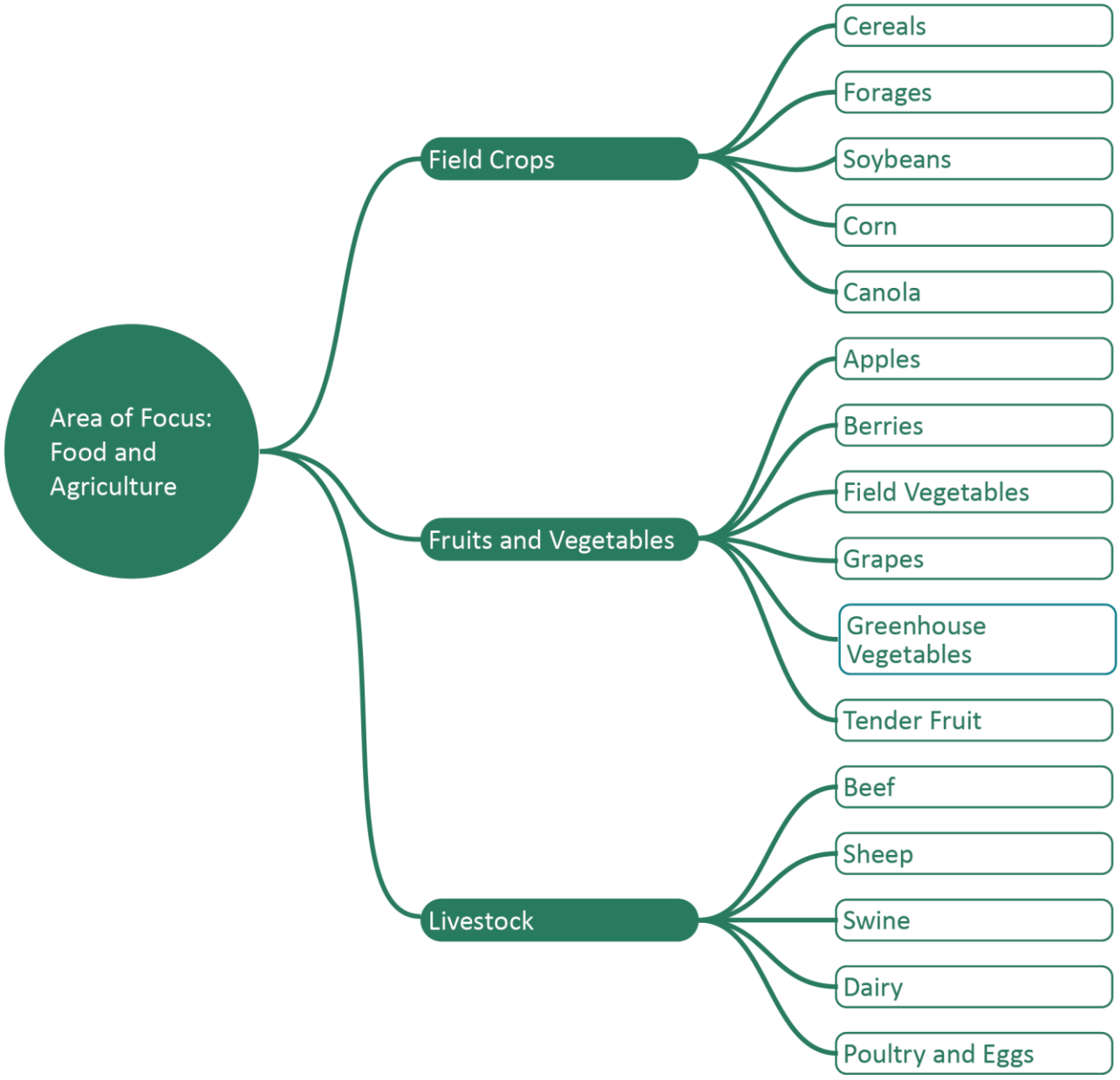
Why are Ontario's Food and Agriculture systems important?

Southwest and Central Ontario are among the richest agricultural regions in Canada, with favourable climate and terrain conditions, access to fresh water and supporting agri-food infrastructure systems. Eastern Ontario also has large areas that contribute to agricultural production for the province. Ontario's northern regions support well-established dairy, beef, grain, oilseed, fruit, and vegetable industries, with potential for future agricultural expansion (e.g. in the Clay Belt).

The sector is multi-faceted and inextricably linked to systems within and outside of the sector, including infrastructure, economic and natural systems. While managing uncertainty and risks is common within Ontario's agri-food sector, and changing climate conditions could present opportunities for agriculture in Ontario (e.g. longer growing and grazing seasons), climate change is also expected to amplify existing risks and introduce new risks to food producers across the province.

Defining Ontario's Food and Agriculture for assessment

The Food and Agriculture Area of Focus was divided into three Level 1 categories to capture key primary agricultural production systems in Ontario. Each of these categories was further delineated to include Level 2 categories to capture major agricultural commodities produced within those systems across the province. For each Region, factors that were considered for selecting each Level 2 category included the portion of total farm cash receipts and farmable land, significant contribution to regional employment or economic activity, and the potential for shifts in a Level 2 category within a Region. By applying these criteria, the Far North Region was scoped out of this Area of Focus, as there is currently limited primary production within the Region.



Food and Agriculture Level 1 Categories

 **Field Crops**

 **Fruits and Vegetables**

 **Livestock**

How were the impacts to Food and Agriculture assessed?

Ontario's agri-food sector is exposed to multiple climate variables and events that lead to direct and indirect impacts, affecting crop and livestock production. The assessment has drawn on research, provincial production and insurance data, socio-economic data, and literature to inform scenario development and consequence scoring related to direct climate risks on field crop, fruit, vegetable, and livestock productivity.

Over 900 separate risk scenarios were assessed for the three Level 1 categories, considering how changes in climate variables could lead to impacts on each Level 2 category. The types of climate variables chosen for application to Level 2 categories depended on their sensitivity and geographic location/distribution. Each scenario was evaluated under current and future timeframes (2050s and 2080s) and for the relevant provincial Regions. The selection of proxy commodities for the assessment of certain Level 2 categories was conducted through a review of literature and production data across the province (e.g. winter wheat was selected as a proxy commodity for cereals).

Consequence was assessed based on financial losses, with scoring criteria represented by percent yield loss. The severity of consequence ranged from 'very low' (<5% yield loss) to 'very high' (>50% yield loss). To update consequence scores for the 2050s and 2080s time periods, socio-economic projections were considered along with specific assumptions on agriculture development in different regions across Ontario. The likelihood of impact for each risk scenario was assessed by considering the probability of each scenario to cause the consequence or loss described in any given year.

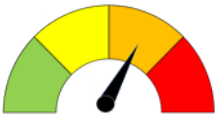
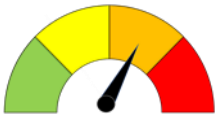
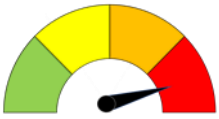
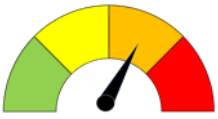
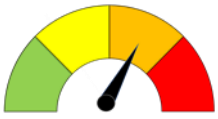
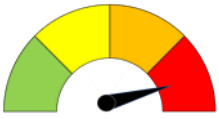
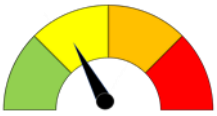
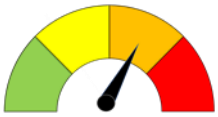
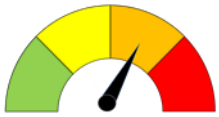
When interpreting quantitative risk scores under this Area of Focus it is important to consider that scores reflect only direct climate impacts to Level 1 and Level 2 categories. The risk scores do not account for indirect impacts within or outside of the sector that could influence current and future climate risk scores.

If you only take one thing away:

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 are expected to face 'very high' climate risks by the end of the century.

In addition to direct impacts to crop and livestock productivity, Ontario's agriculture is vulnerable to indirect impacts caused by climate interactions with pests and diseases, soil and water conditions, and infrastructure that is critical for agricultural production. With proactive adaptation by the agri-food industry, Ontario producers may experience more stability, lower economic losses from extreme weather and a stronger competitive advantage.

How are the risks changing?[1]

Level 1 Category	Now	2050s	2080s
Field Crops	 High Risk	 High Risk	 Very High Risk
Fruits and Vegetables	 High Risk	 High Risk	 Very High Risk
Livestock	 Medium Risk	 High Risk	 High Risk

[1] Risk profiles reflect the highest regional risk score operating under RCP8.5 (high emissions scenario).

What are the risks?

Field Crops

Field crop production is the most common type of primary agriculture in Ontario. The selection of field crop commodities grown across the province varies depending on the climate and land suitability of each region, market drivers, and the needs of producers.

Field crops are inherently vulnerable to weather and climate conditions, due to their direct exposure. The assessment identified a few instances where Ontario's changing climate may present opportunities for field crop production, driven by longer growing seasons, milder winters, and fewer frost days. However, the assessment found that any benefits are likely to be offset by risks associated with increased frequency and intensity of extreme weather events, variability and unpredictability in seasonal temperatures, extreme temperatures, and changing precipitation patterns at critical crop development phases.

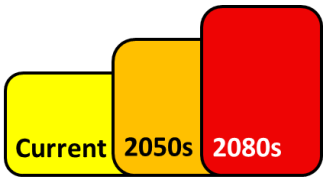
Potential benefits for field crop production were found to be offset by negative impacts, resulting in declining productivity.

High and extreme temperatures, extreme precipitation events, and drought conditions are the greatest drivers of future risk to Ontario's field crop operations and production. Impacts to field crop production include moisture and heat stress, water-logging, winterkill and expansion of pests and disease. Additionally, indirect climate impacts to field crop production, notably to water management, soil health and supporting infrastructure, introduce another layer of complexity that influences how climate impacts can cascade within and across crop regions of the province.

Climate impacts were evaluated across five sub-categories of field crops: **cereals, forages, soybeans, corn, and canola**. There are some minor variances in current risk profiles, but all Level 2 categories of field crops across all Regions are assessed as 'high' or 'very high' by the end of the century.

A greater increase in risk is observed for Southwest, Central and Eastern Ontario by mid-century, with Northeast and Northwest Regions increasing in risk by the end of the century. It is expected that the agricultural industry will expand in northern regions of the province considerably by the second half of the century. Once industry expands, it is anticipated that northern Ontario (e.g. Northeast and Northwest) will have increased agricultural outputs and consequently, exhibit greater exposure to climate impacts. The higher risk scores in Southwest, Central and Eastern Ontario are indicative of existing exposure and sensitivity to changing climate conditions.

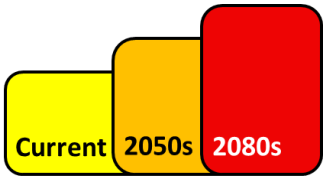
Cereal commodities make up a large portion of the cropping system in Ontario, grown on approximately 25% of the arable land[v]. Winter wheat is the most widely grown cereal crop in Ontario followed by spring barley, spring wheat, and oats. Oats (Northwest Ontario) and winter wheat (Southwest, Central, Eastern and Northeast Ontario) were selected as proxy commodities for cereals based on their presence in the regions and notable climate sensitivities.



The assessment has shown that cereals face 'medium' climate risk under current conditions. This risk profiles increases to 'high' by the 2050s in all Regions, with Southwest, Central, Eastern regional risk profiles increasing further to 'very high' by the 2080s. Extreme heat and winter precipitation are the main climate variables driving future risk to cereal productivity. Frost heaving, icing, low temperatures, and snow mould can significantly impact cereal production, with icing and drowning conditions throughout the winter and early spring being a driver of winterkill in Ontario. Regions with limited sub-surface drainage and heavy-textured soils are particularly sensitive to these impacts. Under a changing climate, increased freeze-thaw cycles, rapid snowmelt, and warming shoulder season temperatures, will likely increase the risk of impacts associated with winterkill in winter cereal commodities.

Forages are an important crop that provides feed for Ontario's livestock industry and are an important component of crop rotations on many farms. Forage crops are grown on over 3.5 million acres of land in Ontario, while the value of forage production is estimated to be nearly 10% of Ontario's agricultural production[vi]. Southwest and Eastern Ontario comprise the majority of forage acreage, followed by Central and Northeast Ontario. Alfalfa, the highest-yielding perennial forage crop grown in Ontario and the most frequently grown forage legume, was selected as a proxy commodity to represent forage crops for this assessment.

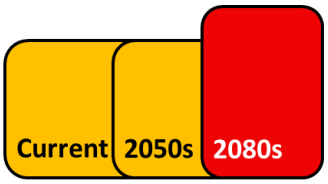
Climate conditions that increase the risk of winterkill are particularly impactful to alfalfa development. Warming fall temperatures and wet saturated soils can compromise winter hardening and contribute to risk of winterkill. Extreme heat is also likely to drive future risk to alfalfa production. The frequency, intensity and duration of heat waves can cause several impacts to forage production including reduced photosynthesis, pollen production and viability, and reduced grain number and weight. Impacts of extreme heat are exacerbated if coupled with prolonged drought conditions.



The risk profiles for forage crops in Southwest, Central, and Eastern Regions increase from 'medium' to 'high' by the 2050s, and to 'very high' by the 2080s. In Northeast and Northwest Ontario, the risk profile increased from a 'medium' to a 'high' score by the 2050s and remains at this score for the 2080s. Importantly, cascading impacts of declining productivity

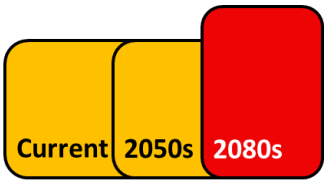
and quality in forage crops and pastures significantly affect the livestock sector. Climate-related impacts on forage crops can result in feed shortages, while declining feedstock quality and quantity can lead to animal health and welfare concerns and further financial losses across the sector.

Soybeans are Ontario's largest row crop by acreage, with close to three million acres grown annually across the province[vii]. Soybeans grown in Ontario are used for specialty food grade markets, oil production and livestock feed and are the province's greatest agricultural export commodity. Southwest Ontario accounts for over 70% of provincial soybean harvest, followed by Eastern and Central Ontario[viii].



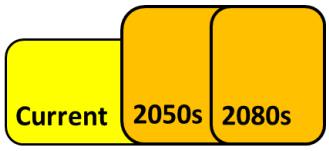
The assessment found that extreme precipitation and extreme temperature are key climate variables driving future risk to soybean production. Soybeans are particularly sensitive to extreme precipitation and flooding during early growth stages, when water -logging of fields and plant submergence can cause significant crop damage and yield losses, resulting in associated financial consequences. Areas with heavier clay soils and inadequate drainage are more vulnerable to impacts of flooding, water-logging, and crusting, resulting in increased risk of yield loss. Extreme heat resulting in plant heat stress, decreased productivity and lower yields, is expected to impact soybean production in the province over the coming decades. Risk to soybean production was found to increase from a 'high' score to a 'very high' score by the 2080s in all Regions except Northeast, which remains 'high' until end of century.

Corn is the second largest field crop grown throughout Ontario for both feed and industrial uses, with 2.1 million acres of grain corn harvested in 2021[ix]. Corn is most widely grown in Southwest Ontario, followed by Eastern and Central Ontario.



Climate risks to corn production are currently 'high' in Ontario and are expected to increase to 'very high' by the 2080s across Southwest, Central and Eastern Regions. Moisture deficit and drought are the most impactful drivers of risk to corn yields, especially at critical stages of plant development. The magnitude and duration of moisture deficit and drought conditions can lead to compromised growth and development and increase risks related to pest and disease outbreaks. Risks are often exacerbated for rainfed corn crops grown on soils with low water holding capacity. While Ontario's agriculture is mainly rainfed and irrigation continues to be limited for common field crop production, producers, especially in the southern regions of the province, may be more likely to consider irrigation options for traditional field crop production as growing season conditions become increasingly hot and dry.

Canola is a cool-season oilseed crop grown across Southwest, Central and Northeast Regions of the province. Both spring and winter canola varieties require well-drained soils for development. The commodity is a less commonly grown cash crop in Ontario, but winter canola specifically, has been on the rise in Southwest and Central Ontario in response to rising yields, linked to advancements in hybrid seeds and market conditions.



In this assessment, heat stress associated with extreme temperatures was identified as the greatest driver of future risk for canola production in Ontario. Canola plants can be damaged from extreme heat conditions and moisture stress due to dry conditions, resulting in abortion of flowers or pods, significant plant damage, yield losses and unmarketable products. Currently, risk to canola is scored as a 'medium' and increases to a 'high' score for the future time periods. The risk profile for canola could increase with acreage rising over recent years, elevating exposure to climate-related impacts.

What are the risks?

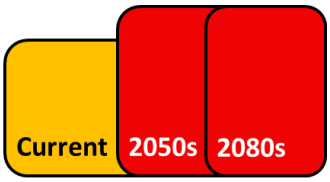
Fruits and Vegetables

Fruits and vegetables across Ontario are produced under diverse soil and climatic conditions. Over 125 different fruit and vegetable crops are grown in the province and contribute more than $4.2 billion in activity per year, with over 30,000 people employed directly on-farm[x]. For the purposes of the PCCIA, six Level 2 categories were used to assess the risks of direct impacts to fruit and vegetable production, including **apples, berries, field vegetables, grapes, greenhouse vegetables,** and **tender fruit**.

It is critical to recognize the diversity and extent of all production, and the unique growing conditions and sensitivities that exist, as not all fruit and vegetable growers may experience climate impacts to the same extent. Multi-year and cascading impacts are particularly important for fruit and vegetable production and may lead to impacts to yields over a longer period of time. Indirect impacts linked to soil quality, nutrient management, invasive species and pests, water supply, and pollination are also critical. Opportunities for the fruit and vegetable sector include reduced reliance on imported fruits and vegetables as local production is bolstered by growing more fresh grapes, pears, strawberries, garlic, eggplant and other commodities.

Numerous climate risks to fruit and vegetable production were identified, with the degree of impact being highly dependent on the season, stage of crop growth, and the duration or extent of the climate event.

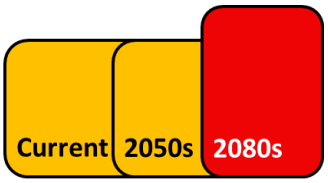
There are 15 different varieties of **apples** grown in Ontario, primarily along the shores of Lake Ontario, Lake Erie, Lake Huron and Georgian Bay. Climate risks to apples were assessed across Southwest, Central and Eastern Ontario, with no significant regional variation detected based on current or future risks to apples at the scale of this assessment.



Current risks to apples are driven by extreme temperature, extreme precipitation, and springtime conditions such as late frost. Key impacts include heat stress, reduced photosynthesis, stunted growth, decreased fruit quality, frost bite and frost kill and yield loss. Drought can also impact apples in several ways, slowing tree growth, and causing reduced root growth, fruit shriveling and yield loss.

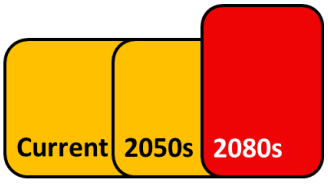
Over time, risks to apples are expected to rise. Under current climate conditions, risks were determined as 'high' and are expected to increase to 'very high' by the 2050s and remain at that level until the end of the century.

Berries (e.g. strawberries, raspberries, and blueberries) are grown across the province, mostly around major urban centres, and have an annual farm gate value of over $44 million in recent years[xi]. Berry crops are generally grown on the best agricultural soils, requiring excellent drainage and high organic matter for optimum production. Climate risks for berries were evaluated across all Regions of Ontario, except for the Far North.



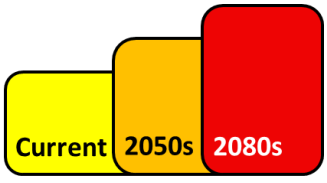
Extreme heat conditions and drought are leading causes of current 'high' risks to berry production. In the future, increasing air temperatures combined with wetter conditions may result in 'very high' risks associated with infections and disease that pose more chronic challenges for berry growers, resulting in decreased yields and premature plant death. Additionally, risks from late spring frost and drought during the growing season may result in significant yield losses due to freeze injury, and lack of moisture and nutrients, respectively. The extent of damage to berries highly depends on the cultivar.

The most common **field vegetables** grown in Ontario include sweet corn, potatoes, green peas, tomatoes, green and wax beans, carrots, and pumpkins. Climate risks were evaluated across Southwest, Central and Eastern Ontario using representative commodities, where appropriate, such as cabbage, potatoes, and tomatoes. Significant regional differences were not found at the scale of assessment, and risks were estimated to be 'high' under current climate conditions, remain 'high' in the 2050s, and increase to 'very high' by the end of the century (2080s).



Impacts to field vegetables are variable, and depend on the crop grown, soil conditions and the intensity or duration of the climate event that occurs. Springtime conditions as well as extreme precipitation and drought are major drivers of risk to field vegetables. Wetter conditions and/or long duration extreme precipitation events may lead to proliferation of disease, poor transplant conditions, soil compaction, as well as missed or delayed cultivation. Extreme heat and drought conditions can lead to reduced yield due to heat damage, reduce fruit set, and compromise plant development.

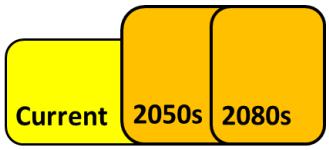
Grape production in Ontario is most prominent on the Niagara Peninsula, followed by Essex-Kent. Prince Edward County is an emerging area for grape production. Ontario produces over 85% of Canada's domestic wines, with the gate value of grapes over $112 million in recent years [xii,xiii]. Climate risks to grapes were evaluated in both Southwest and Eastern Ontario, recognizing that



significant local areas are present within these Regions where impacts would be felt the most.

Grape production is at risk from numerous weather events such as rising temperatures, as well as winter and spring conditions. Impacts from extreme heat in the growing season include higher grape sugar concentrations, reduced acidity, increased alcohol concentration, higher risk of spoilage and reduced harvest window. In altered fall and winter conditions, icewine production may experience total yield loss if a hard freeze (-8°C or colder) does not occur after ripening. Increases in seasonal and extreme precipitation can lead to proliferation of diseases and compromise the timing and effectiveness of field operations. Risks to grapes were determined to be 'medium' under current climate conditions but rising to 'high' by the 2050s and to 'very high' by the end of the century (2080s).

Greenhouse vegetables grown in Ontario include tomatoes, cucumbers and peppers, with 2019 gate value for these crops reaching $376 million, $339 million, and $301 million, respectively[xiv]. Climate risks to greenhouse vegetables were assessed for Southwest, Central and Eastern Ontario given their prominence in these Regions of the province.



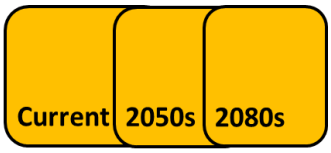
Extreme precipitation, high and extreme temperatures, low temperatures, as well as general growing-related conditions resulted in most risks to greenhouse vegetables. These conditions can lead to yield loss and financial loss to growers through increased production and flowering time, compromised pollination, increased heating costs, and a greater need for temperature regulation inside greenhouses, particularly during extreme heat in the summer season.

Risks to greenhouse vegetables production under current climate conditions is considered 'medium'. In the future, that score is expected to increase to 'high' by the 2050s and remain 'high' by the end of the century (2080s).

Tender fruit production includes peaches and nectarines, pears, sweet and sour cherries, plums, and apricots. Ontario tender fruit gate value in 2019 was almost $83 million, the largest share ($27.5 million) attributed to peaches[xv]. The most significant tender fruit-growing area in Ontario is the Niagara Peninsula, followed by Essex and Kent counties and Lake Huron coast, all in Southwest Ontario. Climate risks to tender fruit were also evaluated for Central and Eastern Ontario Regions.

Key climate-related impacts to tender fruit are linked to extreme heat, drought and spring frost conditions, as well as heavy precipitation events. Impacts include frost injury and yield loss, heat stress to fruit trees, compromised pollination and fruit formation, slowed growth,

disruptions to work operations, physical damage to fruits and flowers by heavy rain events, decreased fruit sweetness and overall fruit quality, and ultimately, yield loss.



Risks to tender fruit are currently rated as 'high' and expected to stay at 'high' risk in all future time periods (2050s and 2080s). Current 'high' risks are driven, in part, by winter injury, extreme cold and spring frost conditions. As temperatures rise and these impacts become less frequent, risks are expected to remain high due to the increasing frequency of extreme heat and extreme precipitation events.

Livestock

Livestock was categorized into five main subcategories for the assessment: **beef cattle, sheep, swine, dairy cattle** and **poultry and eggs**, which are present in commercial farming operations in all Regions of the province except the Far North. Warmer temperatures may be beneficial for livestock production in Ontario, resulting in longer growing and grazing seasons, increased availability of quality feed throughout the year, and lower energy costs. At the same time, the changing climate may introduce new or accentuate existing risks to livestock production, most importantly heat stress. Different types and breeds of livestock respond differently to temperature and precipitation conditions throughout their life cycles, some exhibiting higher sensitivity. As a result some types of livestock are expected to face greater mortality rates, decreased growth, reduced fertility and other negative impacts when exposed to adverse weather conditions such as extreme heat, cold and drought.

In addition to direct climate impacts, indirect impacts on livestock were identified to be significant, most importantly through shortages in feedstock, damaged pastures, limited water supply and increased prevalence of pests and diseases.

Beef cattle in Ontario are raised on over 12,500 farms engaged in breeding and handling of over 1.1 million animals, and bring almost $1.4 billion in farm gate sales and a retail revenue of over $9 billion[xvi,xvii]. The majority of beef farms are located in the Southwest Region, followed by Eastern, Central, Northeast and Northwest Regions[xviii].

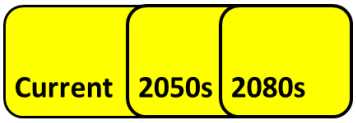
The PCCIA has shown that high and extreme temperatures cause the greatest impacts for beef cattle. Extreme heat results in heat stress, reduced feed intake, compromised weight gains, reduced fertility, higher respiration and heart rates, illness and, in severe cases, even death in beef cattle. Prolonged heatwaves, particularly early in the summer season, before cattle have had a chance to acclimate to hot conditions are especially impactful. Quantification of effects is complicated by breed differences and other factors, with calves, animals with dark

hides (e.g. Angus cattle), compromised immune systems, and more fat cover, being the most vulnerable, especially in cases when adequate feeding, hygiene and housing requirements are not fully satisfied.

Overall risk to beef cattle is found to increase from 'medium' at present to 'high' by the 2050s and remain at that level in 2080s, in Southwestern, Central and Eastern Regions. A consistent 'medium' level of risk is expected in Northeast and Northwest Ontario throughout the century.

Ontario's 322,000 **sheep** are raised on nearly 2,800 farms (most of them in Southwest Ontario), representing sheep, lamb and wool industries[xix].

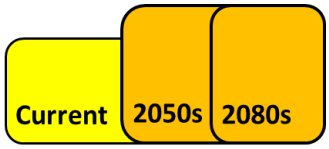
Prolonged drought conditions over the growing season are a key driver of risk for grazing sheep in Ontario. Dry spring and early summer conditions result in soil-moisture deficit, lower-quality feed and pasture losses. Drought-struck sheep face grazing challenges and develop abnormal eating habits, face malnutrition, low immunity, germ recrudescence, and amplified effects of parasites and infectious diseases. Inability to provide adequate feed and ample water to sheep can lead to buying over-priced feed, culling, or prematurely selling livestock at low prices. Regions with low water-holding capacity soils are particularly vulnerable to drought, with long-lasting multi-year impacts and increased costs for sheep farmers.



Sheep are very resilient and can thrive in different climate and weather conditions, provided adequate heat and cold abatement measures are in place. The climate risk profile for sheep is found to be 'medium' at present and expected to remain at that level in the 2050s and 2080s, in all Regions.

The **swine** sector in Ontario includes farming operations engaged in breeding and handling of pigs, managing over four million pigs and bringing in over $1 billion in farm cash receipts[xx,xxi]. Southwest Ontario is the center of Ontario's swine industry, both in terms of the number of farms and the number of animals raised.

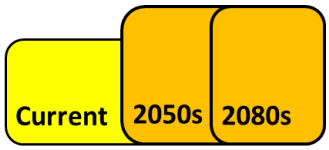
High and extreme temperatures are one of the key climate variables driving risks to swine. Pigs have the lowest heat tolerance compared to other livestock (with comfortable range between 18°C and 24°C), therefore the impacts of high air temperatures are very pronounced, both in indoor and outdoor farming systems. Impacts of heat stress on pigs depend on their age, weight and genetics and lead to compromised production efficiency, reduced and inconsistent growth, poor sow performance, and increased mortality. Most pigs in Ontario are raised in indoor operations and face adverse weather conditions directly during transportation to new facilities or for slaughter. Transportation on days with high air temperatures (over 26°C) can result in high levels of heat stress, reduced meat quality, injuries and death.



Risk to swine is found to increase from 'medium' at present to 'high' by the 2050s and remain at that level in 2080s, in Southwest, Central and Eastern Regions. In Northeast and Northwest Ontario risk to swine is 'medium' at present and in the middle of the century, increasing to 'high' by the 2080s.

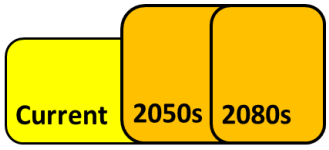
Dairy cattle in Ontario are raised on nearly 3,800 farms engaged in breeding, raising and handling over 485,000 animals[xxii]. Dairy products generate close to $2 billion in market receipts and are Ontario's top agricultural commodity[xxiii]. Similar to beef cattle, the majority of dairy farms are located in the Southwestern Region, followed by Eastern, Central, Northeast and Northwest Regions[xxiv].

High and extreme temperature is identified as the most relevant climate condition for risks to dairy cows in Ontario. Dairy cows are particularly sensitive to high air temperatures due to additional metabolic heat generated during lactation. Exposure to heat over 32°C results in heat stress causing impacts such as reduced feed intake, lower milk yields, and reproductive problems, impacting farm revenue and timing of operations such as calving. Additionally, heat stress compromises cows' immune systems, making them vulnerable to disease, while extreme levels of heat stress result in an increased risk of mortality (27% greater mortality rate compared to a period with no heat stress). Carryover effects of stress are known to persist even after the heatwave ends.



Risk to dairy cattle is found to increase from 'medium' at present to 'high' by the 2050s and remain at that level in 2080s, in Southwest, Central and Eastern Regions. In Northeast and Northwest Ontario, risk to dairy cattle is 'medium' at present and in the middle of the century, increasing to 'high' by the 2080s.

The **poultry and eggs** sector in Ontario includes farming operations engaged in breeding and handling of chickens, ducks, turkeys and gamebirds. Chickens and ducks can be a source of eggs, meat or both; turkeys and gamebirds are raised for meat. In 2021 there were over 53 million chickens (laying hens, pullets, broilers and roasters) and 2.5 million turkeys managed on Ontario farms[xxv]. Farm cash receipts for Ontario's poultry sector (chicken, eggs and turkeys) were over $1.6 billion in 2019[xxvi].



High and extreme temperatures are one of the key climate conditions for poultry. Impacts from hot weather conditions include reduced growth, egg production and size, and shell density. Birds experiencing heat stress have increased susceptibility to diseases, repressed reproduction, with severe heat stress leading to high mortality rates. Temperatures

over 27°C and especially 30°C are particularly harmful to poultry stock, with heat-related impacts exacerbated by high humidity and other environmental factors such as increased bird density, inadequate ventilation, and the presence of diseases or parasites.

Risk to poultry and eggs is found to increase from 'medium' at present to 'high' by the 2050s and remain at that level in 2080s, in Southwest, Central and Eastern Regions. In Northeast and Northwest Ontario risk to poultry and eggs is 'medium' at present and mid-century, increasing to 'high' by the 2080s.

Why do risks vary for different types of agricultural commodities?

The level of risk varies significantly depending on the Level 1 and Level 2 category being assessed, and the Region under consideration. These differences exist for many reasons, including crop- and livestock-specific tolerance thresholds, regional acreages, intensification of production, land, soil, and climate conditions, and the level of consequences that a particular impact may produce. For this Area of Focus, a greater increase in risk is observed for Southwest, Central and Eastern Ontario by mid-century, with Northeast and Northwest Regions increasing in risk by the end-of-century. The lag in increased risk scores across northern Regions of the province is linked to exposure to extreme climate conditions (e.g. extreme heat) and the application of socio-economic indicators, projecting considerable northern agricultural industry expansion in the second half of the century. Once the industry expands in these Regions, it is anticipated that they will have increased agricultural outputs and, consequently, exhibit greater exposure to climate risks. The higher risk scores in Southwest, Central and Eastern Ontario are indicative of existing exposure and sensitivity to changing climate conditions.

What don't we know yet?

Ontario's agri-food sector is complex and diverse. Climate change is among many challenges facing agricultural production in Ontario which also include land-use re-assignment, declining ecosystem and soil health, labour shortages, and shifting market conditions. The quantitative scores reflect only direct climate impacts to Level 1 and Level 2 categories, and do not consider how external factors or pressures could influence current and future climate risk scores. Cascading impacts and possible tipping points were also not included in characterizing risks, due to the inconsistency of literature for all parts of the province.

What can we do about it?

Ontario has the knowledge and solutions to implement measures to lessen many of the climate risks that agriculture is facing. An extract of adaptation options is shown below, with the more fulsome list available in a separate PCCIA document (PCCIA Adaptation Best Practices Report).

Projects or Programs

- Strengthen monitoring and surveillance programs for pest and disease management.
- 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

- Support and advance research on agricultural expansion opportunities under a changing climate.
- Research and development on new and climate-resilient varieties/breeds and livestock nutrition regimes.
- Support technological research and advancements on precision agriculture, advance drainage and irrigation systems.

Investment and Incentives

- Invest in the expansion of existing financial support mechanisms to stimulate growth and resilience in the agricultural sector.
- Support farmers through new and existing crop insurance and business risk management programs
- Fund a knowledge transfer and sharing program for practical adaptation and best management practice sharing with Indigenous knowledge at its core.

Policy and Regulation

- Government support for research efforts and on-farm trials for new crop types and cultivars/cropping genetics.
- Maintain, promote and enhance best management practices.
- Offer guidance on developing and implementing action plans for addressing farm environmental issues.

Navigate back to the Launch Page

Infrastructure

What are the key findings for Infrastructure?

In recent years, Ontario has experienced the impact of infrastructure failures related to extreme weather and changing climate conditions. It has become clear that climate-related impacts on infrastructure are complex, with interdependencies existing between and across different infrastructure systems, including transportation, energy, water, and telecommunications. This impact assessment finds that all infrastructure across Ontario face climate risk. In fact, not a single asset included in this assessment is considered to have a risk less than 'medium' under current climate conditions.

Why are Ontario's Infrastructure systems important?

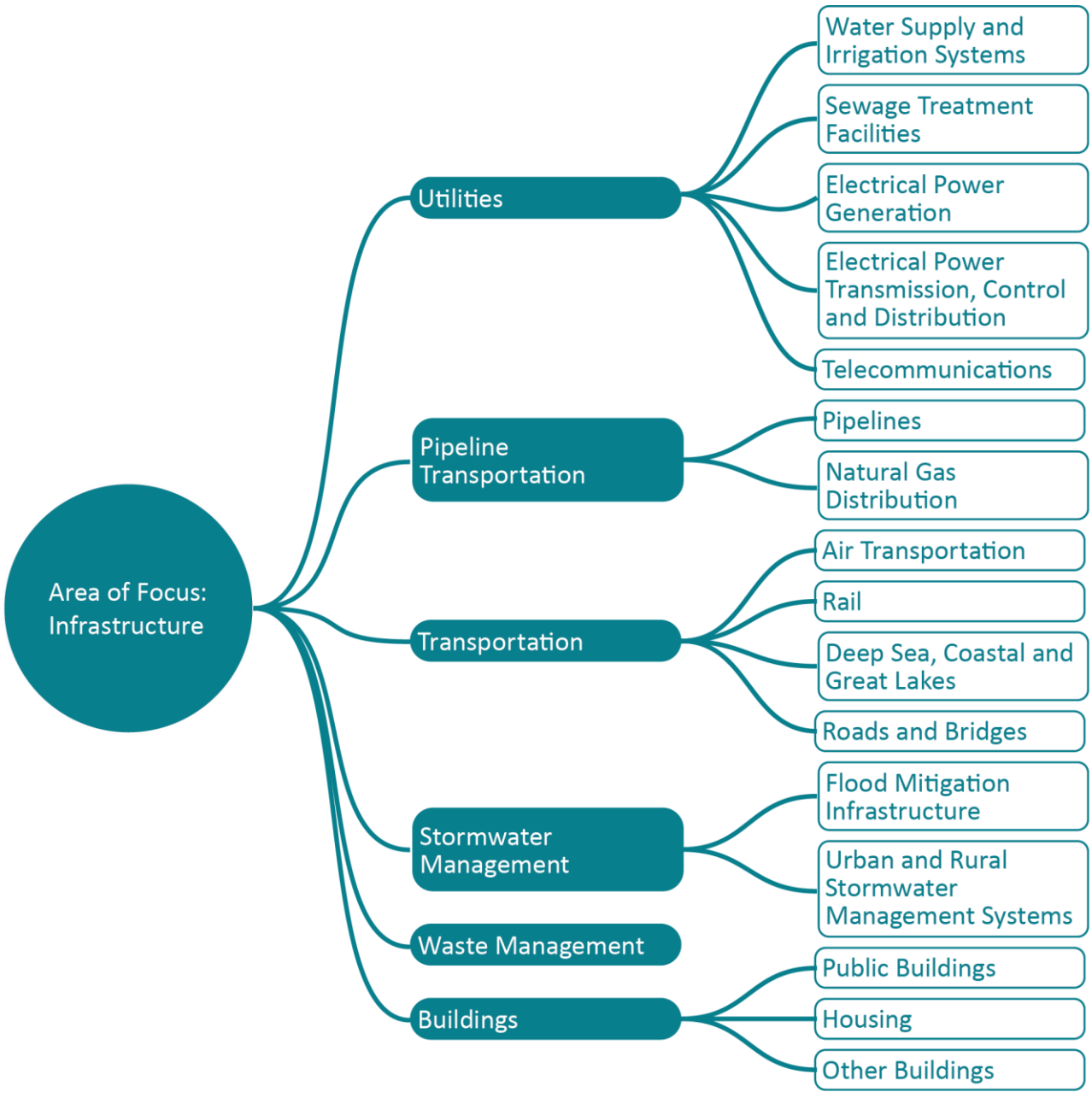
Ontario's infrastructure underpins people's ability to live, work, play, and remain connected within and outside of the province. Current and future assets are also the cornerstone to economic activity. Investing in resilient infrastructure has an enormous positive impact on the economy. Future investments in infrastructure are a key component of the Government of Ontario's 2022 Fall Economic Statement, with $159.3 billion in planned investments for the 2022-2032 Capital Plan. [xxix]

Existing infrastructure condition pressures combined with a changing climate will drive mid- to long- term challenges in managing Ontario's infrastructure.

In general, infrastructure is concentrated in areas where people live and work, with the vast majority within the most populous regions in Ontario including Southwest, Central, the Eastern Ontario, coinciding with approximately 94% of the population[xxvii]. Infrastructure is less concentrated and connected farther north, though critically important for rural, remote and Indigenous Communities in these regions. It is imperative that new climate-sensitive codes and standards inform infrastructure design for both new builds and retrofits, which will improve service quality and service life.

Defining Ontario's Infrastructure for assessment

To assess current and future climate impacts, Ontario's Infrastructure was divided into a series of six categories (Level 1 categories). Some of these categories were further delineated to include sub-categories (Level 2 categories), which are described in the assessment results.



Infrastructure Level 1 Categories

Buildings

Pipeline Transportation

Stormwater Management

Transportation

Utilities

Waste Management

How were the impacts on Infrastructure assessed?

Climate impacts on infrastructure were assessed for every Region of Ontario. For each asset class, various interactions with climate variables were documented and used to quantify impact likelihood and the severity of the consequences. Consequence categories of 'level of service disruption' and the 'extent of financial loss' were used to inform risk profiles. **This portion of the assessment only analyzed direct physical 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 reported on in the Cross-Sectoral Theme section.

Where does green infrastructure fit in?

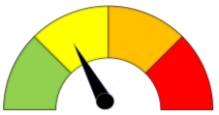
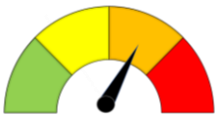
Green infrastructure, which includes both natural ecological elements as well as those engineered to mimic a natural state, represents a critical adaptation opportunity in Ontario. Natural assets must be conserved and protected, but also increased in extent and distribution to slow runoff and erosion, store water, increase infiltration and provide habitat for select species. While it was not included as a distinct category, green infrastructure is highlighted as an adaptation solution, to improve stormwater management by increasing the resilience of water systems to climate change and enhance water security in Ontario's communities.

If you only take one thing away:

All infrastructure across Ontario faces climate risk. In many Regions and for certain assets, this risk is expected to rise in the future. A significant portion of infrastructure across Ontario is not in a state of good repair, and the less investments made to improve assets that all Ontarian's rely upon, the greater the risks from climate change[xxviii]. The results of this assessment can be

used as a foundation for informing adaptation efforts made to improve the resilience of infrastructure assets across Ontario and help mitigate the identified climate risks and the associated cascading impacts.

How are the risks changing?[2]

Level 1 Category	Now	2050s	2080s
Buildings	 Medium Risk	 High Risk	 High Risk
Pipeline Transportation	 Medium Risk	 Medium Risk	 Medium Risk
Stormwater Management	 High Risk	 High Risk	 High Risk
Transportation	 Medium Risk	 High Risk	 High Risk
Utilities	 Medium Risk	 High Risk	 High Risk
Waste Management	 Medium Risk	 Medium Risk	 High Risk

[2] Risk profiles reflect the highest regional risk score operating under RCP8.5 (high emissions scenario).

What are the risks?

Buildings

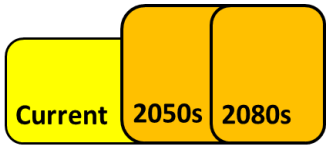
Buildings are common among all Regions of Ontario and provide shelter from the outside environment for people, public services, and businesses. In the province, buildings are designed and constructed based on the Ontario Building Code, regulated under the Building Code Act. Buildings were categorized into three sub-categories and evaluated as part of this assessment:

1. **Housing**
2. **Public buildings**
3. **Other buildings**

Housing refers to all privately owned residential buildings and community housing. When housing-associated climate risk was assessed, distribution characteristics across each Region were considered (e.g. how many single detached houses, mid- and high-density buildings are present). Public buildings are considered to be those owned or operated by a government entity and primarily engaged in providing educational or community services, and government activities. Other buildings include any commercial, institutional, and industrial properties such as hospitals, warehouses, factory buildings, office spaces and stores[xxix].

Climate change can impact buildings in many ways. Extreme precipitation events, extreme heat, and wildfire were found to be particularly impactful. For example, a short-duration high intensity precipitation event can result in water damage to buildings and lead to concrete corrosion to foundations that can weaken the structure and reduce the building's service life. Many indirect impacts also exist for buildings, including the increased pressure from urban growth and corresponding needs for housing. This pressure may lead to poor location decisions with new buildings placed in high-risk areas such as floodplains and wetlands. Building in these areas would increase the risk of damage to infrastructure in areas associated with worsening flood risk from changing climate conditions.

Extreme precipitation events, extreme heat and wildfire are driving the highest climate risks to buildings.



The risk profile for all three types of buildings (**housing**, **public buildings** and **other buildings**) is similar. It was determined to be currently scored as ‘medium’ but rises to 'high' risk by mid-century. Risks are rising faster in the Far North where the rate of climate conditions is accelerating and building improvements face a more significant backlog.

Pipeline Transportation

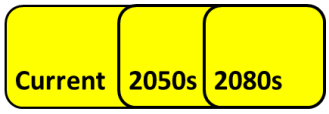
Pipeline infrastructure and the transportation network are an essential component of Ontario's energy system, contributing $7.7 billion to the province's gross domestic product in 2017[xxx]. For the purposes of this impact assessment, two Level 2 categories were evaluated within pipeline transportation:

1. **Natural gas distribution**
2. **Pipelines**.

Natural gas distribution refers to the distribution of natural or synthetic gas to residents and businesses through mains. Pipelines refer to various types of pipelines and integrated systems that include pumping stations, storage facilities and other facilities.

In Ontario, several major pipeline infrastructure systems exist, ranging from major transmission to regional and local distribution lines. Particular regions and municipalities in the province also contain significant pipeline infrastructure and supporting industry – such as Sarnia in Southwest Ontario. The TransCanada Energy Mainline crosses Ontario in between Alberta and Quebec and carries 445 million cubic metres of natural gas per day[xxxi]. Numerous other lines such as Line 5, 7, 8, 9, 11 and others are located in various areas of the province which bring gas to market.

Climate change can impact pipelines and subsequent gas distribution in many ways. Extreme precipitation can lead to soil saturation, movement or undermining of pipes and buried assets, and increased maintenance requirements to ensure operational safety. Shifting seasonal precipitation and flooding events can increase the exposure of infrastructure and lead to asset damages. Increasing air temperature and extreme heat can shift soil conditions, leading to a higher risk of erosion, instability and more indirect impacts of sun. Indirect impacts that cause damage to infrastructure can result in reputational issues for infrastructure owners and operators, increase the financial costs of managing assets safely, and reduce the serviceable lifespan of assets before they need replacement.



The risk profiles for both **natural gas distribution** and **pipelines** were found to be similar across all Regions of Ontario. Risks are 'medium' under current climate conditions and remain the same in the future.

This unchanging risk profile reflects, to an extent, the fact that large portions of these assets are buried, actively managed and monitored, and not directly exposed to extreme weather events.

Stormwater Management

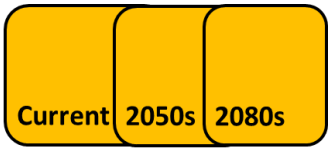
Stormwater management broadly refers to reducing runoff of precipitation across surfaces and managing water systems to maintain the natural hydrologic cycle. The objective of stormwater management is to prevent flooding, erosion, and maintain water quality. To assess the risks of climate change on stormwater management, two Level 2 categories were used:

1. **Flood mitigation infrastructure,** such as berms, dams, dikes, and wetlands;
2. **Urban and rural stormwater management systems (SWM)** such as storm sewers, culverts, storage structures and pump stations; tile drains, municipal drains and ditches.

Ontario owns and manages a significant amount of stormwater management infrastructure. However, it is aging, which compounds vulnerability to climate change impacts. As an example, of the 188 large dams in Ontario, 89% of them are over 50 years old[xxxii].

Risk to stormwater management is already high and may be higher if development occurs in areas with high flood risk, or where water is infiltrated or stored.

Naturally, growth and development of urban centres in Ontario have led to lower permeability in surfaces. The Greater Toronto Area, for example, is comprised of 73% impervious surfaces[xxxiii]. Dense urban areas are easily overwhelmed by the rapid influx of water, leading to 'flashier' runoff and flooding. Natural assets and green infrastructure slow runoff, promote on-land storage and increase infiltration to restore ground water. Increasing extreme precipitation events are expected to have damaging impacts on stormwater infrastructure in Ontario. Extreme flooding presents a risk of dam washout and failure, or physical damage to assets, which can be worsened by more debris in floodwater. Increased damage incidents may cause increased maintenance or replacement of this infrastructure, as well as a risk of downtime or reduced capacity in the system while damage is being addressed. Debris can block or impede the efficiency of urban and rural infrastructure, reducing infiltration and flow capacity, and contributing to flooding and worsening water quality.



The risk profile of **flood mitigation infrastructure,** as well as **rural** and **urban and rural stormwater management systems** is considered to be 'high' under current climate conditions and remain 'high' in the future. The risk may be higher if development occurs in areas with high existing flood risk, or where water is infiltrated or stored like wetlands. If infrastructure is not properly maintained or replaced with future climate conditions in mind, risk to stormwater management infrastructure is likely increase.

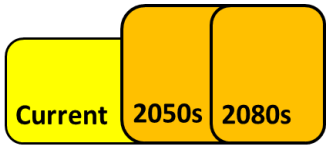
Transportation

Ontario's transportation network is significant, and connects residents and businesses within, across and external to the province. Strongly linked with results from the **Transportation Economy** assessment under Business and Economy, this infrastructure category focuses on the assets themselves. There are over 4,300 km of 400-series highways in Ontario, serving as primary road transportation network, connecting east-to-west and north-to-south[xxxiv,xxxv]. The 400-series highways are critical infrastructure supporting Ontario, Canadian, and international business with over 416,000 vehicles per day. Rail lines in Ontario are operated by Canadian National Railway (CN), Canadian Pacific Railroad (CP), and VIA Rail, providing freight and passenger transportation services. Ontario is also home to 48 airports along with Canada's busiest travel hub - Lester B. Pearson International Airport[xxxvi].

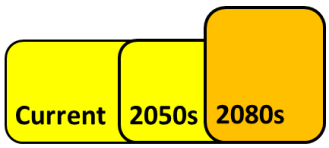
Climate impacts were evaluated across several sub-categories:

1. **Air transportation**
2. **Deep sea, coastal and great lakes transportation**
3. **Rail transportation**
4. **Roads and bridges**

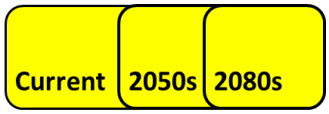
Climate risks posed to each of these transportation systems vary considerably.



The highest risks identified under Transportation Infrastructure are associated with **rail transportation** and **air transportation** infrastructure. Risks are considered 'medium' now and increasing to 'high' by the 2050s, for all Regions except the Far North. These risks reflect the significant impacts associated with extreme heat, which can lead to bleeding of asphalt or buckling of concrete runways that can lead to closure of airport lanes due to the safety concerns. Likewise, extreme heat can lead to heat kinks or buckling of rail lines, particularly during later stages of their lifespan.



Climate risks to **roads and bridges** across Ontario are 'medium' now and increasing to 'high' by the end of the century. As an example, the results reflect decreasing asset life expectancy due to freeze-thaw cycles and increasingly frequent washouts or flooding due to extreme precipitation. Regionally, risks are relatively higher in Central and Eastern Ontario.



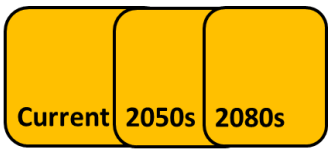
The risks to **deep sea, coastal and great lakes** infrastructure were determined to be 'medium' now and remain the same in future time periods. This isn't to say that climate change will not impact this type of infrastructure. For instance, extreme precipitation can lead to the formation of weather-driven cracks. Locks may be closed for longer due to the increase in maintenance, and docks may periodically be submerged or stranded due to higher and lower water levels compared to historical observations.

Utilities

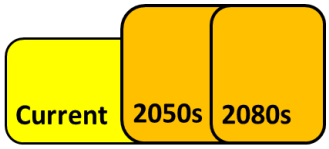
Utilities refers to establishments that are primarily engaged in operating electric, gas, and water generation and distribution. Strongly linked with results from the **Utility Services** assessment under Business and Economy, this category focused on the assets themselves and the directs impact of climate change on utility infrastructure. Climate impacts were evaluated across several sub-categories:

1. **Water supply and irrigation systems**
2. **Sewage treatment facilities**
3. **Electrical power generation**
4. **Electrical power transmission, control and distribution**
5. **Telecommunications**

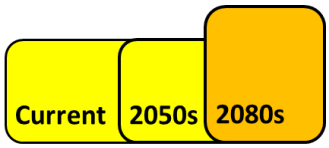
Electrical power generation includes any facility engaged in the generation of electric power, by hydraulic energy, fossil fuels, nuclear energy, or other processes (e.g. solar farms, wind turbines). Electrical power, once generated, requires transmission and distribution to consumers for end use. Telecommunications includes infrastructure primarily engaged in providing telecommunications and/or video entertainment services. Telecommunications infrastructure consists of both wired and wireless technologies as well as satellites, all of which are integral to support institutional, residential, retail and commercial services. Water supply and irrigation systems includes potable and non-potable water supply sources and the distribution infrastructure of the water such as irrigation systems. Sewage treatment includes sewer systems and sewage treatment facilities that collect, treat, and dispose of wastewater.



The highest risks across all sub-categories were found to be for **electrical power generation** infrastructure. Risks are 'high' now and expected to remain 'high' for all future time periods. Electrical power generation can be impacted in a variety of ways from climate change, and in part depends on the energy sources. For example, low water flows due to drought conditions can reduce hydroelectricity generation efficiency or outputs. Extreme precipitation events can lead to water damage and damage from objects carried by overland flow and flooding damaging equipment and decreasing the useful life of the infrastructure. Regions where nuclear power generation occurs, such as in Central Ontario, may be impacted by high and extreme temperatures which could result in an increase to the baseline temperature of cooling water (lakes, rivers). As the cooling water temperature increases, it will require a larger volume of water or more time to cool. More generally, extreme heat could increase demand for electricity thereby leading to brownouts and cascading impacts.

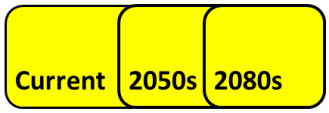


Climate risks to **electrical power transmission, control and distribution** were found to be the next highest under the utilities assessment. Risks are currently rated 'medium' but expected to rise quickly by mid-century and remain elevated at a 'high' score. Electrical transmission, control and distribution infrastructure can be impacted in several ways. For example, extreme heat can reduce the carrying capacity of transmission and distribution lines and damage substations and transformers. Seasonal precipitation changes or a shift to freezing rain or wet snow can negatively impact transmission and distribution infrastructure and cause equipment damage. Extreme precipitation may also lead to increased maintenance due to traveling debris, backups or eroding sump pumps. Structures near riverbanks can wash out and may require reinforcements or need to be replaced or repaired more frequently.



The climate risk profiles for **sewage treatment facilities** and **telecommunications** assets were found to be similar. Risks are scored as 'medium' now and out to mid-century but increasing to high by end of the century. Across Ontario, the Southwest, Eastern and Central Regions were found to have slightly higher risks due to increased population density and demand for infrastructure. Climate change can impact sewage treatment facilities through increasing the flow of water and the risk of infiltration and inflow into assets or by worsening leaky collection pipes. Sudden fluctuations in temperature at sewage treatment plants can cause cascading impacts such as reduced efficiency and function, frozen service lines, frozen sewage lagoons, and worsen microbial health and function. This could lead to partially treated or untreated water discharging to water bodies.

Telecommunications assets can be impacted in different ways. In addition to physical damage from fire, heat from the wildfire can cause damage to fibreoptic lines and above-ground junction boxes which can interrupt services. Extreme precipitation can lead to flooding of low-lying areas or impacts to underground or ground-level telecommunication infrastructure. Increases in precipitation, coupled with rising air temperatures (humidity), can affect the radio spectrum on which wireless communications rely upon. Extreme precipitation can also disrupt transmitted signals or require increased transmission power to withstand poor weather conditions.



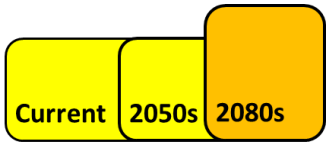
Climate risks to **water supply and irrigation systems** were found to be 'medium' now and remain more or less the same in future time periods. Regional differences were not found at the scale of assessment. However, several climate conditions can impact the physical infrastructure of these systems. As an example, extreme precipitation can cause flooding which carries debris and can cause slope failure of assets.

Waste Management

Waste management refers to infrastructure and establishments involved in providing waste management services, such as waste collection, treatment and disposal. In 2021, this sector employed over 3,200 full time and part time employees[xxxvii]. This includes environmental remediation, material recovery and septic tank pumping services. Ontario has over 800 landfills to accommodate waste produced but relies heavily on seven of them. About 73% of waste is landfilled within the province, while 27% is transported to the United States for disposal[xxxviii]. These major landfills are located primarily in Southwest, Central and Eastern Ontario. Northern Regions of Ontario have a greater number of smaller landfills, dedicated to communities due to transportation limitations. With such an important percentage of waste managed at a limited number of landfill sites, climate-related impacts to these sites holds significant risk to regular waste management operations.

Climate-related impacts to landfill sites holds significant risk to waste management operations.

Climate change can impact waste management in several ways. Extreme precipitation events may cause increased leachate generation and ponding or flooding within a landfill. This may lead to slope instability at the site with subsequent waste displacement and potential contamination of the surrounding environment. Extreme heat events may increase the risk of landfill fires under dry conditions. Changing climate conditions may also lead to increased risk of odour generation, thereby decreasing air quality. Shifting species changes and temperature regimes can increase vermin and small animals, leading to higher risk to public health and increased landfill management requirements and associated costs.



The risk profile of **waste management** was determined to be 'medium' under current climate conditions. This is expected to remain similar by mid-century but increase to 'high' by end of the century, reflecting considerable changes in extreme precipitation and heat by that time period. These risks are consistent across every Region of Ontario except the Far North, reflecting less demand, density of landfills and waste management services.

Why do risks vary for different types of Infrastructure?

Not all assets are exposed to the same climate conditions and impacts, and in some cases have very different responses and vulnerabilities that may drive higher risks. The consequences of a risk occurring differs and depends on the type of infrastructure, its state of repair, and how well it is maintained within a particular Region of Ontario. Consequences considered in this assessment include:

1. Increased maintenance and rehabilitation requirements of assets
2. Cracked, damaged or the need for full replacement of infrastructure components
3. Increased operational demands resulting in shorter asset lifespan
4. Increased costs or disruptions for those operating the infrastructure
5. Increased costs to asset owners for replacement or costs for relocating those who occupy assets
6. Increased need of repairs or replacement that require specialized expertise for certain types of assets

What don't we know yet?

Infrastructure is highly inter-connected, and the degree and location of this **inter-connectedness** across Ontario was not quantitatively assessed. A more in-depth, systems-level assessment of climate impacts would include asset failure thresholds and inform areas of compounding risk and where risks could manifest in other Areas of Focus. As an example, a climate impact that causes major disruption to one asset (e.g. extreme rainfall results in major flooding along a roadway) may result in cascading impacts on other assets (e.g. undermining of below ground assets located adjacent to the road, or result in basement flooding of buildings close by). **Site-specific or infrastructure performance data** for each asset class was not available in consistent quality or comprehensiveness to include in the assessment. Instead, the approach considered asset types, extent, region and literature to characterize the types of impacts to inform risk scenarios.

What are the risks to winter roads?

Winter roads have a unique context and provide critical connections to many communities across northern Ontario. As part of this assessment, winter roads were included within the Transportation Level 1 category, and specifically when considering assets such as roads and bridges. Due to increasing variability in conditions throughout shoulder seasons, and rapidly increasing air temperatures in the winter season, risks should be considered particularly elevated for these types of road systems.

What can we do about it?

Ontario has the knowledge and solutions to implement measures to lessen many of the climate risks facing infrastructure. An extract of adaptation options is shown below with a more fulsome list provided in a separate document (PCCIA Adaptation Best Practices Report).

Projects or Programs

- 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 requiring to incorporate green infrastructure into designs and renewed development, and incorporate Indigenous Knowledge into design and planning.

Research and Development

- Support and encourage the release of quantitative datasets that can be used to assess risk and inform infrastucture design.
- Require that new research and modeling should factor in climate change scenarios where they inform infrastucture planning and design, such as floodplain mapping.
- Develop climate resiliency design guidelines with technical specificity.

Investment and Incentives

- 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

- Increase the frequency of maintenance and monitoring and develop extreme weather response plans.
- Require climate change risk assessments for new, rehabilitated and replaced infrastructure.
- Develop policies to adopt climate risk frameworks to build sustainability and resilience principles into infrastructure projects.

Navigate back to the Launch Page

Natural Environment

What are the key findings for Natural Environment?

Climate change is already a threat to Ontario's natural environment, and is expected to drive risks to species, habitats, and ecosystems even higher in the future. Climate change risk profiles are rising to 'high' by mid-century for almost all natural systems and species. By end of the century, one quarter of risks under this Area of Focus are expected to be 'very high'.

Why is Ontario's Natural Environment important?

Ontario's natural environment is comprised of a significant diversity of species, forests, wetlands, lakes, streams, and other natural features. A healthy natural environment, including more than 30,000 species occurring in Ontario, sustains biodiversity, and critical ecosystem functions that are essential lifelines[xxxix]. These include the distribution of water, climate regulation and air filtration, and providing essential functions and connection to the environment, like access to water, medicines, natural resources, and space for recreation.

Ontario's natural environment consists of three distinct ecozones, based on ecology, climate and geology: Hudson Bay Lowlands, Ontario Shield, and Mixedwood Plains. These ecozones and the ecosystems within face unique regional stresses and pressures. For example, Southwest Ontario is the in the Mixedwood Plains ecozone, contains one third of the rare, threatened and endangered species found in all of Canada yet also has high human population density.

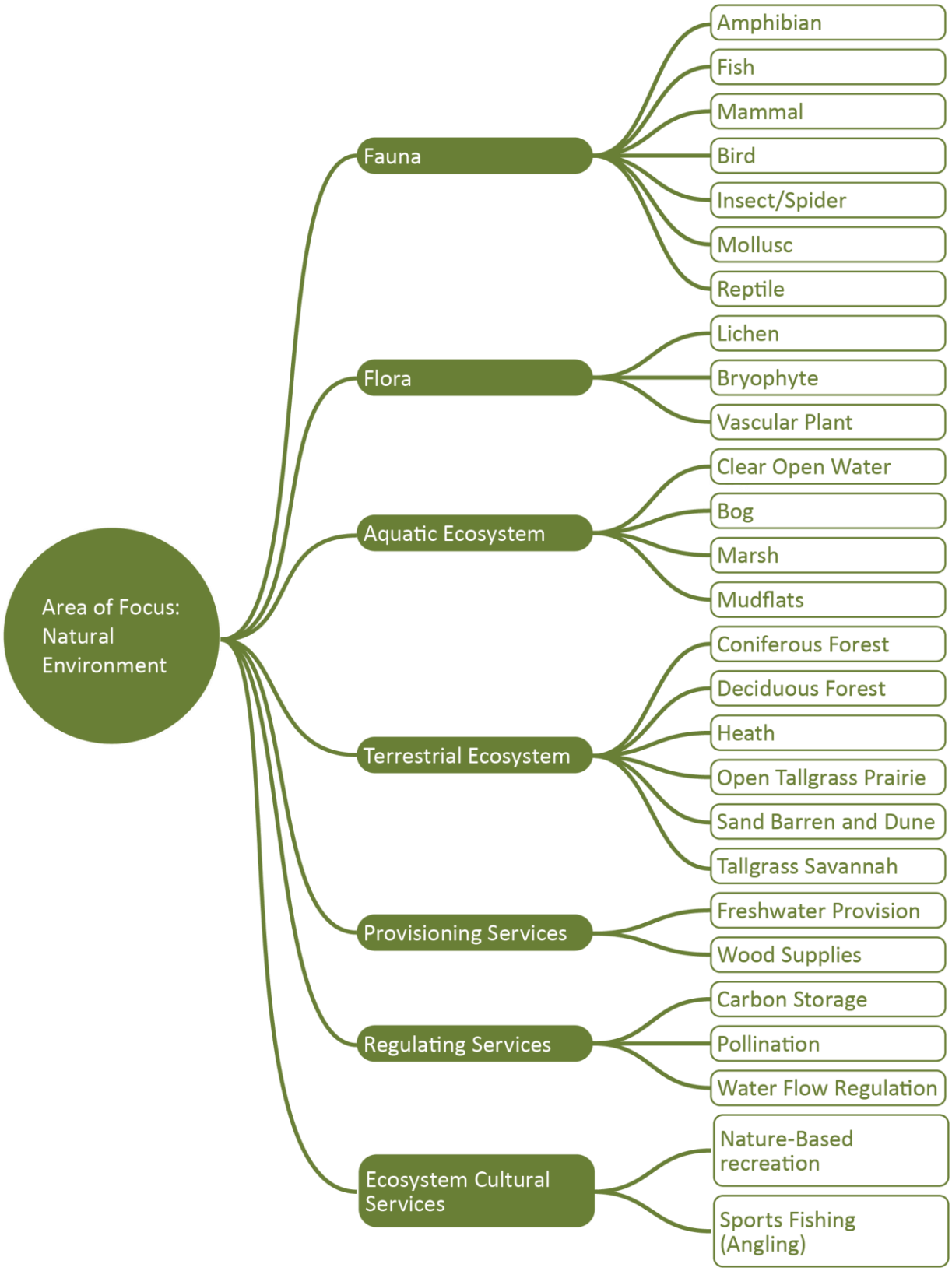
Species and habitats are irreplaceable, and replicating ecosystem services is challenging, costly, and in some cases not possible.

Each of the Regions across Ontario faces unique threats and challenges from the effects of climate change. Species and habitats are irreplaceable and replicating ecosystem services is challenging, costly and in some cases impossible. A healthy and resilient natural environment, therefore, is essential to adapt to a changing climate.

Defining Natural Environment for assessment

To assess climate impacts now and in the future, we defined Ontario's Natural Environment as a series of seven Level 1 categories. These categories were defined to cover the intrinsic value of nature and biodiversity, natural resources, and values important to humans. All of these categories are delineated to include Level 2 categories, which include specific species, land cover types and ecosystem services. Level 2 categories were chosen based on their ecological significance and climate sensitivity, distribution and abundance in Ontario, importance to

human communities, data availability, and advice from environmental professionals working in Ontario.



Natural Environment Level 1 Categories

Fauna

Flora

Aquatic Ecosystems

Terrestrial Ecosystems

Regulating Services

Provisioning Services

Ecosystem Cultural Services

How were the impacts to Natural Environment assessed?

A changing climate is impacting and will continue to impact Ontario's natural environment in multi-faceted ways. Climate change presents direct stressors to species, influencing species' population dynamics, distribution and abundance of plants and animals, water quantity and quality, and frequencies and intensities of disturbances. Level 2 categories were defined to represent specific species, land cover types, and ecosystem services. A significant literature review was completed, identifying impact pathways and the level of risks that climate change poses to each category.

Risks were evaluated based on the consequences associated with environmental degradation and damage, or natural asset service disruptions. For example, consequences were considered 'very high' if widespread or potentially permanent damage or loss to populations demographics or habitats occurred due to deterioration in habitat conditions, reduced food availability, or other factors.

Assessing climate change impacts at the species level was not possible due to the vast number of plants, animals, and lichen in Ontario. Illustrative species were selected to enable assessment of a mix of species with wide and limited distribution, varying levels of sensitivity to climate change, diversity in conservation status, information availability, and the inclusion of a few species of human interest (e.g. managed species).

Defining Level 2 Categories for Natural Environment Area of Focus

Level 1 Categories	Description of how species and components were selected for each Level 2 Category	Examples of Level 2 Categories
Flora and Fauna	Taxonomic groups were selected along with illustrative species, considering a mix of species of wide and limited distribution, low to medium to high sensitivity to climate change and information availability.	Fish (walleye), Mammal (moose), Birds (wild turkey)
Aquatic and Terrestrial Ecosystems	The Ontario Land Cover Compilation was used to consider individual habitat types (e.g. land cover) that were then assessed. Ten of 27 land cover types to were selected, and included a mix of localized and widespread habitats, and considered the potential amount of literature on each habitat type specific to climate change.	Bogs, marshes, mudflats, coniferous forests, heaths
Ecosystem Services	The Common International Classification for Ecosystem Services (CICES) was used to select seven services, based on literature and importance for the province. Note that 'services' include the essential functions that are provided by the environment and should be understood beyond 'services' for solely human use.	Angling, carbon storage, wood supplies

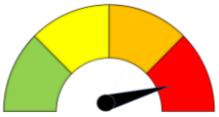
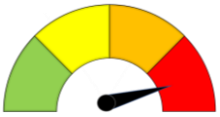
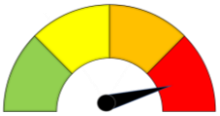
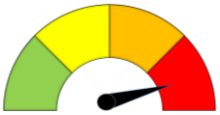
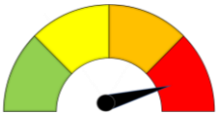
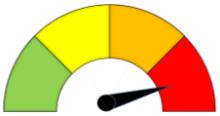
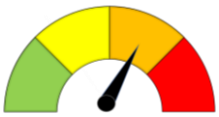
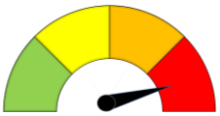
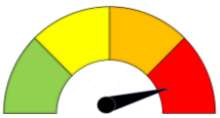
If you only take one thing away:

Climate change is already a threat to Ontario's natural environment, and is expected to drive risks to species, habitats and ecosystem functions even higher in the future. Considering significant human development pressures in the short-term, risk profiles across almost all natural systems assessed are rising to 'high' by mid-century. By end of the century, one quarter of these are expected to be 'very high'. Regional differences are also significant, with human development worsening risks in regions further south and a faster rate of change in climate conditions worsening risks in ecosystems across regions further north.

A changing climate is only one type of threat facing Ontario's natural environment. Stressors linked to human development, economic and population growth are significant.

These include land clearing, wetlands draining, habitat fragmentation, increased waste, introduction of invasive species, and others.

How are the risks changing?[3]

Level 1 Category	Now	2050s	2080s
Fauna	 High Risk	 Very High Risk	 Very High Risk
Flora	 Medium Risk	 High Risk	 Very High Risk
Aquatic Ecosystems	 High Risk	 High Risk	 Very High Risk
Terrestrial Ecosystems	 Medium Risk	 High Risk	 High Risk
Regulating Services	 High Risk	 Very High Risk	 Very High Risk
Provisioning Services	 Medium Risk	 High Risk	 Very High Risk
Ecosystem Cultural Services	 Medium Risk	 High Risk	 Very High Risk

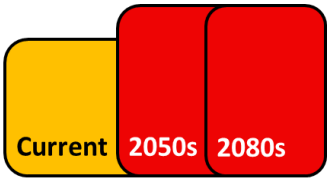
[3] Risk profiles reflect the highest regional risk score operating under RCP8.5 (high emissions scenario).

What are the risks?

Fauna

Fauna refers to the animal life in a particular region. Fauna are the fish, mammals, birds, insects/spiders and other organisms that are present throughout all regions of Ontario. Important ecosystem functions such as pollination, food provision, and nature-based recreation, depend on healthy fauna, and the broader ecological communities and functions they support. Climate change can impact fauna in numerous ways and were evaluated across numerous sub-categories using illustrative species:

1. **Fish**
2. **Insect/Spider**
3. **Mollusc**
4. **Waterfowl**
5. **Mammals**
6. **Birds**
7. **Amphibians**
8. **Migratory Songbirds**
9. **Reptiles.**



The highest risks for Fauna were found to be 'high' risk now and rising to 'very high' risk in future time periods. This risk profile applies to several Regions for the following categories assessed **Fish**, **Mollusc** and **Waterfowl**.

The current climate risk profile associated with the environmental consequences from climate change impacts to **fish** is rated as 'high' in southern Ontario (Central, Eastern and Southwest) and 'medium' in northern Ontario (Northeast, Northwest and Far North), increasing to 'high' for future time periods. Current risk levels are consistent with observed impacts of warming temperatures on fish distributions, phenology, among other traits, as well as studies simulating changes in volumes of thermal lake habitat available to fishes. Risk profiles differ among cold-water (e.g. brook trout), cool-water (e.g. walleye and redside dace) and warm-water (e.g. smallmouth bass) fish species. Increases in average annual temperature in Ontario will alter the amount of suitable habitat for fishes, influencing their growth rate, abundance, and distribution. Risks are expected to rise the fastest for cold- and cool- water fish species.

Brook trout, a representative cold-water fish species, has an optimal temperature range between 14-17°C[xl]. Warming air and water temperatures are expected to cause high stress and adverse physiological impacts. These impacts lead to less ability to compete with other species like the non-native Brown trout, avoid predators, and capture prey. Risks are increasing faster in Southwest and Central Ontario where hot summer seasons are already reducing habitat.

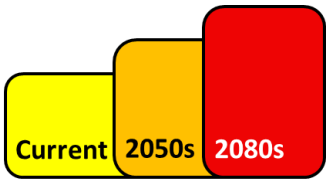
In contrast, **walleye's** thermal tolerance presents a mixed picture when comparing across regions. In southern regions of Ontario, warmer temperatures in summer and fall could well

exceed the optimum performance range for walleye (24˚C), offsetting any benefits from increased recruitment due to warming temperatures in the spring

Redside Dace is an endangered cool-water fish species who prefer water temperatures below 20°C and spawn when temperatures reach ~18°C[xli]. Rising air temperatures are expected to cause up to 100% of redside dace in Ontario to experience acute temperature increases that exceed their survivability and cause total loss in many locations.

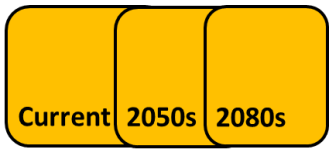
Mollusc: Mollusc species are sedentary in adult life stages, relying on other species to disperse larvae to new areas. The **Salamander Mussel** was found to be at risk to rising temperatures and shifting precipitation patterns. When stranding (low flows) occurs combined with consistently high temperatures exceeding critical thresholds, the species would put the species at high risk of total loss. This species was only assessed in Southwest Ontario.

Waterfowl: The **American coot** is a waterfowl bird found across most regions of Ontario. Rising air temperatures are expected to lead to drier climates and changes to water levels. As a marsh nesting obligate species, the American coot is vulnerable to hydrological variability, especially when water depth decreases below 0.5 meters over long-term periods during the breeding season. These factors may contribute to a loss of suitable habitat, population declines and total losses in some locations. Risks are considered highest in Southwest and Central Ontario.



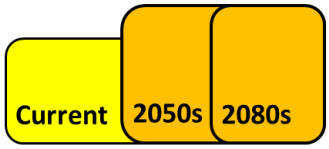
Mammal: The high variability and habitat requirements for mammal species, including survival, distribution and abundance of hibernating mammals, are likely to be influenced by climate-related changes. Risks to **Moose** were found to be 'medium' across Ontario but rising to 'very high' by end of the century. These risks are more significant in Southwest, Central and Eastern Ontario. Rising temperatures that tolerance thresholds cause heat stress, altering metabolic, heart, and respiration rates, reduces their food intake and causes them to lose weight.

A similar risk profile was found for **Insect and Spiders.** While insect and spider species in general have shown resilience to large-scale climatic impacts, changing hydrologic regimes can threaten these species. The **Lake Huron Grasshopper** is threatened, and risks are expected to rise from 'medium' now to 'very high' by end of century in Southwest and Central Ontario. These species may lose suitable habitat from lower lake water levels that favour vegetation succession over the building of dune habitat along the lake coast.

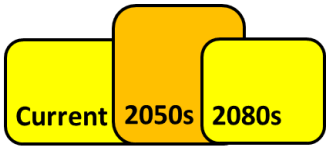


Risks to **Amphibians** are wide-ranging, with changing hydroperiods, seasonal shifts in freeze-thaw, and drought causing significant threats to habitats and breeding grounds. **Spring Peeper** was specifically assessed, and risks are already 'high' in Southwest

Ontario and rising to 'high' by end of century across all Regions. Earlier breeding season increases food competition and creates mismatches in food webs (predator-prey systems) affecting the health of populations.



Migratory Songbirds were found to have a similar but slightly reduced risk profile. Migratory birds are vulnerable to phenological changes resulting from shifts in climatic cycles and suitability of habitat depending on drought. The **Prothonotary Warbler** was assessed with risks found to be the same across all Regions of Ontario: 'medium' now and rising to 'high' by mid-century where they remain 'high'. Drought conditions reduce suitable breeding habitat for the prothonotary warbler, potentially to the point of losing species from Ontario.



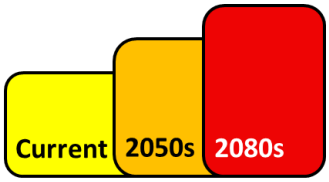
The final category assessed was **Reptiles**. Warming temperatures may actually facilitate range expansion over the long term of the **Common Five-Lined Skink**, increasing genetic diversity. The potential advantages of warming temperatures for populations of Common-Five Lined Skinks counteract with natural and human-made barriers may prevent range expansion northward thereby limiting increased benefits. The counterintuitive results illustrate the challenges of analyzing potentially positive effects of climate change, with heightened risk in Eastern and Northeast regions in mid-century, but then falling to medium by the end of century, denoting a potential upside for the lizard.

Flora

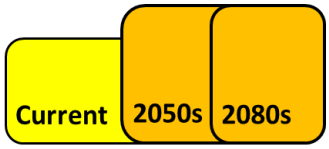
Flora broadly refers to the plant life in a region and are present across all of Ontario. There is significant complexity in understanding the risks climate change poses to flora since the impact of climate hazards are unique for every species and differ depending on the region. Many plant species also depend on other organisms for critical functions including growth and dispersal. In other words, climate impacts on flora will have indirect effects to ecosystems. The primary climate hazards that affect flora include warming, moisture levels, wildfire, pathogens, and invasive species. Climate impacts were evaluated across several sub-categories:

1. **Lichen**
2. **Vascular plants**
3. **Bryophytes**

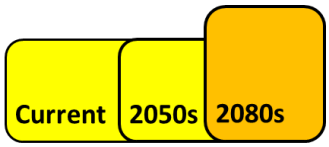
A single illustrative species is described for each taxonomic group below, along with their associated risk profile.



Lichens are composed of a symbiosis between algae and fungi, found across a range of ecosystems supporting important functions such as rock weathering, nutrient cycling, soil formation, and regulating humidity. The **Alpine dot lichen** was used as the illustrative species for this category, which is found in Northwest and Southwest Ontario. The risk profile for this species was found to be 'medium' under current climate conditions, rising to 'high' by mid-century in both Regions. Risks continue to rise to 'very high' in Southwest Ontario. Warming temperatures are expected to reduce suitable habitat potentially resulting in population contractions. As well, many lichens' growth and survival rates are influenced by hydrological regimes, including extremes such as spring runoff and seasonal precipitation events.



Vascular Plants are a broad group of flora comprising conifers, flowering plants, and ferns with a wide distribution throughout Ontario. There are 3118 known species occurring in the province[xlii]. **Eastern white pine** was used as the illustrative species for this category, which is found in all Regions of Ontario except the Far North. The risk profile is determined to be the same across all Regions, which is 'medium' now and rising to 'high' risk by mid-century. Warming temperatures and a longer growing season are expected to decrease this species' productivity and limit regeneration in sites limited by moisture and with favourable conditions for pathogen infection.



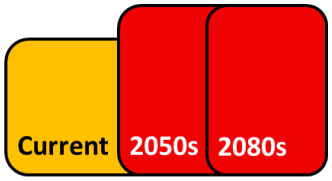
Bryophytes are a group of low-lying plants that consist of mosses, liverworts, and hornworts. There are 680 known species in Ontario[xliii]. **Alpine copper moss** was used as the illustrative species for this category, which is found in Northwest Ontario. The risk profile for this species was found to be 'medium' now and in mid-century and rising to 'high' by the end of century. For example, moisture deficits and drought can negatively impact the maintenance and establishment of alpine copper moss which has specific habitat requirements. This increases the risk of local extirpation.

Aquatic Ecosystems

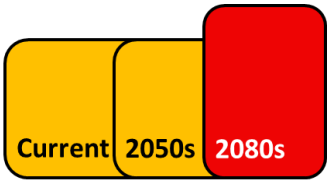
Ontario's aquatic ecosystems include freshwater ecosystems such as lakes, ponds, rivers, streams, springs, bogs, and wetlands. These ecosystems are vulnerable to the impacts of climate change because once degraded, they lose functionality. For example, warming water temperature can have detrimental and lasting effects on freshwater fish populations. Freshwater fish and mussel species occur throughout Canada, but a particularly high diversity of freshwater mussels and fishes can be found in Ontario's aquatic systems. Beyond freshwater fish and mussel populations, aquatic ecosystems support numerous reptile and amphibian species, waterfowl, mammals, rare vegetation communities, and support specialized habitats for a variety of species. Climate impacts were evaluated across several sub-categories:

1. **Bogs**
2. **Marshes**
3. **Clear open water**
4. **Mudflats**

Climate risks posed to each of these aquatic ecosystems vary significantly.

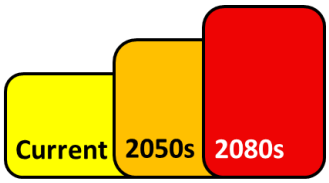


Bogs were found to have the highest risk profile. These ecosystems make up the second highest proportion across Ontario occupying 14,157,933 hectares [xliv]. Risks to bogs were found to be 'medium' across Southwest, Central and Eastern Ontario and 'high' across all northern Regions under current climate conditions. All regional risk profiles are expected to rise to 'high' or 'very high' by the end of the century. Risks are highest and accelerating the fastest in Ontario's Far North. Many climate variables and conditions can impact bogs. For example, higher air temperatures were found to be the main driver of Sphagnum decline, likely due to loss of competitive advantage over vascular plant species. Over the long term, shifts in climate and peatland moisture status would be accompanied by shifts in the composition of vegetation and changes in carbon cycling processes. Future climate conditions and warming will lead to reduced peat accumulation in bogs and will turn most bogs from being carbon sinks to sources and result in severe drying of peatlands.

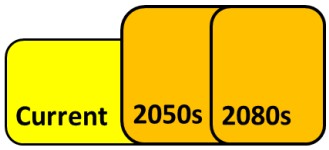


Mudflats were found to have the second highest risk profile. These ecosystems occupy the lowest area of all aquatic ecosystems in Ontario, consisting of 10,739 hectares[xlv], but are essential to a variety of migrant shorebirds. Risks were only characterized in Ontario's Far North and are considered 'high' under current climate conditions rising to 'very high' by end of the century. Warming temperatures are anticipated to shorten the ice cover season, shift spring snow melt and lead to the tundra ecozone of northern Hudson Bay retreating northward, impacting shorebird species nesting. Mudflats will be

degraded or lost entirely, and disappearance of these mudflats due to the combined effect of climate change and isostatic rebound will result in long-term reductions of migrating shorebird habitat.



Climate risks to **marshes** are considered 'medium' under current climate conditions and rising to 'high' by mid-century across most Regions. In Central Ontario, risks rise even further to 'very high' by end of century due to socio-economic pressures. Marshes makeup 228,874 hectares[xlvi] of Ontario and provide staging areas for many waterfowl species, and are home to species at risk birds, fish, mammals, reptiles, and amphibians. Many climate hazards can impact marshes. For example, moisture deficit and drought can draw down the water table and lead to stress on many marshes, swamps, vernal pools with some disappearing. By the end of the century, most systems will be changed significantly. Moisture deficit events cause water level fluctuations, changing the native vegetation of freshwater marshes favouring more invasive species. These decreases in native marsh plants may result in decreased abundances of marsh nesting obligate bird species, and increased abundance of tree or shrub nesting species due to higher abundance of sedges.



Clear Open Water ecosystems in Ontario occupy 14,453,250 hectares[xlvii] when considering a combination of detailed provincial land-cover inventories. This is the largest area covered for any one ecosystem described in the Ontario Land Cover Compilation. The risk profile for these ecosystems is considered to be 'medium' across all Regions now but rising to 'high' risk by mid-century. Increases in extreme precipitation were found to be particularly impactful. For example, water clarity is influenced by heavy rainfall events that increase erosion and wash inorganic sediment and increase limiting nutrients (e.g. phosphorus) into water bodies. Increases in turbidity in clear open water systems can have negative impacts on species at risk mussels such as the salamander mussel and nutrient runoff can stimulate the creation of harmful algal blooms. Higher temperatures can worsen these impacts through increasing dissolved organic carbon in lakes causing thermal stratification and increased levels of noxious cyanobacteria.

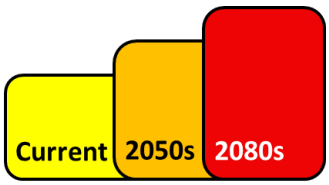
Terrestrial Ecosystems

Terrestrial Ecosystems are land-based communities of organisms, which include interactions between them and abiotic components of the community. The benefit of assessing climate impacts at the terrestrial ecosystem level is such that some of the impacts and ecosystem responses can be generalized based on the characteristics of species such as geographic range size, region in Ontario where the population occurs, mobility, and genetic variation. Climate impacts were evaluated across several sub-categories:

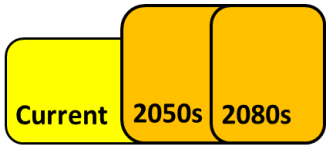
1. **Coniferous forests**
2. **Deciduous forests**
3. **Sand barren and dunes**
4. **Tallgrass savannah**
5. **Heath**
6. **Open tallgrass prairies**

Climate risks posed to these terrestrial ecosystems vary significantly. Several of these ecosystems are considered to be rare vegetation communities (Tallgrass Savannahs, Open Tallgrass Prairie, Sand Barren and Dune) or habitats and breeding areas for migratory birds (Deciduous and Coniferous Forests).

In several terrestrial ecosystems, continued incremental climate change and impacts were found to compound risks resulting in potentially irreversible effects.



Coniferous Forests make up 250,410 hectares of the land base in Ontario[xlviii], with the majority located in the northern regions of the province. The risk profile for these ecosystems was determined to be 'medium' in all Regions and expected to rise to 'high' risk by mid-century. In Eastern Ontario, risks are expected to rise even further to 'very high' by the end of century. This risk reflects the increased risk stemming from wildfire. Warming contributes to northward shift of coniferous forest ranges. The traditional boreal forest region is expected to change through the encroachment of southern zone species and the northward shift of boreal species to occupy more northern locations. Other effects of temperature increases include impacts to photosynthesis, respiration, and transpiration on coniferous forest flora species as well as on the activities of fauna. Due to the long lifespan of tree species, rapid climate change is likely to have direct and indirect negative impacts on vegetation health, composition, structure and productivity within half of many species' lifetimes.

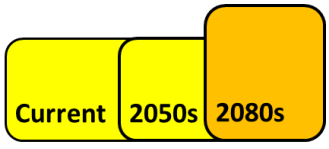


The second highest risk profile for terrestrial ecosystems was found to be relatively consistent across several Level 2 categories: **Deciduous Forests, Sand Barren and Dunes**, and **Tallgrass Savannah**. Risks for these different ecosystems are considered 'medium' under current climate conditions but will change to 'high' by mid-century. Some regional variations exist for deciduous forests, where risks are considered higher in Ontario's northeast and northwest.

Deciduous forests cover 705,510 hectares[xlix] of land in Ontario and provide habitat for flora and fauna as well as numerous ecosystem services. Driven by warming temperatures, habitats will become more suitable for southern species and vulnerability will be higher to invasive species, insect pests and pathogens that will increase and become more severe. Composition of deciduous forests are expected to shift as well, including declines in vegetation health, structure, and productivity.

Sand Barren and Dunes are characterized by their open nature (not treed) and cover 698 hectares of Ontario. Warming temperatures and related loss of protective ice cover is expected to reduce the extent of sand barren and dune ecosystems in Ontario and reduce their species richness.

Tallgrass Savannah ecosystems are some of the most endangered in Canada and only consist of 693 hectares[l] of the Ontario landscape. While many native prairie and savannah species are well adapted to drought and hot summer seasons, those degraded or stressed may become vulnerable to environmental stress and biotic threats in the face of longer hot-weather seasons.



The final risk profile under terrestrial ecosystems relates to **Heath** and **Open Tallgrass Prairie** ecosystems. Risks for these ecosystems are found to be 'medium' under current climate conditions across all Regions where they are present in Ontario and remain at this risk level until end of century when risks increase to 'high'. Heath ecosystems were only assessed in the Far North Region, whereas open tallgrass prairie ecosystems were assessed in Southwest, Central and Eastern Ontario.

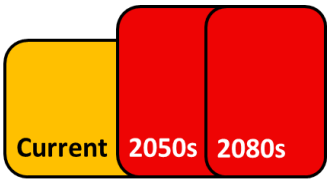
Heath habitats are shrubland habitats found mainly on free-draining infertile, acidic soils and characterized by open, low-growing woody vegetation and lichen. In Ontario, they cover 67,122 hectares[li]. Fluctuations in summer precipitation frequency and amount affects the soil moisture content and negatively impacts respiratory activity of heath systems.

Open tallgrass prairie is the smallest of all terrestrial ecosystems assessed in Ontario consisting of 336 hectares[lii] but is considered one of the rarest and most endangered ecosystems globally. Climate change impacts, and particularly prolonged hot and dry conditions were found to be particularly harmful. Repeated seasonal droughts combined with warming can lead to losses of some species within this ecosystem, although functionality is retained.

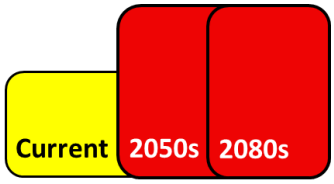
Regulating Services

Ecosystem processes provide beneficial regulating services for human health, safety and comfort. Climate change poses significant direct risks to these services. The risks then cascade onto other facets within the broader ecological and human system. For example, climate change impacts on pollinating insects can lead to catastrophic consequences for fruit production, loss of carbon storage, further loss of pollinator habitat and other impacts down the connected chain. Climate risks were evaluated across three sub-categories of regulating services:

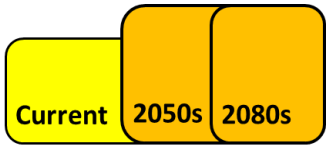
1. **Carbon storage**
2. **Pollination**
3. **Water flow regulation**



Carbon storage occurs across all of Ontario, but more prominently in the least developed, more vegetated areas. The risk profile was found to be 'high' at current and rising to 'very high' by end of century in all northern Regions of Ontario, most notably in the Far North. Risks in Southwest, Central and Eastern Ontario are considered 'low' now but rising to 'high' in future time periods. Carbon storage will be most impacted by rising temperatures and drought and be most significant in peatlands, wetlands and forests. Temperature increases result in shifts in ecosystem composition and carbon cycling, leading to reduced carbon storage. Boreal forests and wetlands found in Ontario's northern regions may experience reduced carbon storage ability and potentially release substantial amounts of carbon under a warmer future.



Pollination is critical to maintaining healthy ecosystems and is essential for agricultural function. Risks are currently considered 'medium' across all of Ontario and rising to 'very high' in Central, Southwest and Eastern Ontario. Rising temperatures drive some of the most significant impacts when increasing temperatures exceed pollinator species' thermal limits. Range shifts are almost certain to occur, but there are concerns pollinators will not shift their range quickly enough to keep up with climate change. This may also lead to a loss of synchrony between pollinator species emergence and the availability of quality floral resources in the spring, causing widespread species richness declines.



Water flow regulation is the process of vegetation or other ecosystem structures acting as a barrier or buffer and reducing the frequency and severity of flood events. Risks are currently considered 'medium' across all Regions of Ontario and rising to 'high' in the future. Risks are rising fastest in Southwest, Central and Eastern Ontario where

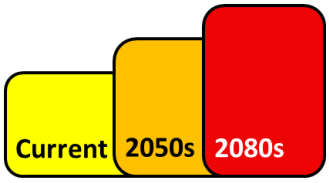
more community growth and development has occurred, and higher water demand is present. Drought may change ecosystem composition leading to physical changes to hydraulic connectivity and routing. Those changes will then lead to reduced capacity for water retention and protection against high flow regimes. Protecting forests and wetlands will be vital to maintaining water flow regulation services.

Provisioning Services

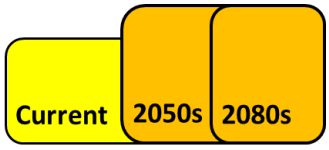
Provisioning services are materials or energy harvested from the natural environment that can benefit humans in terms of use, consumption, or based on their inherent value. Provisioning services are susceptible to climate change, but the associated impacts are not clearly delineated. Potential opportunities may exist in some cases, such as increased forest biomass in northern Ontario. However, climate risks are generally significant and are being driven by rising temperatures, drought, wildfire, and changes in precipitation. Climate risks were evaluated across two sub-categories:

1. **Freshwater provisioning**
2. **Wood supplies**

The climate risk profiles for each are different and vary by region of Ontario.



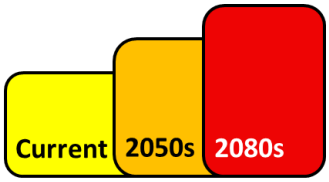
Risks to **freshwater provision** were found to be the highest for this category. Freshwater provision is the acquisition of surface or groundwater for human use, such as for electricity generation, manufacturing, household use and agricultural purposes. Climate change may bring extreme consequences for freshwater provision. Risks were found to be currently 'medium' and rising to 'high' by mid century everywhere in Ontario. In Southwest, Central and Eastern Ontario risks continue to rise to 'very high' by end of century. Regional differences reflect higher severity of consequences where population density is higher and where a greater number of activities requiring water are found. Moisture deficit and drought could lead to declines in availability of freshwater for human use and further affect the ecosystems that require freshwater for proper function. As a result, drought could lead to heightened restrictions and increased conflict within the province. Increasing temperatures could change aquatic species compositions and alter long-term ecosystem function.



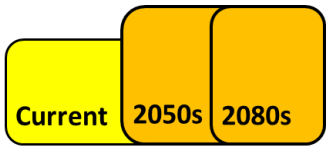
Wood Supplies are vital to the forestry industry and play an essential economic role in Ontario. Key products produced from wood supplies in Canada include northern bleached softwood kraft pulp, newsprint, and softwood lumber. Risks are classed as 'medium' across all Regions of the province and rising to 'high' in the future. There are slight regional differences in how fast risks are rising, but by end of century, risks are 'high' across all of Ontario. Moisture deficit and drought can impact wood supplies by worsening wildfire regimes and insect disturbances and tree mortality. Increasing temperature and changing precipitation will likely alter climate suitability for tree species, changing their growth rate and causing shifting forest composition. As a result, many tree species, especially those whose southern edge lies within the Great Lakes Basin, will likely experience reduced growth rates, reproductive failure, and increased disease and mortality.

Ecosystem Cultural Services

Ecosystem cultural services refer to the outputs of ecosystems (biotic and abiotic) that affect the physical and mental states of people. These benefits promote people's engagement with the natural environment in ways that are culturally enriching. The primary climate hazards that affect ecosystem cultural services include warming, moisture levels and drought, and extreme heat. Indirect impacts of climate change on ecosystem cultural services will impact communities that rely on recreational hunting and fishing for their economy and will face pressures and stresses due to changed fish species ranges, habitat disruptions, fish mortality increases, and seasonal timing changes. Climate risks were evaluated across two sub-categories, **nature-based recreation** and **recreational fishing**. The climate risk profiles for each were found to be different and are described below.



Opportunities for **nature-based recreation** exist throughout the province. The risk profile associated with nature-based recreation was found to be 'medium' across all Regions and rising to 'high' by mid-century. Risks are also expected to continue to rise in Ontario's northern Regions to 'very high' by end of century. Nature-based recreation will be impacted by several climate hazards such as extreme heat, extreme precipitation, wildfire, and seasonal precipitation changes such as rain-on-snow. Climate change is projected to lead to substantial reductions in both depth and length of the snow cover season. Warmer winters reduce the seasonal availability and quality of snow-based recreation such as downhill and cross-country skiing and snowmobiling. This is also expected to impact ice fishing, which is anticipated to decline due to climate change.



Recreational fishing is an important outdoor recreational activity for Canadians. In particular, many northern Ontarians view recreational fishing as an activity central to their life. Sport fishing is also an important part of many local economies and a driver of tourism. The risk profile associated with recreational fishing was assessed across every Region of Ontario and found to be largely consistent. Risks under current climate conditions are considered 'medium', rising to 'high' and remaining elevated out to the end of century. Increased temperatures are expected to impact sportfish species' distributions and availability, reduce access to fishing areas through increased evaporation/lowered water levels, and affect ice fishing viability, resulting in direct economic consequences through lowered angling participation and reduced success due to species changes.

Why do risks vary for different species, habitats, or ecosystem services?

The level of risk varies significantly first among Regions, but also depending on the unique nature of Level 1 and Level 2 categories. These differences exist due to many reasons, including habitat-specific tolerance thresholds, the extent to which ecosystems are intact and continuous versus fragmented, and the level of consequences derived from a particular impact. For example, risks to fauna reach the highest levels by the end of century in the Central and Southwest Regions, in part because of higher levels of expected development, exacerbating climate stressors and impacts. When considering risks to aquatic and terrestrial ecosystems, Ontario's Central Region and all northern Regions stand out as having highest risk levels by the end of the century, with much of the risk driven by the impacts of climate change on northern wetlands ecosystems, such as changes in community structure, matter, and nutrient cycling. Ontario's Far North contains vast swathes of ecosystems and related ecosystem processes of global significance (e.g. peatlands as natural carbon stores), with climate threats (combined with potential development) leading to risks that are not only extensive but also irreversible.

Ontario's Far North contains vast swaths of ecosystems and related ecosystem processes of global significance. Climate threats combined with potential development could lead to risks that are not only extensive, but also irreversible.

What don't we know yet?

Ontario's natural environment is incredibly complex and diverse. Risks evaluated as part of this assessment include illustrative species, habitats and ecosystem services. Assessing more species would lead to a more comprehensive assessment of the Natural Environment. Local weather and climate data and additional land-based GIS information would also benefit in characterizing habitat, as would a more specific assessment of species-specific tolerance and response thresholds. Cascading impacts and possible tipping points were also not included in characterizing risks, due to literature and information constraints across every Region of the province. In future assessments, these should be evaluated more quantitatively to inform adaptation options of the natural environment.

What can we do about it?

Ontario has the knowledge and solutions to implement measures to lessen many of the climate risks facing the natural environment. An extract of adaptation options is shown below, with the more fulsome list provided in a separate document (PCCIA Adaptation Best Practices Report).

Projects or Programs

- Fill gaps across Ontario's regions and develop formal partnerships, with funding, to manage natural ecosystems.
- 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.

Research and Development

- Adopt international standards for the practice of ecological restoration.
- Develop collaborations among communities and support Indigenous-led conservation.
- Develop provincial policy for landscape management to support assisted migration and re-establishment.
- Develop education resources for forest and urban forest managers.

Investment and Incentives

- Invest in research and Indigenous-led community-based monitoring and research programs (e.g. National Indigenous Guardians Network (NIGN)).
- 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

- 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 for climate refugia protection and management.
- Maintain, promote and enhance ecosystem connectivity.
- Protect and conserve peatlands and other carbon-dense ecosystems as intact ecosystems.

Navigate back to the Launch Page

People and Communities

What are the key findings for People and Communities?

Climate change has already had significant impacts on residents, communities, and associated services in Ontario. These risks are expected to continue into the future. The PCCIA reveals that climate risks are highest among Ontario's most vulnerable populations and exacerbate existing disparities and inequities (e.g. unhoused population, Indigenous Communities. Climate risks to Indigenous Communities and associated systems are found to be significant based on the additional layers of sensitivity and exposure related to their close relationship with the environment and its natural resources, and the dispersed nature of Communities noted in the Far North Region of Ontario.

Why are Ontario's People and Communities important?

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.

In Ontario's recent history more acute climate events have garnered the widest coverage and attention, with flooding, heat waves, ice storms causing direct and indirect impacts for Ontarians. While the physical impacts to property and infrastructure often receive the greatest focus and have consequential impacts for people, the direct impacts on human health and the systems that people rely on for their well-being have also been significant.

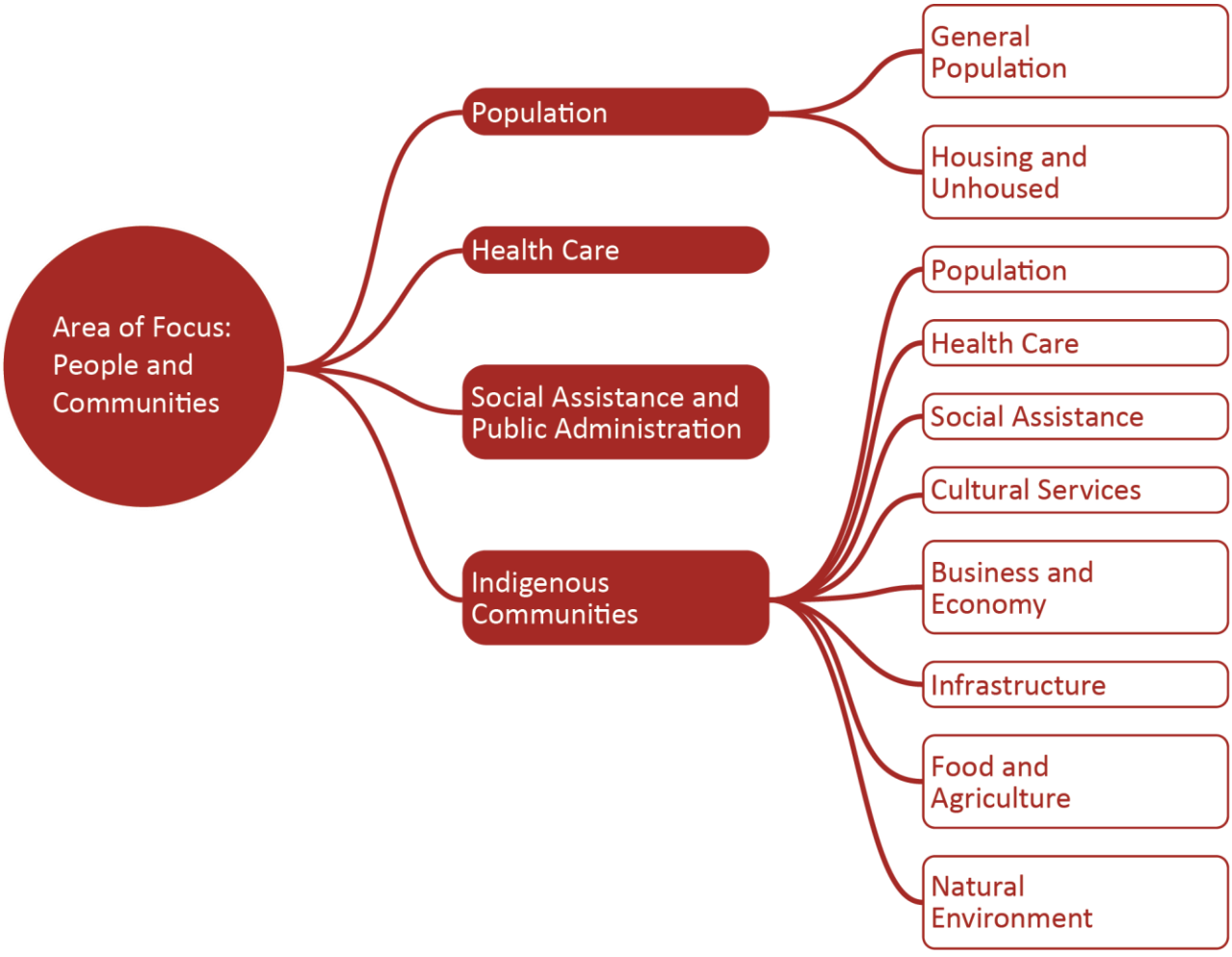
Vulnerability to climate change is not distributed evenly across Ontario, with climate change disproportionately impacting individuals and communities facing systemic inequities, such as marginalisation and racialisation. The assessment of climate impacts and capacity considered how environmental justice and equity issues create disproportionate impacts for specific segments of the population, especially Indigenous Peoples and Communities.

Climate risks are disproportionately impacting individuals and communities facing systemic inequities.

This portion of the assessment evaluated how climate change is affecting risk levels for Ontario's population, as well as impacts to health care systems, social services, and to Indigenous Communities. Successful and equitable climate change adaptation requires an understanding of how individuals, communities and associated services are at risk, and where losses and disruptions are most likely to affect Ontarians' health and well-being.

Defining Ontario's People and Communities for assessment

The complexity and range of considerations that are part of People and Communities Area of Focus is significant. The context for this Area of Focus was set with an attempt to avoid overlap with risks covered in other Areas of Focus in the assessment. To assess current and future climate change impacts, we defined Ontario's People and Communities Area of Focus as a series of four categories (Level 1 categories). Some of these categories are further delineated to include sub-categories (Level 2 categories), which are described in the assessment results.



People and Communities Level 1 Categories

Population

Health Care

Social Assistance and Public Administration

Indigenous Communities

How were the impacts to People and Communities assessed?

Various interactions were identified for each Level 1 category and Region, and considered how impacts interact and affect needs and services that are essential for overall health and well-being. Indirect impacts that cascaded from other Areas of Focus, such as impacts resulting from infrastructure failures, were qualitatively characterized to accompany the numerical risk scores for the People and Communities Area of Focus. Further information specific to health and well-being outcomes associated with climate change can be found under the **Human Health, Safety and Well-being Cross-Sectoral Theme.**

For this Area of Focus, consequences were assessed as the portion (%) of population that is adversely impacted by a given risk scenario. For a deeper regional analysis of the six provincial Regions, a representative census area was selected to represent the typical population characteristics of each given Region.

How were Vulnerable Populations Assessed?

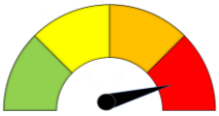
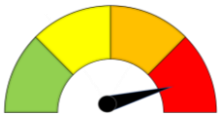
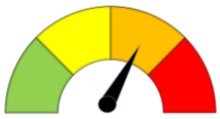
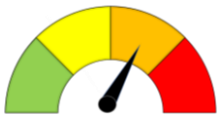
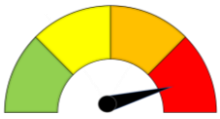
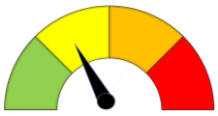
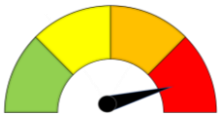
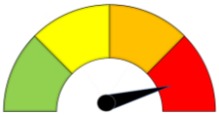
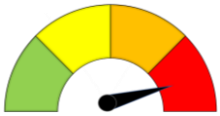
The social determinants of health, including income, education, employment, and working and living conditions were used to describe conditions and factors that affect health outcomes. These determinants were applied as a lens to understand how people and communities in Ontario are impacted by climate change, enabling an intersectional approach to evaluate how individuals and groups are and will continue to experience disproportionate impacts of climate change.

If you only take one thing away:

Climate change has already had significant impacts on individuals, communities, and associated services in Ontario. Without additional coordinated and inclusive adaptation efforts, climate change will continue to drive risks into the future. This assessment demonstrated that climate risks are highest among Ontario's most vulnerable populations, exacerbating existing disparities and inequities. Climate risks to Indigenous Communities and associated systems are significant based on the additional layers of sensitivity and exposure.

The results of this impact assessment highlight the urgent need to limit key health, social and cultural risks to Ontario's people and communities, in order to avoid outcomes that can become inter-generational and further exacerbate inequities for marginalised populations. Adaptation efforts to address the underlying health and well-being inequities are critical for reducing population vulnerability and building climate resilience. It is also important that the voices of Indigenous Knowledge-Holders are centered in the effort to develop meaningful and effective climate adaptation programs for not only Indigenous Communities, but for all Ontarians. This is particularly important given the need to apply an environmental and social justice-oriented approach to climate change adaptation.

How are the risks changing?[4]

Level 1 Category	Now	2050s	2080s
Population	 High Risk	 Very High Risk	 Very High Risk
Healthcare	 High Risk	 High Risk	 Very High Risk
Social Assistance and Public Administration	 Medium Risk	 High Risk	 Very High Risk
Indigenous Communities	 High Risk	 Very High Risk	 Very High Risk

[4] Risk profiles reflect the highest regional risk score operating under RCP8.5 (high emissions scenario).

What are the risks?

Population

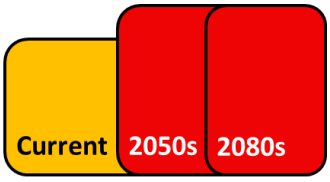
Ontario is home to some of the fastest growing communities in Canada and is projected to continue to grow at significant rates over the coming decades. There is a high degree of regional variability in population demographics and diversity across the province, driven in part by local job attraction and relative levels of housing affordability and supply.

Two subgroups of population were evaluated as part of this assessment, **general population**, and **unhoused population**. These two subgroups (Level 2 categories) were developed to recognize the specific vulnerability of people without access to safe and secure shelter. Vulnerable populations were also considered under the general population category.

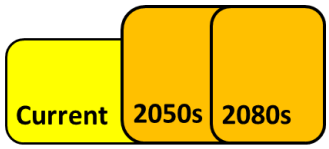
In 2021, the Financial Accountability Office of Ontario (FAO) estimated that over 179,000 households in Ontario lived in housing that was 'deeply unaffordable' and were at risk of homelessness[liii]. The connections between housing insecurity and insufficiency, and vulnerability to climate change are well documented, identifying homelessness, inadequate cooling, and exposure to flood risk, as key factors of increasing exposure and vulnerability to climate change.

Housing insecurity and insufficiency contribute to climate change vulnerability.

Climate change increases existing threats to population health and compounds existing pressures on personal safety, health, and well-being. This assessment found that impacts related to extreme heat and precipitation are driving the greatest risks to population health, with specific impacts related to temperature stress, respiratory illness, and threats to physical safety. Many of these impacts result in situations where Ontarians require medical attention or are forced to relocate or evacuate to a safe area away from the hazard. Unhoused and other vulnerable groups are affected to a greater extent given the high potential that their living conditions have greater exposure to temperature stress and extreme weather.



The risk profile for the unhoused population across all Regions of the province is 'high' under current conditions and expected to rise to 'very high' by the 2050s and remains 'very high' until the end-of-century.



General population ranked slightly lower in risk than the unhoused population subcategory, with current risk profiles exhibiting a 'medium' score, and increasing to 'high' in future time periods. This reflects differences in existing climate vulnerability between general populations and unhoused populations.

Health Care

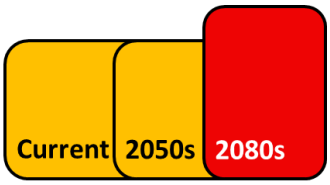
Health care facilities and services comprise establishments primarily engaged in providing health care by diagnosis and treatment and providing residential care for medical reasons. This includes ambulatory services, hospital care, nursing and residential care, and in-home health care. This assessment captured the impact of climate change on the functions and service delivery of health care services to Ontarians, including emergency services and hospital/clinic-based care.

Health care facilities and services are among those most affected during climate-related events and disasters.

There is disparity in the presence of, and access to, health care facilities across the province, particularly in growing communities and in less densely populated areas across northern Ontario. The types of care that are available and wait times to access urgent and emergent health care needs vary significantly across the province.

Health care facilities and services are among those most affected during climate-related events and disasters (e.g. flooding, severe storms). This assessment found that extreme temperatures (heat and cold) and extreme precipitation events are driving the greatest risks to health care facilities and services across Ontario. These climate events were found to result in increased demand for health care services, longer wait times and caregiver/provider stress, with severe events potentially causing temporary closures, and cancellations of critical services.

Times of extreme events and climate-related disasters are when emergency services are most needed and disruptions to those services can have considerable impacts on Ontarians' health and well-being. Even if health facilities and services remain operational during climate-related events, capacity limitations can impact the ability to respond adequately. In addition, the cascading effects of climate change on health care systems, such as disruptions to supply chains for medical equipment, building damages, road closures, and power outages can compound impacts on Ontarians health and well-being.



Overall, climate risk to health care in Central and Eastern Ontario is found to maintain a ‘high’ score from the current timeframe until the 2050s. In the Southwest Region, the risk is found to increase from ‘high’ to a ‘very high’ risk score by the end of the century, reflecting existing capacity constraints. For the northern Regions of the province, the current risk profile for health care was found to have ‘medium’ score, increasing to ‘high’ by mid-century and remaining ‘high’ until end of century.

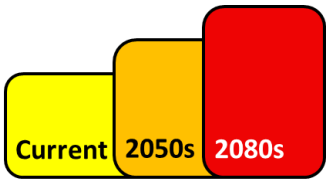
Social Assistance and Public Administration

Social and administrative services are a key contributor to maintaining the health and well-being of Ontarians. These services include counselling, welfare, child protection, community housing and food services, vocational rehabilitation and childcare, legislative activities, taxation, national defense, public order and safety, immigration services, foreign affairs and international assistance, and the administration of government programs. Closures of these public administrative services can cause significant disruption and impact the population. Notably, more than 1.5 million people in Ontario live in poverty, and approximately 6.5% of Ontarians receive and rely on social assistance (2019)[liv].

Social and administrative services are fundamental to the health and well-being of Ontarians. Limitations in social assistance support reduces capacity for Ontarians to respond to climate-related impacts.

Similar to health care services, social and administrative services are fundamental to the health and well-being of Ontarians and are called into high demand during and after climate-related events and disasters. Administrative and social care workers involved in delivering social assistance are more likely to experience increased demand and high stress during prolonged extreme weather events, potentially leading to a reduction in availability of service providers and increased system wait times.

Limitations in social assistance support, for example through welfare programs including the Ontario Disability Support Program, would result in reduced capacity for low-income residents to be able to afford shelter with adequate temperature controls or regulation. This could lead to a larger number of cases of temperature stress and mortality risk, which in turn impacts the demand for and availability of those tasked with providing care in emergency situations.



The risk profile for social assistance and public administration is found to increase from a 'medium' risk score to a 'high' risk score by the 2050s, in the Southwest, Central, Northwest, Northeast and Far North Regions. For the Eastern Region, risk is expected to increase further to a 'very high' score by end of century.

Indigenous Communities

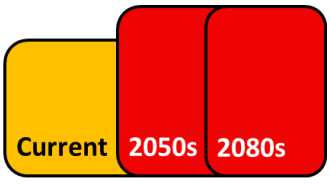
Ontario's Indigenous Communities are the original inhabitants of Ontario. For thousands of years, they have developed distinct languages, cultures and ways of life, and rich laws and traditions. The Truth and Reconciliation Commission aptly states the imperative for enhanced relationships with Indigenous Peoples based on reconciliation and mutual respect. While Indigenous Communities in Ontario contribute least to climate change, the effects of it are being felt disproportionately by them [lv]. Warming winters are impacting the reliability of winter roads which connect many remote First Nation Communities to critical services; warm spells are causing rapid snow melts and flooding; and wildfires have caused community evacuations and deep emotional and psychological impacts not only from the loss of property but also from damage to sacred lands and loss of cultural heritage [lvi, lvii].

Indigenous Peoples and Communities across Ontario are disproportionately impacted by climate change.

The Indigenous Communities Level 1 category of this assessment relates to First Nation, Inuit, and Métis, living on and off reserve across Ontario. This distinction as a unique Level 1 category was applied to properly reference unique vulnerabilities and challenges and to adequately assess climate change risks to Indigenous Peoples across the province.

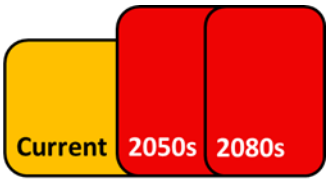
Climate impacts on Indigenous Communities were assessed across several subcategories, including Population, Health Care, Cultural Services, and Social Assistance. In addition, an assessment of the other Areas of Focus, including Infrastructure, Food and Agriculture, Natural Environment and Business and Economy was undertaken for Indigenous Peoples.

The direct and indirect impacts of climate change on Indigenous Communities in Ontario are far-reaching and complex. Observed climatic changes and projected conditions indicate that Indigenous Communities in Ontario will continue to be disproportionately impacted by climate change, due to existing socio-economic disparities, injustices, environmental racism, remoteness of many communities, and lack of adequate infrastructure (water, wastewater, roads, etc.)[lviii]. Additionally, Indigenous Peoples and Communities are particularly sensitive to the impacts of climate change due to the strong ties and connection they have to the land, water, animals and environment.

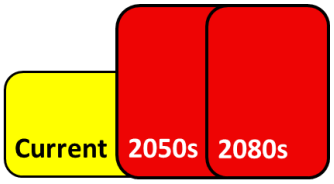


Changing climate conditions present a range of direct and indirect health and well-being impacts on **Indigenous Populations**, threating their personal safety, water and food security, mental well-being, knowledge systems, ways of life and cultural cohesion. The indirect impacts of climate change will disrupt the livelihoods of Indigenous Communities in Ontario,

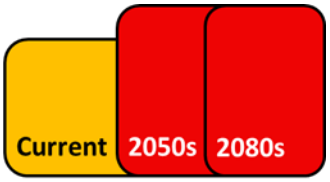
compounding existing inequities and vulnerability[lix]. The risk profile for Indigenous Populations is scored 'high' under current conditions and anticipated to increase to 'very high' by mid-century and remain 'very high'.



Climate impacts to **Indigenous Health Care,** particularly in remote communities, enhance existing challenges. Extreme weather events (e.g. extreme precipitation events) can lead to shortfalls in service provision, inaccessibility to services, and travel delays for health and emergency services for remote Indigenous Communities. These impacts result in access limitations to medical services and supplies and compromise patient health and safety. Among medical supplies are traditional plants and medicines that play an important cultural role and are being impacted by climate change. The fragmentation of health care between agencies and a lack of dedicated long-term funding for mental health services are additional complicating factors that further constrain the provision of health care supports in Indigenous Communities. The risk profile for Indigenous Health Care is scored 'high' under current conditions and anticipated to increase to 'very high' by mid-century and remain 'very high'.



Climate change has and will continue to impact **Indigenous Social Assistance**, including increased demands on social services as a result of extreme climate-related events (heat waves, flooding) resulting in longer wait times, caregiver/provider stress, shortfalls in service provision and inaccessibility to services. These effects are particularly impactful on remote Indigenous Communities in northern Ontario. In addition, impacts to **Indigenous Social Assistance** can be exacerbated by existing capacity limitations across the sector. Existing social services are constrained due to the availability of trained professionals, with knowledge of culturally appropriate practices, integrating Indigenous ways of being and considering the current context of disproportionate socio-economic inequities and harms from colonization on Indigenous Peoples and Communities. The risk profile for Indigenous Social Assistance is scored 'medium' under current conditions and anticipated to increase to 'very high' by mid-century and remain 'very high'.



Indigenous culture, language, and livelihoods are tightly intertwined with the land and environment. Climate change has resulted in significant losses for **Indigenous Cultural Services**, including impacts to cultural practices and heritage, traditions, special places and sites, and social fabric, as well as physical and mental health and identity, among others. For example, Indigenous knowledge systems and practices are key to Indigenous Peoples' ability to observe, respond, and adapt to climate and environmental changes. Climate change is threatening the transmission of intergenerational knowledge and skills due to drastically changing climatic and environmental conditions. Indigenous Knowledge remains one of the

most crucial elements in understanding climate change impacts and advancing adaptation mechanisms for Indigenous Communities and others, further highlighting its value and cause for critical concern. The risk profile for Indigenous Cultural Services is scored 'high' under current conditions and anticipated to increase to 'very high' by mid-century and remain 'very high'.

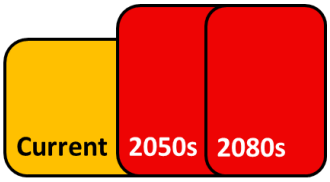
Indigenous Communities across Ontario face varying forms and degrees of **Infrastructure** limitations. Infrastructure across Indigenous Communities in Ontario is often multifunctional and integral to sustaining healthy community life, providing a range of services. The infrastructure gap between Indigenous and non-Indigenous communities across Ontario is significant, with severe critical infrastructure deficits identified across Indigenous Communities. Climate change is expected to exacerbate infrastructure deficits, with damages and failures expected to increase on drinking water, wastewater, waste management, roads, and stormwater management infrastructure[lx]. In addition, many Indigenous Communities in Ontario rely on winter roads for transportation of goods, services, and supplies. Winter roads are an example of critical infrastructure that are particularly vulnerable to climate change. Warming winters and temperature variability are shortening the winter road season, resulting in construction and maintenance challenges and safety concerns related to road stability. Increasing unpredictability of winter road conditions is impacting the supply of critical supplies and emergency services for Indigenous Communities in Ontario.

Climate-related impacts to **Food and Agriculture** production can have direct and indirect impacts for Indigenous Peoples and Communities across Ontario. First Nations, Inuit, and Métis Peoples have disproportionately higher rates of food insecurity, and climate change is expected to compound existing food security and access issues. Both acute (e.g. extreme weather event) and chronic (e.g. warming seasonal temperatures) climatic changes can disrupt Indigenous hunting and gathering practices and the impact the availability, accessibility and safety of traditional food sources. These impacts have cascading impacts on Indigenous Communities, for not only food security, but also cultural identity, well-being and mental health. See the **Food Security Cross-Sectoral Theme** for more information.

Indigenous culture, language, and livelihoods are tightly linked to the **Natural Environment**. Under the Natural Environment Area of Focus of this assessment, several risk scenarios were identified on the changing distribution and abundance of certain species under a changing climate. Indigenous Peoples and Communities will be considerably impacted by these changes, as access to certain culturally significant plant, fish and mammal species may be limited or lost entirely in some areas.

As noted, direct and indirect climate change impacts will threaten the Indigenous livelihoods. Impacts to forestry, fishing and hunting economies in **Business and Economy**, are expected to be experienced disproportionately by Indigenous Communities. For example, losing access to

traditional places and natural resources due to changing ice conditions or shifting seasonal events (e.g. spawning), directly impact livelihoods and cultural practices across Indigenous Communities.



The overall Level 1 risk profile for Indigenous Communities was determined to be 'high' under current conditions and increases to 'very high' by the 2050s. It is expected this risk profile remains at 'very high' into the 2080s, across all Regions of the province.

Despite inequities and compounding vulnerability faced by Indigenous Peoples in Ontario, they have continuously demonstrated resiliency through their knowledge systems, ability to respond to impacts, and withstand challenging and changing climate conditions. Indigenous-led adaptation, policy and research should be prioritized across all Regions of the province to support not only Indigenous Peoples and Communities, but all Ontarians in preparing for the impacts of climate change.

What were the limitations to assessing climate impacts on Ontario's Peoples and Communities?

A climate change impact assessment requires holistic knowledge of risk perceptions and risk tolerances from rights holders and stakeholders, especially when assessing impacts on people and communities. Engagement efforts for the PCCIA were constrained due to the COVID-19 pandemic. In-person engagement was planned for the entirety of the assessment process but had to be changed to fully virtual. This resulted in engagement limitations across the project, including Indigenous engagement. Climate change knowledge and adaptation activity within Indigenous Communities, associations and organizations is apparent and should be emphasized in the PCCIA outcomes, as well as prioritized within subsequent iterations of province-wide climate change impact assessment.

What don't we know yet?

Within the People and Communities Area of Focus, certain elements could not be fully categorized due to lack of comprehensive province-wide data and information. Examples of specific knowledge gaps include impacts on specific vulnerable segments of the population such as incarcerated populations, newcomers to Canada, outdoor workers, migrant workers, and those in long-term care facilities. These data and knowledge gaps somewhat constrained the assessment in certain categories. A future more fulsome assessment of climate impacts would require a deeper review of populations and vulnerable groups in Ontario.

What can we do about it?

An entirely separate and distinct report has been developed considering adaptation options for people and communities across Ontario. The province has the solutions and knowledge to act to lessen and avoid many of the climate risks Ontario's people and communities are facing. A high-level summary is provided below, with more specific adaptation options available in a separate document (PCCIA Adaptation Best Practices Report).

Projects or Programs

- 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 in appropriate forms.

Research and Development

- Encourage the use of novel technology to increase capacity to respond to climate-related health crises (e.g emergency response planning scenarios).
- Mobilize existing research and work to fill remaining knowledge gaps on climate changes impacts to people and communities in Ontario.

Investment and Incentives

- Invest in early warning systems for climate hazard events.
- Invest in the establishment and enhancement of extreme heat impact reduction strategies.
- Invest in Indigenous-led adaptation initiatives.
- Build safety nets to protect vulnerable populations and retain community function.

Policy and Regulation

- Develop policies and tools to support respectful and meaningful incorporation of Indigenous knowledge systems into adaptation planning and decision-making.
- 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.

Navigate back to the Launch Page

Business and Economy

What are the key findings for Business and Economy?

Climate change is fueling more extreme weather, impacting local economies, driving up costs, and challenging economic growth. These impacts and the associated economic shocks will not be uniform across Ontario. The PCCIA finds that most Ontario businesses will face increased risks due to climate change, with the largest increases expected for businesses dependent on natural production systems and where historical infrastructure deficits exist (e.g. fishing, hunting and trapping industries, forestry and logging).

Why are Ontario businesses and the economy important?

Climate change impacts are fueling more extreme weather, impacting local economies, driving up costs and challenging economic growth. Economic shocks that stem from climate change and the ability to recover from these impacts will not be uniform across Ontario. Businesses and communities that subscribe to a resilient and low carbon future will be best positioned to deal with climate change and thrive in face of the impacts. A resilient Ontario economy has a competitive advantage and can support businesses at all scales and across industries in the face of an uncertain and extreme future.

A resilient Ontario economy has a competitive advantage.

The economic contribution of Ontario businesses is significant - contributing almost 39% of Canada's overall gross domestic product in 2021[lxi]. The economic conditions and the businesses that are foundational to this success are undergoing a period of rapid change. Increasing globalisation, urbanisation, and technological transformation are all challenging the status quo and redefining what it means for Ontario businesses to be competitive. Climate change, both the pace at which greenhouse gas emissions are mitigated and the ability to adapt and foster resilient businesses is a crucial factor now and in the coming decades.

Defining Business and Economy for assessment

To assess current and future climate change risks, Ontario's 'business and economy' has been divided into a series of 11 industries (Level 1 categories). Some of these industries are further delineated to include sub-industries, which are described in the assessment results.

Business and Economy Level 1 Categories

Accommodation and Food Services

Arts, Entertainment and Recreation

Construction

Finance and Insurance

Forestry, Fishing and Hunting Economies

Information and Cultural Industries

Manufacturing

Mining, Quarrying, Oil and Gas

Retail Trade

Transportation Economy

Utility Services

How were the impacts to Business and Economy assessed?

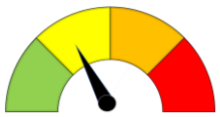
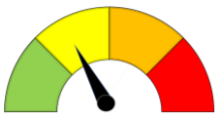
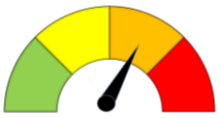
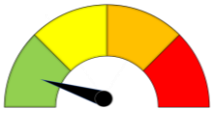
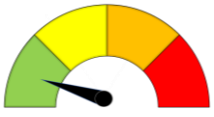
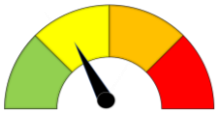
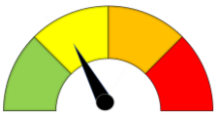
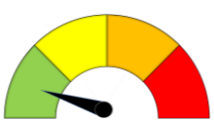
Climate impacts to the Business and Economy Area of Focus were assessed for each industry at the scale of an individual (archetype) firm operating within the province and using an individual firm risk score as a proxy for industry risk. In other words, climate risks characterized within the Business and Economy Area of Focus are unique. In many cases, climate impacts and risks in other Areas of Focus (e.g. Infrastructure) may lead to cascading or indirect risks to businesses. Climate risk was scored numerically and characterized qualitatively based on possible business financial loss and service disruptions.

Climate risks are already impacting Ontario firms of all sizes, but smaller sized businesses are more at risk in an increasingly extreme climate future.

If you only take one thing away:

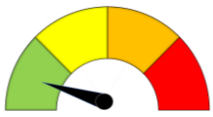
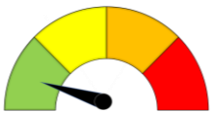
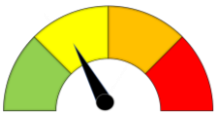
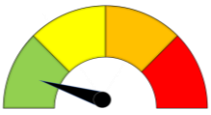
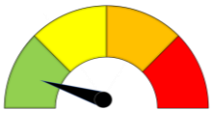
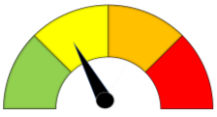
Most Ontario businesses will face increased risks due to climate change, but the largest increases in risk are expected for businesses dependent on natural resources and those that have existing infrastructure deficits. Local economies and businesses that subscribe to resilience as well as the transition to a low carbon future will have increased growth, prosperity and thrive in the context of climate change.

What are the risks?[5]

Level 1 Category	Now	2050s	2080s
Accommodation and Food Services	 Medium Risk	 Medium Risk	 Medium Risk
Arts, Entertainment and Recreation	 High Risk	 High Risk	 High Risk
Construction	 Low Risk	 Low Risk	 Medium Risk
Finance and Insurance	 Medium Risk	 High Risk	 High Risk
Forestry, Fishing and Hunting Economies	 High Risk	 High Risk	 High Risk
Information and Cultural Services	 Low Risk	 Medium Risk	 Medium Risk

[5] Risk profiles reflect the highest regional risk score operating under RCP8.5.

How are the risks changing?[6]

Level 1 Category	Now	2050s	2080s
Manufacturing	 Low Risk	 Low Risk	 Medium Risk
Mining, Quarrying, Oil and Gas Extraction	 Medium Risk	 Medium Risk	 Medium Risk
Retail Trade	 Low Risk	 Low Risk	 Medium Risk
Transportation Economy	 Medium Risk	 Medium Risk	 High Risk
Utility Services	 Medium Risk	 High Risk	 High Risk

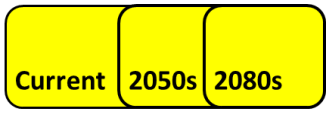
[6] Risk profiles reflect the highest regional risk score operating under RCP8.5 (high emissions sceanrio).

What are the risks?

Accommodation and Food Services

When it comes to the accommodation and food services industry, businesses are on the front lines of experiencing climate impacts and other non-climatic economic shocks or stresses. For example, over 85% of food services and drinking places experienced decreases in revenue during the COVID-19 pandemic in 2020, with declines of 40% of revenue and significant employment layoffs observed in Ontario[lxii,lxiii]. Accommodation and food businesses are also heavily tied to tourism in the province. Ongoing skilled labour shortages are a key challenge of this industry, with many employees not returning to the same work since the beginning of the pandemic. The smaller sizes of businesses active in this industry, and the ongoing lack of skilled labour, can compound impacts from climate change and associated extreme weather events.

Businesses involved in providing accommodation and food services can be impacted in many ways, such as by extreme heat, drought events, extreme precipitation, wildfires, and rising temperatures. Loss and damage to business infrastructure or decreased serviceable life to materials can lead to financial losses. Climate impacts will drive lower service productivity and impact the health and safety of staff and customers. Impacts to supply chains can result in reduced availability of commodities thus driving financial losses. Interruption or failure of external power supply results in financial effects for both food service and accommodation industries. The duration of power interruption is dependent on the presence of on-site back-up power generation capacity.



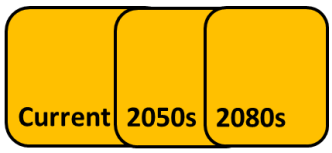
Risks to accommodation and food services industry are considered ‘medium’, and not expected to increase or decrease significantly over time. However, cascading risk due to loss of commodities (e.g. food) or physical loss of infrastructure (e.g. inability to access/occupy or use infrastructure) were not quantitatively evaluated as part of this risk rating. These results are for a typical business within Ontario, which does not lose total access to the building in which services are provided nor total ability to provide their services.

Arts, Entertainment and Recreation

The arts, entertainment, and recreation sectors are a smaller industry in Ontario, but a prominent and culturally important one that is expected to grow in the future. Businesses in this industry tend to hire more part time or seasonal workers, and their services are relatively unique. As an example, several types of businesses are highly seasonal, such as amusement parks and golf clubs during the summer months, and ski resorts in the winter months. Tourism from within Canada and the United States plays a significant role to this industry's success. This is also an industry that has strong regional differences across Ontario, with Southwest Ontario (e.g. Niagara) and Central Ontario (e.g. Toronto) attracting a significant number of tourists due to cultural and heritage institutions, sporting events and casinos. Eastern Ontario (e.g. Ottawa) attracts international visitors and tourists related to seeing Canada's capital and the parliament buildings. Northern Ontario tends to attract significant visitors for resource-based attractions such as boating, fishing, hunting, and camping.

Climate impacts on arts, entertainment and recreational services may be particularly pronounced in certain Regions of Ontario.

Ontario is home to the largest volume of sport and recreation facilities in Canada and impacts such as flooding could result in damage to the interiors of several community sport and recreation facilities, impacting the delivery of, and access to, sport and recreation services. Impacts are also expected from seasonal changes, such as shortening of winter outdoor recreation (e.g. skiing, snowmobiling, ice fishing) or lengthening of summer outdoor recreation and culture (e.g. golfing, hiking, boating, festivals). Disruption to indoor organized sport and recreation resulting from climate-related events (e.g. flooding) can also reduce annual revenue for sport and recreation entities and organizations as they would no longer be functioning at normal levels. These impacts may be particularly pronounced in certain Regions of Ontario, or even occur in a different Region but lead to indirect impacts on arts, entertainment, and recreational services across the province.

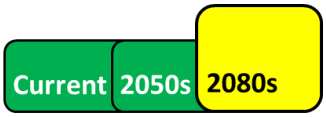


Risks to the arts, entertainment and recreation industry are expected to remain at 'high' through mid-century (2050s) and end of the century (2080s). Regionally, a slight difference was determined for Central Ontario, where risks are already 'high' due to the increased density of arts, entertainment and recreational services.

Construction

The construction industry in Ontario is pivotal to the economy and is at the crux of building and constructing resilient infrastructure in the face of a changing climate. Ontario's construction industry comprises any business primarily engaged in constructing, repairing, or renovating buildings, including engineering works and land development. There is significant need for additional and upgraded infrastructure across Ontario which will drive growth in this sector. Employment in Ontario's construction industry is expected to rise by almost 24,000 workers compared to 2020[lxiv]. However, an aging labour force poses significant challenges over the next decade with Ontario expected to see more than 92,500 workers retire, or about 21% of the current labour force[lxv]. Rising costs of raw materials, labour shortages, and schedule and price increases brought on by the widespread disruption to global supply chains continue to pose challenges for construction.

Ontario's construction industry is confronted with many impacts stemming from climate change. Resilient construction practices are combined with the dire need to reduce greenhouse gas emissions, both in building materials and as part of the construction process. This has put pressure on the industry to adopt low carbon resilience principles. At the same time, the construction industry is exposed to climate hazards leading to physical impacts such as extreme weather impacting construction sites, water shortages, and deteriorating environmental conditions with increasing temperatures. Construction activities can also be impacted by changes in extreme heat, extreme precipitation, drought, and wildfire. In all cases, loss and damage, changes or reduction in key industrial outputs and costs of materials and health and safety of staff are concerns. Climate-related impacts to one or more chain components could result in reduced availability of construction materials and moderate short-term financial losses for construction and engineering companies.

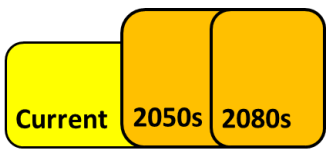


The risk profile for the construction industry across Ontario is currently considered 'low' but expected to increase to 'medium' by the end of the century.

Finance and Insurance

Ontario's financial services industry generates $63 billion for the provincial economy and employs 365,000 people[lxvi]. Concentrated in the City of Toronto, North America's second largest financial services hub, financial services are provided by 12,000 financial services firms. Canada's four largest banks, three of the top five largest Canadian insurers, two of the top 20 global pension funds, eight of the 10 largest Canadian asset managers, and the Toronto Stock Exchange are all located within Toronto. From an insurance perspective, property and casualty insurance is particularly relevant considering their exposure to physical climate risks[lxvii]. Over 192 private property and casualty insurers compete across Canada and the Insurance Bureau of Canada identify that insurance claims have risen over the last decade, as a percentage of total claims (from 28% in 2010 to 34% in 2020)[lxviii].

The impacts associated with climate change are particularly complex in the finance and insurance industry, in part because companies consider, model and price in risk in their products. The extent to which current physical climate risks have been factored into financial products, markets, and financial portfolios varies but future impacts will continue to pose disruptions to the continuity of their operations. Extreme precipitation resulting in flooding and cascading impacts to the supply chain could subsequently impact a company's cash flow. The requirement for disclosure of this information will continue to increase and force transparency of climate-related risks. Insurance carrier activities could be impacted by changes in climate conditions that directly affect financial counterparties (insurance policy holders) which again could lead to financial impacts. Studies have also shown that extreme temperatures can adversely affect corporate earnings and that extreme weather can be reflected in stock and option market prices. It is very plausible that in the future, increasing frequency and continued exposure of the finance and insurance industry results in year-over-year losses that continue to mount, resulting in a loss of confidence, devaluation, or other financial implications. If these conditions persist insurance companies may remove certain types of coverage (e.g. flood insurance) or be forced to pull out of certain Regions because it is too high-risk. These responses have a compound effect on homeowners/liquidity and the overall housing market.



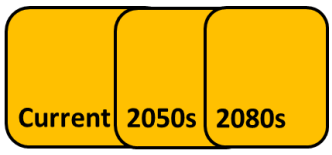
Risks were evaluated for two sub-industries: 1) Insurance and 2) Monetary, Credit, Securities, Funds and Other Financial Vehicles. In both cases, risks were determined to be 'medium' under current conditions and expected to rise to 'high' by mid- and end of the century.

Forestry, Fishing and Hunting Economies

Forestry, fishing, and hunting economies play a key role in tourism across Ontario, most notably in northern regions. Resource-based tourism relies upon crown lands, waters, and natural resources to attract domestic and international visitors to enjoy activities such as hunting, fishing, camping, hiking, visiting nature reserves and parks, and viewing wildlife. Due to restrictions and loss of revenue since the COVID-19 pandemic, these industries face a longer road to recovery. Investments in climate resilience (e.g. natural and green infrastructure), will support pandemic recovery through climate resilience lens. Forestry and logging companies play a significant role in Ontario's exports with over 12,000 businesses in 2021 engaged in managing and harvesting timber on a long production cycle[lxix].

Ontario's forestry, fishing and hunting economies have significant exposure to climate-related risks.

Ontario's forestry, fishing and hunting economies have significant exposure to climate hazards, and the impacts from climate change on these economies will be wide-ranging. In many cases, these economies produce goods upstream of other businesses that subsequently manufacture products for consumer use or consumption. Changes in climate regime can impact forestry and logging companies due to changes in the abundance and distribution of coniferous and deciduous tree species, resulting in decrease in volume or quality of potential supply of timber products. Climate change can also impact forestry road systems that underpin the ability for companies to harvest, transport, plant, maintain and manage forests across Ontario. For example, extreme precipitation can lead to flooding and washout of forest roads and the inability to access certain forest management units. Impacts could also result in stoppage of logging operations, and potential loss of merchantable timber. Likewise, changes in climate regime may lead to changes in terrestrial and aquatic species distribution and timing of biological events (spawning, larval life cycles, zooplankton availability) that impact commercial fishing, hunting, and trapping companies (such as disease proliferation).



Risks were evaluated for two sub-industries:

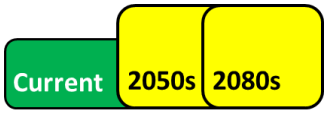
1. **Forestry and logging**
2. **Hunting, fishing, and trapping.**

In both cases, risks were determined to be 'high' under current conditions and remain 'high' in the future. This reflects the high exposure of businesses reliant upon natural resources in this industry and the potential impacts on finances.

Information and Cultural Services

Information and cultural industries comprise businesses that produce or distribute information and cultural products, the value of which is contained in their information, educational, entertainment, and cultural content. Over 48,000 businesses across Canada are part of this industry, where Ontario has the largest cultural industries sector in the country, accounting for almost half of all cultural industries nationally[lxx]. The province is also among North America's top entertainment and media economies, ranking third in employment (behind only California and New York). This is an industry where the majority of businesses are small enterprises, many of which lack capital to grow.

Climate change can impact businesses in this industry in several ways. Hazards such as changes in extreme temperatures, extreme precipitation, and wildfire can lead to financial losses to businesses by loss and damage or decreased serviceable life to assets used by within the industry, particularly if those are unique (e.g. movie film sets) with few alternatives. Climate impacts that lead to any interruption or failure of external power supply could result in financial effects. Increasingly variable consumer demand for indoor and outdoor activities, cultural services and entertainment could also reduce revenues. For example, a music venue and performance companies affiliated with performances may lose revenue in the event of shutdowns due to extreme weather or need for infrastructure repair.

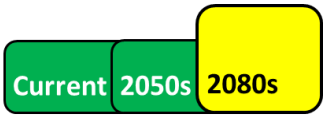


In many cases, businesses within this sector rely upon infrastructure, buildings, venues, studios, and numerous other assets to continue operation. For example, an extreme precipitation event could lead to flooding and put in peril important main floor or basement contents. The climate risks are currently considered to be 'low'. In the future, it is expected that climate risks will increase to 'medium' across all Regions of the province. This increasing risk profile reflects extreme weather events and/or impacts on businesses within this sector where financial losses or service disruption may become more frequent due to climate change.

Manufacturing

The manufacturing industry in Ontario includes businesses involved in the physical or chemical transformation of materials or substances into products. Major manufacturing industries in the province include motor vehicles and parts, food and beverages, machinery, plastics and rubber, petroleum and coal refining, electronics, and paper products. This is an industry with significant history across Ontario, and one that faces intense global competition, decreasing investment and relatively stagnant growth. For example, in the last decades of the 20th century, many textiles and clothing manufacturing businesses moved operations offshore or to locations with cheaper labour or less stringent regulation. Businesses in this industry play an important role in that they foster economic growth and employment in smaller to mid-sized communities, though that growth has historically been uneven across Ontario[lxxi].

The manufacturing industry is organized around a complex system of interdependent supply chains, which facilitate input materials (e.g. commodities such as crops) and products that are manufactured (e.g. food products). Climate hazards are already posing risks to global supply chains which are likely to worsen. The more specialized the supply chain, the more severe the consequences for a downstream organization (e.g. if only one source supplies a critical input and has been disrupted). Climate impacts on supply chains that have become highly commoditized may affect a larger number of downstream organizations. Impacts could limit key inputs such as water, timber, or energy, which could negatively impact production. The industry may face additional challenges due to disruptions in supply chains or impacts to supporting infrastructure and services such as energy or communications. This, in turn, can lead to disruption in services or downtime and financial losses for manufacturing companies.

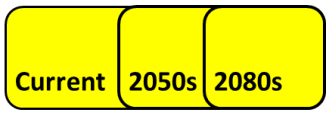


Climate risk was determined to be currently 'low' but expected to rise by end of the century. These risk scores reflect strategic risks to continued operation, rather than the tactical capacity of manufacturing to absorb climate impacts or adopt new technologies. Manufacturing processes tend to be more energy, and waste intensive than other industries and thus risk scores should be considered a baseline of what businesses may face particularly in light of mounting financial costs.

Mining, Quarrying, Oil and Gas Extraction

Ontario is one of Canada's largest mineral producers, generating $11.1 billion worth of minerals in 2021 and representing 20% of Canada's total mineral production value[lxxii]. This industry relies upon international market pricing for commodities such as oil, copper, nickel, and gold, all of which are important to employment in Ontario. Oil and gas extraction is a relatively small subsector in Ontario and thus a decline in oil prices and investment has had less employment impact in the overall industry. Regionally, Northeast Ontario employs the greatest numbers of workers in this sector accounting for almost 50% of employment.

Similar to other industries, businesses need to reduce the carbon intensity and emissions associated with activities to mitigate climate change, as well as reduce the impacts and risks to businesses and their operations. Activities by businesses in this industry typically result in changed landscapes which tend to require lasting remediation with long-term management, containment, and treatment to avoid health and environmental impacts adjacent to sites or downstream. Many climate variables could drive impacts for these businesses. A wildfire could halt operations and result in direct health and safety impact to company staff, disruption electricity supply and transportation or supply chain networks. Extreme precipitation or changes in groundwater flow regimes could lead to increased contaminant transport (e.g. acid mine drainage) stemming from increased runoff of untreated water into adjacent watercourses. For oil and gas infrastructure specifically, extreme precipitation could lead to soil saturation, movement or undermining of pipes and buried assets, and increased maintenance requirements to ensure safety.

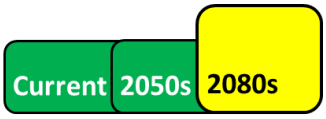


Climate risk was determined to be currently 'medium' and not expected to increase or decrease significantly in future time periods. These results reflect potential financial losses associated with fines due to time-limited impacts on operations or fines levied for discharges exceeding regulatory limits.

Retail Trade

Businesses involved in retail trade include store and non-store retailers. Store retailers operate fixed point-of-sale locations designed to accommodate walk-in customers. Non-store retailers serve the public but use different methods such as infomercials, direct-response advertising, electronic catalogues, door-to-door sales and distribution by vending machines. Retail Trade can include various types of stores, such as motor vehicle dealers, furniture stores, electronics and appliance stores, food and beverage stores, gas stations, clothing stores, sporting goods, bookstores, among many others. Regionally, in Central Ontario, retail and wholesale trade remain significant components of Toronto's economy with the sector employing over 400,000 people[lxxiii]. All regions, except Northeast Ontario, saw positive employment growth in 2021 and moderate to strong rebound from the pandemic in Windsor-Sarnia and Kingston-Pembroke, with Northwest Ontario seeing a milder rebound.

Climate change poses a variety of risks to retailers across Ontario including direct physical risks, transition risks and systemic risks across the industry. The increasing frequency and intensity of acute events such as flooding and wildfires can destroy retail assets, disrupt supply chains and distribution channels, creating uncertainty in product availability, prices of raw materials, and increased insurance costs. Risks facing retailers are worsened when suppliers are in countries that experience similar or more severe climate change impacts. Climate impacts may also lead to interruptions or failure of external power supply resulting in financial losses for retail trade companies, assuming limited back up power supply.



Climate risks for a typical Ontario retail company were evaluated based on a most probable worst-case event. Risks were considered to be 'low' at current but rising to 'medium' by end of the century. These scores reflect time-limited or low to moderate financial losses within a single business year.

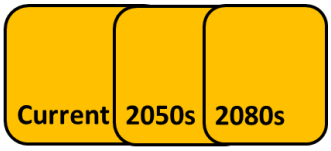
Transportation Economy

The transportation economy broadly refers to the movement of people and products both within and across Ontario, as well as external to the province to international markets. The Transportation Economy can refer to movement by trucking on roads (both long distance and local freight), on rail corridors, through air transportation, or by water. The transportation economy not only underpins numerous other sectors, but the infrastructure it relies upon is also in deficit and in need of capital investment. Infrastructure ownership varies depending on the type of transport. In general, roads are owned by governments, railways are privately owned, airports operate under a not-for-profit model, and ports have mixed ownership and operation.

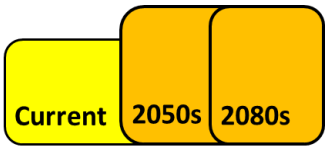
Climate impacts were evaluated across several sub-industries (Level 2 categories):

1. **Air transportation**
2. **Local and long-distance freight trucking and delivery services**
3. **Rail transportation**
4. **Deep sea, coastal and great lakes transportation**

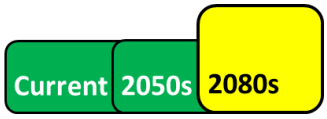
Risks posed to each of these transportation economies vary significantly. Risk profiles are briefly described below:



The highest risks are associated with **deep sea, coastal and great lakes** transportation across every Region of Ontario. Risks for this sector are considered 'high' now and remain 'high' in all future time periods. These scores reflect the potential financial losses of extreme weather and variability of the Great Lakes and reflect the reliance of businesses on highly exposed (and location-specific) assets, that if damaged, could take several years to replace.



Risks to **rail transportation** are considered to be 'medium' under current climate conditions but rising to 'high' by mid-century and remaining 'high' until end of the century. This reflects increasing frequency or impacts associated with extreme heat, namely heat kinks or impacts to rail corridors resulting in disruptions to transportation schedules and reliability.



Climate risks to **local and long-distance freight trucking** and **air transportation** were evaluated to be 'low' under current climate conditions, but rising to 'medium' by end of century. These climate risk profiles for businesses are largely based upon extreme precipitation and the impacts associated with shorter duration extreme events causing flooding or winter conditions that may pose issues of access, delays, or inability of freight to travel to destinations.

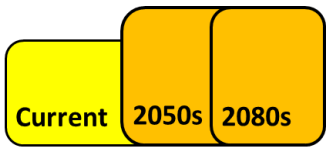
Utility Services

Utility Services comprise establishments that generate, transmit, control and distribute electric power, distribute natural gas and provide related services through infrastructure such as power lines, pipes, and processing facilities. In 2020, Ontario generated 154.7 terawatt-hours of electricity, with just over 92% of this electricity stemming from zero-carbon sources: 56.8% from nuclear, 24.4% from hydroelectricity, 8.7% from wind and 2.4% from solar[lxxiv,lxxv]. Electrical power, once generated, requires transmission and distribution to consumers and for end use. The Ontario electricity grid includes high voltage transmission lines delivering electricity from generators to large customers (e.g. major industry) and to local distribution companies who distribute electricity at lower voltages to homes and businesses. Natural gas is also widely used across Ontario to produce electricity, to heat homes and facilities and for other fuels and purposes. Lastly, the telecommunications industry provides critical transmission of information between sites either wirelessly or based on wired infrastructure.

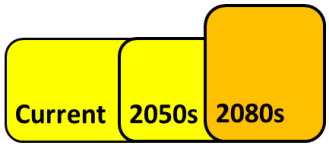
Climate impacts were evaluated across several sub-industries:

1. **Electrical power generation**
2. **Electrical power transmission, control and distribution**
3. **Natural gas distribution**
4. **Telecommunications**

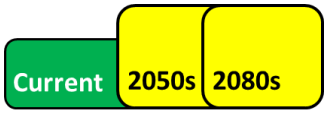
Risks posed to each of these Utility Services vary significantly.



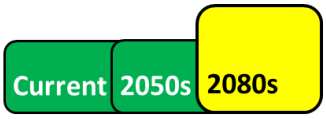
The highest risks are associated with **electrical transmission, control, and distribution** businesses. For this industry, risks were determined to be 'medium' now and rising to 'high' in the future. Climate impacts may damage or lead to other impacts to assets (e.g. poles, wires, switches) and performance, resulting in financial effects.



Similarly, climate risks to **telecommunication** businesses are expected to increase from 'medium' to 'high' by the end of century. Increasing heat events can impact assets (e.g. towers) and their capacity and performance, resulting in financial losses to the companies that own and operate them.



Climate risks to **electrical power generation** businesses, are considered to be currently 'low' but rising to 'medium' in the 2050s. As an example, extreme weather events could lead to shortages in inputs or reduced cooling ability for electrical power generation, depending on different power generation modes (natural gas, nuclear, hydro, solar, wind).



Climate risks to **natural gas distribution**, are considered to be currently 'low' but rising to 'medium' in the 2080s. As an example, extreme weather events could degrade or damage natural gas distribution assets (e.g. pipelines) and their performance.

Why do risks vary between industries?

Not all industries are exposed to the same climate hazards, and in some cases, they have very different infrastructure vulnerabilities that may drive higher risks. Consequences that stem from the occurrence of an impact also differ and are dependent on the presence of that business (operations) within a particular Region of Ontario and many other factors. Consequences considered in this Area of Focus assessment were:

1. Operational or service disruptions such as work slow or stop orders
2. Asset or infrastructure loss and damage
3. Change in availability or quality of inputs, as well as the costs of those inputs for service delivery
4. Legal liability or non-compliance issues
5. Worker and customer safety and well-being
6. Supply chain and distribution network interruptions

What don't we know yet?

The scope of Business and Economy was necessarily constrained to direct impacts and proxy businesses were used for the assessment. In an attempt to distinguish between assets and the business activity, the assessment was constrained to the business function and results relate to economic losses. **Interdependencies** between industries or infrastructure systems lacked province-wide, publicly available information, and specific impact thresholds were too broad and varied to assess financial impacts at the firm level. Climate-induced, business-specific **tipping points**, or the point at which impacts to business operations cannot be overcome, were also challenging to assess across all industries and thus were not part of the assessment.

Where is real estate?

Real estate, rentals and leasing have not been forgotten as part of this climate change assessment. Real estate underpins many industries and their ability to remain economically viable in a changing climate. The assessment included real estate (e.g. buildings and assets themselves) under the industry in which it exists (e.g. retail trade, construction, manufacturing, and others). Real estate investment trusts (REITs) and companies that own or finance income-producing real estate were assessed as part of the finance and insurance industries.

What can we do about it?

An entirely separate and distinct report has been developed considering adaptation options for industries within business and economy. Ontario has the solutions and knowledge to act to lessen and avoid many climate risks that industries face. A high-level summary is provided below but industry-specific adaptation options are available in a separate document (PCCIA Adaptation Best Practices Report).

Projects or Programs

- Develop a suite of decision-support tools for climate change adaptation
- Integrate climate change into financial valuation, natural environment impacts, and business continuity planning.
- Facilitate development of knowledge sharing networks across levels of government, Indigenous organizations and Communities, the private sector and academia.
- Support the use of public-private partnerships to reduce climate risk impacts to businesses.

Research and Development

- 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

- 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

- Provide government support and leadership for climate change adaptation action in the private sector.
- Enhance the use of green technology and natural assets in construction
- Take steps to minimize supply chain disruption at across Ontario.

Navigate back to the Launch Page

Cross-Sectoral Themes

Climate change impacts occur against the backdrop of complex and dynamic social and ecological systems. Most conventional impact assessments consider discrete themes or sectors with some recognition of interconnections. Climate change can cause cascading and compounding effects, depending on the exposure and capacity of systems.

We undertook a systems approach to characterizing cross-sectoral climate impacts across the province, identifying areas where impacts cascade or amplify, to help prioritize resilience needs and target adaptation responses. To do this, five general cross-sectoral themes were analyzed:

1. Food Security
2. Energy Security
3. Water Security
4. Human Health, Safety and Well-being
5. Community Function

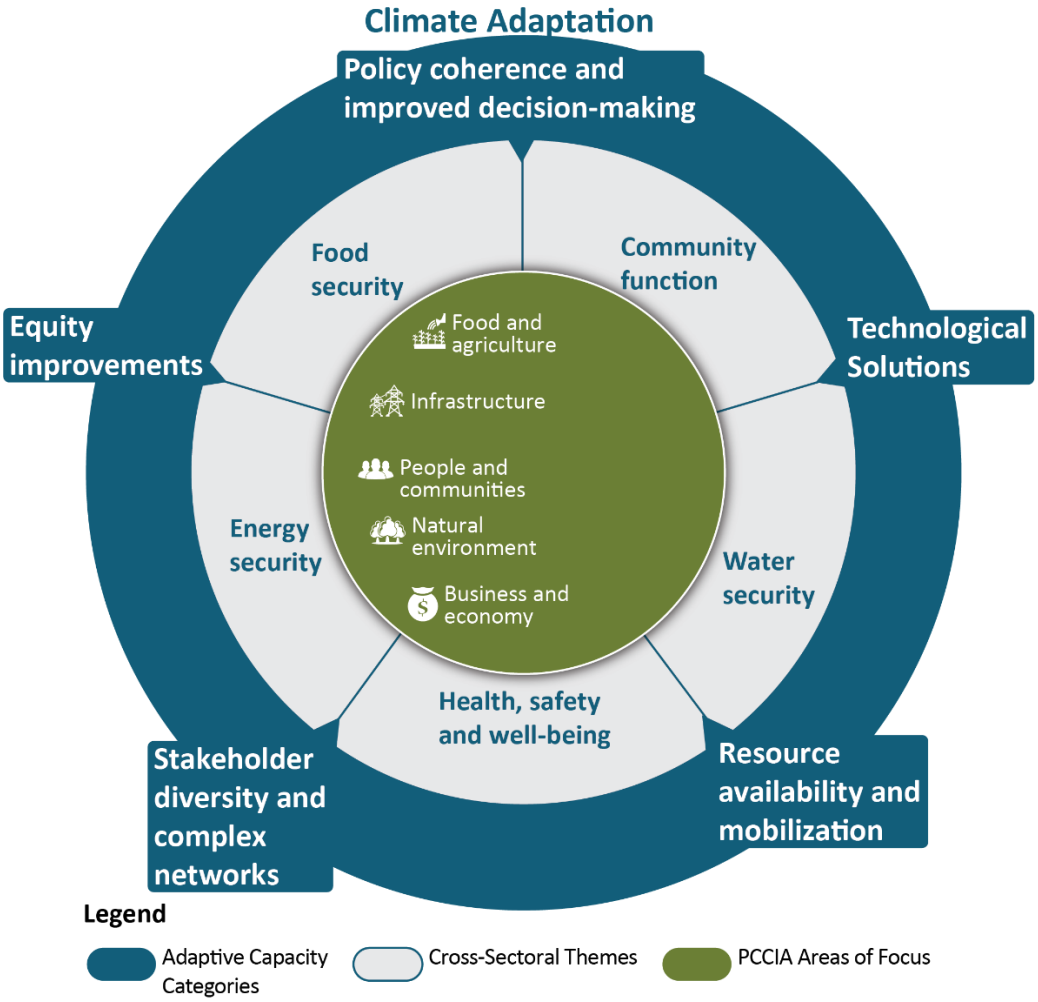


Figure Caption: A conceptual framework outlining the interconnectedness between each Area of Focus and Cross-Sectoral Theme, and the role of capacity building to effectively adapt and reduce climate risk across Ontario

Food Security

What is food security?

Food security is defined as continuous and undisrupted access to sufficient, safe, nutritious, and culturally appropriate food that meets an individual's dietary needs. It is a multi-dimensional concept that can be influenced by various sectors and is affected by impacts that cascade through food systems. Climate change is expected to present several risks to provincial food systems, impacting key dimensions of food security. These include:

Food Availability: Losses in productivity, disruptions in distribution, limitations to harvesting and hunting activities and food exchange challenges are all expected under a changing climate.

Food Accessibility: Food affordability could be challenged in Ontario, as prices of food increases. In addition there could be risks associated with food allocation and access to culturally preferred foods.

Food Utilization: Declining nutritional value and/or social value is expected, along with increased risks to food safety.

Food Stability: Overall disruptions to access and availability of food for Ontarians.

Climate change is expected to pose risks to provincial food systems, impacting key dimensions of food security.

What is Ontario's food system?

Food systems underpin food security, and are comprised of activities that span across several sectors and industries in Ontario. The components of Ontario's food system include:

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 – involves the transformation of raw food inputs into retailed food products (e.g. washing, sanitizing and packaging).

Food distribution – involves the transportation of food products to users (e.g. grocery stores, restaurants etc.).

Food preparation and consumption – includes the preparation and consumption of food by the consumer.

How is climate change impacting food security?

Food Production	Food Processing	Food Distribution	Food Preparation and Consumption
Crop failure and yield losses on-farm. Livestock production losses and feed shortages. Soil health degradation causes lower yields and declining productivity. Limitations to water access impact irrigation and field applications. Increased prevalence of pests and disease, and declining pollinator species. Changes in species distribution and abundance impact food availability in communities that rely on subsistence hunting and harvesting activities.	Risk of prolonged power outages in food storage and processing facilities, results in wide-reaching consequences. Disruptions to water management infrastructure and limitations to water access. Disruptions and delays to the transportation of food inputs to processors and manufacturers.	Impacts to utility and transportation infrastructure result in implications for food distribution to markets, retailers, and consumers. Supply chain disruptions causes shortages of food products and influence food affordability. Disruption to public transportation and infrastructure can impact food accessibility for retailers and consumers.	Increased occurrence and persistence of bacteria, viruses, parasites, and their vectors increase risks from food-borne illnesses. Climate-related impacts could result in declining nutritional content of some agricultural crops. Reduced access to a range and diversity of foods options in Ontario throughout the year from declining imports.

What is an equity-based approach to improve food security?

Climate-related impacts on food security vary across Ontario and stand to contribute to existing vulnerability and inequities. A variety of social, cultural, and economic determinants can be used to identify pre-existing vulnerability to food insecurity in Ontario. Low-income households and neighbourhoods, remote regions, and Indigenous Communities have been identified as being at a disproportionate risk of food insecurity in Ontario.

The impacts of climate change are expected to influence food affordability, amplifying risks for low-income households. Neighbourhoods categorized as 'food deserts' are particularly vulnerable, as these regions face pre-existing challenges with accessing quality and affordable food products. Remote regions of the province have fewer food purchasing choices, limited transportation options, lower capacity to store food products locally, and generally experience higher retail food prices.

Many Indigenous Communities rely on the land and water for sustenance and food security. The traditional and cultural aspects of hunting and gathering foods are important for building a sense of community and maintaining cultural identity. Under a changing climate, these food sources are being threatened as the distribution and abundance of species changes. Ecological changes compound risks to food security, resulting in declining diet quality and nutrient access and accompanying impacts to mental health, cultural well-being, and community cohesion.

Building cross-sectoral resilience is key for addressing climate-related risks to food security.

Coordinated adaptation efforts that enhance climate resilience for priority populations, and consider the linkages between interconnected sectors, will help to address food insecurity across the province. Ontario plays an important role in supporting food security within and outside its borders now and in the future. Investments from all levels of government and advancements in research on how climate change may impact food security merits closer consideration for identifying suitable and effective intervention measures.

If you only take one thing away

Climate change poses risks to food systems across Ontario, with important implications for food security. Building cross-sectoral resilience is key for addressing climate impacts on food security. Coordinated adaptation efforts that enhance climate resilience and consider the linkages between interconnected sectors, such as food and agriculture, natural environment, water management, energy supply and transportation, will help to address food insecurity challenges across the province.

Navigate back to the Launch Page

Energy Security

What is energy security?

Energy security is defined as the uninterrupted availability of energy sources at an affordable price. Energy security involves long-term considerations of timely investments to supply energy in line with economy development and environmental needs, as well as short-term considerations ensuring the energy system can react promptly to sudden changes in the supply-demand balance.

Energy security means that everyone has access to the amount of energy they need when they need it.

Three 'dimensions' of energy security were assessed using a climate change lens:

Energy access – There may be a lack of access to adequate or sufficient energy sources across Ontario, or a lack of energy infrastructure to support alternative choices in more rural or remote communities.

Energy affordability – Energy pricing, and the ability for Ontarians to afford energy in any context in which they may require it, including areas that could be considered to be fuel or energy 'poor' relative to other areas across the province.

Energy demand and consumption – Consumer behavioural patterns, how and where energy is consumed, changes in energy demand and potential over-consumption of energy.

What is Ontario's energy system?

Energy systems underpin energy security, and they do not fit within any one particular industry or sector of the economy.

Energy sources and supply – energy resources that comprise Ontario's current energy mix, such as nuclear, hydroelectricity, wind, solar, natural gas, biomass, and refined petroleum products, as well as potential future energy supply options such as hydrogen.

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 powerlines, transmission lines, pipelines, freight, and other forms of energy transport.

Energy consumption – the supporting infrastructure to bring energy products to market and the ultimate use of energy in any technology, service, manufacturing, transportation, or any other form relying on energy such as inhabiting a building.

How is climate change impacting energy security?

Energy Sources and Supply	Energy Generation	Energy Transmission and Distribution	Energy Consumption
Shifting water resources, reducing ability to generate electricity or for cooling. Changing energy sources – such as biomass availability. Lesser ability to generate sufficient electricity during peak demand.	Increasing air and water temperatures can lead to less thermal capacity for power generation and decreased efficiency of turbines. Rising operational costs and cascading increases in energy prices to afford necessary investments.	Increase system demand or damage distribution infrastructure (e.g. due to falling trees, washouts, etc.) Worsening system reliability and higher risk of power outages due resulting in wide-reaching consequences.	Increase peak demand for cooling and heating. Added system pressure due to new technologies, electric vehicles, etc. Rising costs of energy and fuel poverty for disproportionately impacted communities.

What is an equitable transition for Ontario's energy system?

An equitable energy transition involves actions at every level of government that acknowledge and incorporate the fact that climate change has different impacts on priority populations and adjusting energy systems accordingly. Many uncertainties remain regarding the speed at which low carbon technology is adopted and deployed in the market. However, it is known that demand, particularly for electricity, is expected to increase in Ontario[lxxvi]. Expansion and the development of a low carbon resilient energy system has major implications for affordability. An equitable transition towards a low carbon energy system requires acknowledging and managing improved reliability, access, and affordability particularly in rural or remote communities, Indigenous Communities, and for Ontarians with lower incomes. Clearly, as Ontario's energy systems are expanded, electrified, and upgraded, this will take resources and increased investments. It is critical that these additional costs do not further disproportionately impact these more vulnerable populations or those that work in energy-related employment.

An equitable transition towards a low carbon energy system requires acknowledging and managing improved reliability, access, and affordability.

If you only take one thing away

Climate change risks to Ontario's energy systems are expected to continue and become increasingly impactful to energy system reliability, capacity, and pricing. In making investments in technologies such as energy storage, smart grid technologies, electric vehicles, and distributed energy resources, increased system flexibility can enable energy systems to become more resilient to climate impacts and minimize service disruptions. Other opportunities also exist that can increase resilience across energy systems and reduce vulnerability among consumers during climate impacts – such as enhancing energy efficiency, upgrading, and burying infrastructure to be more climate resilient, and implementing measures to support recovery.

Significant investments are needed to meet emissions reduction targets and to ensure a resilient, equitable and affordable energy system for Ontarians.

Navigate back to the Launch Page

Water Security

What is water security?

Direct and indirect impacts of climate change on water resources pose risks to water use and ultimately compromise water security for human health, livelihoods, and economic development in Ontario. 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. Key elements of water security were assessed using a climate lens and include:

Water availability – a safe and reliable freshwater supply important for maintaining human, plant and animal populations and supporting economic development.

Water access – the ability of community members to obtain water that factors in elements like available water quantity, distance to a water source and time required to reach it.

Water quality – chemical, physical and biological characteristics of water based on the standards of its usage.

Direct and indirect impacts of climate change on water resources pose risks to water use and ultimately compromise water security.

What is Ontario's water system?

Water security is linked to and depends on the proper functioning of diverse elements of the water system. These elements include:

Water sources – surface aquifers and groundwater that provide water to public drinking water supplies as well as private wells.

Water transmission – transport of treated water from storage facilities to distribution networks and sewer/storm water from the location of end-use to a water treatment facility, taking place through water transmission pipelines.

Water treatment – any process that involves physical, chemical, physicochemical and 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 consumption – using withdrawn water for a variety of household, agricultural and industrial purposes/activities without returning it to the source.

How is climate change impacting water security?

Water Sources	Water Transmission	Water Treatment
Disrupted water flow, reduced surface and ground water levels, losses of fish and animal species and limited freshwater supplies for human use, agricultural production and more. Greater peak flow risks, increased erosion and washing of contaminants into water bodies, degrading the quality of surface and ground water.	Damaged or destroyed water transmission infrastructure, disrupted service, drinking water contamination and sewage backups. Reduced ability of infrastructure to provide adequate levels of service during severe weather events.	Extreme precipitation and flooding affect wastewater treatment plants, resulting in damage to tanks and subsurface discharge. Contamination of drinking water sources during flooding presents challenges to water treatment and risks to human health. Disruptions in wastewater treatment process, resulting in unpredictable effluent concentrations and impacting the receiving water body.

Water Storage	Water Distribution	Water Consumption
Loss of reservoir storage and physical damage to dams and pump stations leading to downtime or reduced capacity in the system. Increased loads to pumping infrastructure, electrical failure in pumping stations resulting in flooding, risks to human safety, and property damage. Reduced groundwater recharge, lack of water in water-storage tanks and reservoirs to support agriculture, communities and businesses.	Storms and flooding can damage infrastructure and result in functional disruptions of underground water transmission and distribution systems. Release of noxious substances into municipal drinking water supplies, threatening human health and compromising basic needs. Reductions in water supply due to drought, resulting in allocation challenges, distribution disruptions and increasing water costs.	Declining water quality from excessive run-off and warming water temperatures, affecting drinking water supplies and overall ecosystem health. Compromised basic needs such as sanitation and hygiene as well as increased risks to human health. Increased water demands due to drought and heat, requiring allocation restrictions and causing disruptions to industry operations, impacts to productivity and revenue losses.

What is an equity-based approach to improve water security?

Climate-related risks to water security vary across Ontario and often contribute to existing vulnerability and inequities. Eighteen percent (18%) of Ontario's population live in areas that are not covered by the Clean Water Act[lxxvii] and, therefore, do not have source water protection plans to prevent the contamination of their sources of drinking water. This number includes people living in communities that draw drinking water from domestic wells and over 40 municipal drinking water systems that are not within a source water protection area. Additionally, a limited number of Indigenous Communities are protected by the source water protection system. Those living in large mixed-use watersheds (e.g. the Grand River watershed) are most likely to be impacted by competing interests between communities, agriculture and industry.

Climate change alters water sources and reliable supplies of clean drinking water, amplifying water safety risks and allocation challenges.

Importantly, the Provincial Policy Statement[lxxviii] requires coordination between local municipalities, Conservation Authorities and other sectors in planning, development, conservation, and the management of resources, balancing the interests of rights holders and stakeholders in a single watershed. Investing in upgrades to water transmission infrastructure and construction of water and sewage services in rural, remote and northern communities will help to build resilience throughout water infrastructure. In addition, adopting source water protection best practices[lxxix], undertaking vulnerability assessments of source water systems[lxxx], and extending the protective coverage of the Clean Water Act to include all municipal drinking systems, Indigenous Communities and private wells, will contribute to reducing inequities related to water safety, minimize distribution disruptions and save costs in the long-term.

If you only take one thing away

Climate change is expected to present challenges to Ontario's water systems through impacts on water resources, drinking water, stormwater, and wastewater infrastructure. Importantly, assessing impacts and risks at the water source level, can help to advance resiliency throughout the water system. Opportunities for a shared vision and coordination of climate adaptation actions within the water sector may include a holistic One Water Approach, a management framework that could integrate drinking water, wastewater and stormwater into one entity, accounting for all water resources, at a river basin level, enhancing climate resilience, reducing existing vulnerabilities and strengthening Ontario's water security.

High complexity of the water sector and interconnectedness of its elements stress the need for collaboration, improved decision-making processes and policy coherence.

Navigate back to the Launch Page

Health, Safety and Well-being

What does Health, Safety and Well-being Include?

Public health, safety and well-being is a critical cross-sectoral theme considering the importance of a healthy human population in the face of climate change. 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. 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 will impact many of the primary determinants of health, highlighting how certain populations across Ontario stand to be disproportionately affected by climate change.

Climate change can impact the health, safety, and well-being of Ontarians both directly, through different climate and weather events (e.g. extreme heat), and indirectly through a range of environmental, built, and economic pathways.

Climate impacts can result in health, safety and well-being impacts and outcomes for Ontarians. Climate impacts can be summarized under the following categories and associated health outcomes:

- Disease vectors and pathogens relate to infectious and vector-borne disease health outcomes.
- Water quality and food safety relate to food and water borne disease and illness health outcomes.
- Impacts on cultural heritage and well-being relate to psychosocial illness and mental health outcomes.
- Declining air quality relates to with respiratory morbidity and illness health outcomes.
- Public safety and emergency response relate to injury and mortality outcomes associated with extreme weather events and conditions.
- Extreme temperature exposure relates to morbidity and mortality health outcomes associated with extreme heat and cold.

How is climate change impacting Human Health, Safety and Well-being?

Infectious Diseases	Water Quality and Food Safety	Mental Health and Well-Being
Increased prevalence of infectious diseases, due to an expansion of their vectors and more favourable conditions for transmission (e.g. West Nile and Lyme Disease). Increased prevalence of pathogens and disease outbreaks in wildfire (e.g. deer and moose), cascading to human health and safety risks.	Impacts on water quality and quantity can increase risk of water-borne diseases. Increased occurrence and persistence of bacteria, viruses, parasites, and pathogens across the food system, increasing risk of food-borne illnesses. Harmful algal blooms can have significant human health impacts associated with exposure through drinking water systems and recreational water use.	Impacts on culture and heritage, language, and knowledge transmission. Climate-related disasters can often lead to mental health outcomes. Degradation of cultural identity and community cohesion. 'Climate grief' can affect mental health and well-being, resulting in emotional and behavioural responses, such as worry, grief, anxiety, anger, hopelessness, and fear.

Declining Air Quality	Public Safety and Emergency Response	Extreme Temperature Exposure
Extreme heat events can increase smog and ground-level ozone. Wildfire smoke can cause the exacerbation of asthma and respiratory conditions. Drought conditions can contribute to increased dust.	Increased likelihood of accident, injuries and mortalities during extreme weather and flooding events. Power outages and damage to critical infrastructure, result in a disruption of critical and emergency services.	Increased risk of heat-related illness and mortality. Increased hospitalization rates during extreme heat events, resulting in capacity constraints. Health impacts associated with extreme heat are exacerbated by the urban heat island effect.

What is an equity-based approach to improve Health, Safety and Well-being?

The primary determinants of health and health equity considerations play a crucial role when assessing how climate change will impact the health, safety, and well-being of Ontarians. Determinants of health include conditions and characteristics that influence an individual's health and well-being. Examples of determinants of health include, social and community contexts, education, working and living conditions, access to healthcare services, employment, and economic stability and other identify factors (age, race, gender etc.).

Health inequity considerations tend to overlap with the determinants of poor health, including low socioeconomic status, poor living conditions (e.g. housing), and limited access to healthcare services. These determinants can be drivers of vulnerability to climate-related health, safety, and well-being outcomes, influencing individual and community exposure and sensitivity to climate risks, as well as associated capacity to adapt or cope. These factors and conditions can also present barriers for adaptation, amplifying vulnerability to climate-related impacts on human health, safety, and well-being.

The intersections of health inequities across Ontario are crucial to integrate into adaptation and response planning.

Adaptation can help to address not only climate impacts to health and safety, but also strengthen the determinants of good health across priority populations. It is important the adaptation efforts are inclusive of those who are experiencing climate impacts on health and safety disproportionately. Prioritizing adaptation measures that also integrates human, animal, and environmental health can support equitable resiliency building, providing co-benefits, including benefits for ecosystems, greenhouse gas mitigation and reconciliation. As the understanding of health vulnerability under a changing climate evolves, the intersections of health inequities across Ontario are crucial to integrate into adaptation and response planning.

If you only take one thing away

Changes in climate are and will continue to affect the health, safety, and well-being of Ontarians. In response, health-related adaptation in Ontario requires several players both inside and outside of the health sector (e.g. ecosystem and water resource management, infrastructure, emergency management), as well as coordination across all levels of government, as well as Indigenous organizations and communities. Moving forward, actions to address existing health inequities and vulnerability should be prioritized for interventions to minimize the health, safety, and well-being outcomes that climate change poses to Ontarians and their communities.

Navigate back to the Launch Page

Community Function

What is community function?

From a systems perspective, 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 must 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 – help accessible to an individual 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.

Economic stability – the absence of excessive fluctuations in economy meaning that people have the resources essential to a healthy life.

Access and infrastructure redundancy – available backup alternatives when other components are disrupted (e.g. due to flooding, landslides etc.).

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 and the support of Indigenous-led initiatives.

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. In addition, Land Relationship Visioning from an Indigenous perspective is important to also include, where we live sustainably and in balance with nature.

Climate change can impact community function both directly, through different climate and weather events, and indirectly through a range of environmental, built, and economic pathways.

How is climate change impacting community function?

Social Support and Inclusion	Economic Stability	Access and Infrastructure Redundancy
Property damage and communications system failures, resulting in increased lack of access to support and daily needs. Increased potential for localized and widespread power outages leading to service disruptions. Altered distribution and abundance of species of importance for Indigenous Communities impacts food security, daily activities and use of social spaces.	Asset and infrastructure loss and damage, decrease in asset serviceable lifespan, supply chain disruptions. Changes in consumer demand for seasonal goods and services, health and safety impacts on staff. Changes in availability of key industrial inputs and costs, leading to production delays.	Compromised access to services. Damage to roads, property and infrastructure, power outages and shutdowns of facilities providing essential goods and services. Blocked access for emergency vehicles caused by flooding. Disruption of supply chains for medicines, food etc.

Emergency Response Management	Ecological Stewardship	Land Use Planning and Development
Power outages, damages to critical infrastructure (e.g. emergency transportation routes, stormwater and sewer systems etc.) and disruption of critical services (e.g. healthcare etc.). Extreme weather events affect organized response actions including evacuation measures, search and rescue missions, provision of basic needs and emergency services, and recovery or substitution of critical infrastructure. Weather-related impacts on infrastructure and natural environment amplify risks to personal safety and security, access to daily needs and support systems as well as physical and mental health outcomes.	Degradation of air and water quality, increased range of pathogens, pests and diseases, altered distribution and abundance of species and changes in ecosystem health and services. Compromised environmental sustainability, poor physical and mental health outcomes, limited access to nature and decreased quality of life. Failures of critical infrastructure (e.g. waste management plants) could have significant cascading impacts on surrounding ecosystems and, ultimately, communities that rely on them.	Changing climate and extreme weather events affect the natural environment and various sectors of Ontario's economy, causing impacts on critical infrastructure, agricultural lands and production, ecosystem health and services, recreation, fishing and other economies as well as cultural heritage resources and assets. Coupled with socio-economic changes (e.g. population growth) these impacts result in the need to adjust land use planning and development approaches to minimize risks and achieve cross-sectoral resilience improvements.

What is an equity-based approach to improve community function?

Climate-related impacts vary across Ontario and often contribute to existing vulnerability and inequities within and between communities, with rural, remote, Indigenous and Northern Communities being at the greatest risk of insecurity in the province. Exposure sensitivity to extreme weather conditions is high among people living in community housing, low-income, inner city, and high homelessness areas where impacts to critical infrastructure, air and water quality have a pronounced effect on communities. Inequitable provision and access to community and essential services is expected to increase in extreme weather conditions, with people relying on healthcare and home care supports, unable to access these due to increased demand and service disruptions. Disruptions to transportation and supply chains are expected to have dramatic effects on rural, remote, northern, and Indigenous Communities, who rely on materials and goods from weather-impacted transportation routes to support construction, manufacturing, retail, recreation and accommodation economies.

Without equitable adaptation efforts, communities and individuals that are vulnerable in the current climate, will only be more vulnerable in the future.

Increased networks between different levels of government and community groups coupled with knowledge sharing and better understanding of lived experiences and resource needs of diverse rights holder and stakeholders will improve decision making and ensure better outcomes for people and communities across the province.

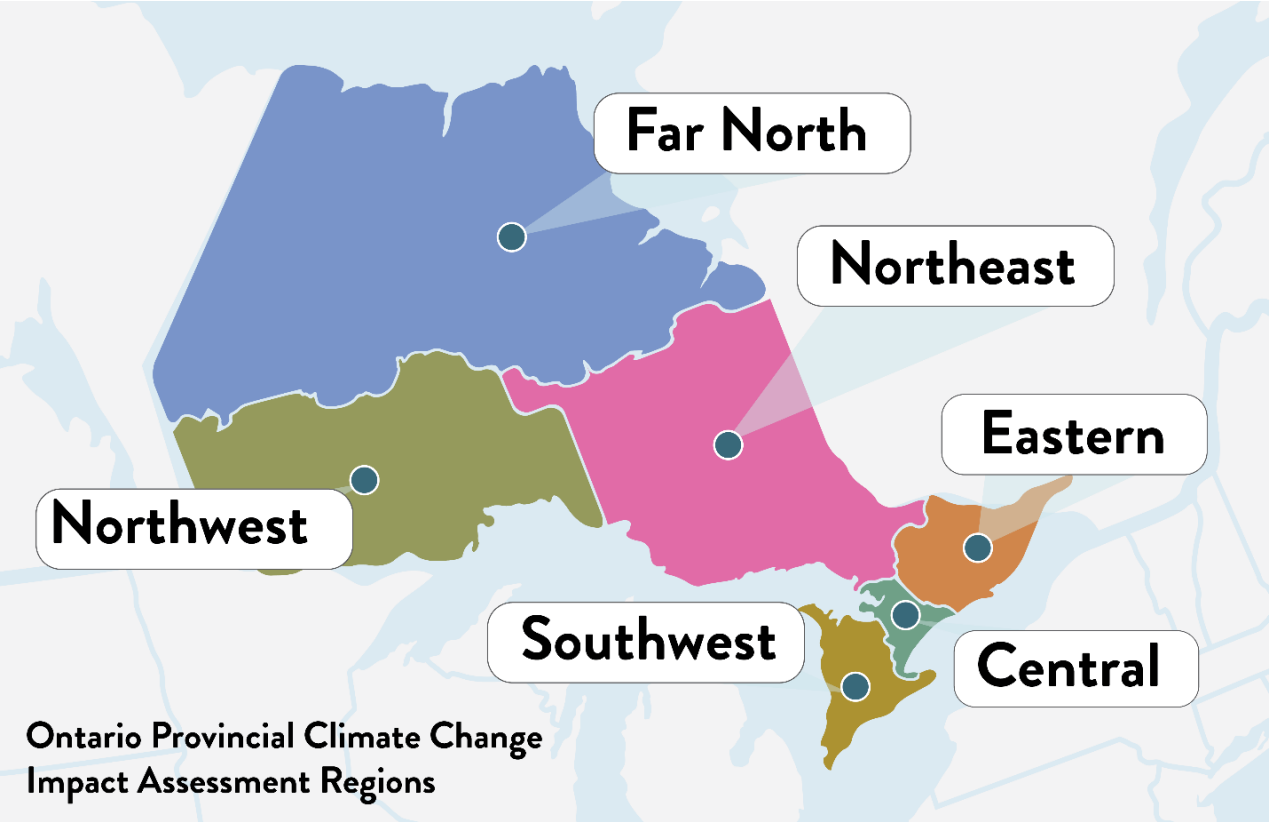
If you only take one thing away

Climate risks will impact the resiliency of Ontario's communities through impacts on various components of the Natural Environment, Business and Economy, Food and Agriculture and Infrastructure. Use of approaches that consider future climate change considerations will provide opportunities for making policy decisions to improve infrastructure redundancy, emergency response management, foster social support and inclusion, economic stability, and ecological stewardship.

A better understanding of risks and impacts, coupled with collaboration and knowledge sharing, will help to achieve resilience of community function while adequately considering equity issues in adaptation planning.

Navigate back to the Launch Page

PCCIA Regional Profiles



Southwest Ontario

The Southwest Region includes all areas between Essex County in the southwest up to Grey and Bruce Counties in the north, to Niagara in the east. Southwest Ontario excludes Hamilton, Halton and Peel Region, but does include Haldimand-Norfolk, Brant and Wellington Counties.

It is the agricultural heartland of Ontario.

Southwest Ontario is one of the richest agricultural regions in all of Canada, with Class 1 – 3 soils, favourable climate and terrain conditions, and supporting infrastructure systems. Niagara grows the vast majority of Ontario's fruit crops, and in recent years, about two million acres of land in Southwest Ontario have grown soybeans, which represent almost 70% of Ontario's harvest[lxxxi].

It provides critical import-export trade routes to the U.S.

Southwest Ontario is the first point of entry for goods movement into and out of areas in northeast U.S. across the Gordie Howe International Bridge in Windsor. It offers critical trade routes and employment contribution in the construction industry. Natural gas transmission and distribution also plays a major role in this Region, largely focused within Sarnia and employing about 12,000 people[xxxii].

It has significant history in manufacturing and local economies still depend on it.

Manufacturing plays a critical role in peoples' livelihoods and identity, and particularly in being a source of economic growth in small to mid-sized communities. Historically, Southwest Ontario has relied on manufacturing jobs in many communities, although growth has been uneven across Ontario, with the southwest growing more slowly than areas further east. Local economies are diversifying with many areas (like Niagara) attracting significant numbers of tourists due to cultural and heritage institutions, sporting events and casinos.

Its ecosystems already face significant threats due to development.

Historic development in the area enhances the impacts of climate change and this trend is expected to continue. Southwest Ontario is rich in biodiversity and contains one-third of the total rare, threatened, and endangered species found in Canada. The consequences of climate impacts are higher in this Region, especially where population density is high and where a greater number of activities exist that involve water taking.

High temperatures in Southwest Ontario are expected to drive the highest risks in the future.

The Southwest Region already experiences some of Ontario's longest growing seasons and hottest weather. It frequently experiences low flow conditions in rivers and streams during late Summer, punctuated by drought conditions in some years.

Top Climate Drivers for the Southwest Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	 Extreme Precipitation Events	 Drought	 High and Extreme Temperatures	 Low Temperature
Mid-century	 High and Extreme Temperatures	 Extreme Precipitation Events	 Drought	 Winter Precipitation

Considering all 'high' and 'very high' risks evaluated as part of this assessment, it is clear that increases in extreme temperature and precipitation events will be the key drivers of climate risks in Southwest Ontario. It is expected that extreme heat related risks will accelerate, and that extreme precipitation will remain a consistent driver of risk in the coming decades.

Drought conditions will persist as a major driver, but the rate of increase in high temperatures and extreme precipitation impacts is expected to make up a larger portion of the highest risks in this Region. Winter precipitation (e.g. Rain to Snow Ratio) is expected to drive more risks in the future, compared to the amount of current risks being driven by low temperature (e.g. Extreme Cold Days).

Central Ontario

For the assessment, Central Ontario is defined as all areas that lie between Georgian Bay and the eastern end of Lake Ontario. The Region includes the Greater Toronto Area, including Hamilton, Halton, Peel, York, Simcoe, Durham, Kitchener-Waterloo, and Toronto. Central Ontario excludes Niagara Region, which is included in Southwest Ontario.

It contains half of Canada's most densely populated metropolitan centres.

The Central Region has by far the highest population density, with approximately 625 people per square kilometre. Most of Ontario's projected population growth will continue to be in urban areas, particularly within the Greater Toronto Area.

Central Ontario is an economic centre for Ontario.

The Central Region contributed 52% of Ontario's GDP 2020[lxxxiii]. Regionally, Central Ontario accounts for the most significant share of employment in Ontario's Finance and Insurance industry, driven by rising population growth and growing technology clusters. Culture and heritage institutions, sporting events, and casinos also play a vital role for tourism in Central Ontario.

It is the fastest growing Region in Ontario.

The population of this Region is expected to grow faster than other provincial Regions. However, it is important to note a significant amount of this growth is occurring in the Greater Toronto Area. To keep up with this growth, the Region is experiencing increased urbanisation of areas traditionally focused on agricultural practices. Halton, Peel and Durham are examples of counties that have undergone redesignation of agricultural land to meet urban development needs. However, agriculture and the agri-food industry remain a core component of the Region's economy.

The Region serves as a transportation hub for the province.

This Region includes the Canadian portion of Lake Ontario which is critical for the provincial shipping industry. There are also several public transportation operators within the Region, providing services across jurisdictions. Metrolinx manages transportation planning including public transport in the Greater Toronto and Hamilton Area, and operates GO Transit, UP Express and PRESTO which connect transportation in the Greater Golden Horseshoe. Highway 401 serves as the primary route for east-west travel within Ontario and serves as critical connection points to intermodal terminals, with some of largest trucking facilities located within the Greater Toronto Area, serving as key hubs for the efficient movement of goods. The Region also operates Toronto Pearson International Airport, the busiest airport in Canada, handling over 47 million passengers per year[lxxxv].

The natural environment provides water resources and ecosystem services for the Region.

The Central Region is in the Mixedwood Plains ecozone and contains Lake Simcoe, an ecologically important body of water, significant for its lucrative recreational fishing industry, fresh drinking water provision, and agricultural irrigation.

High temperatures and extreme precipitation events will continue to drive risks, with drought-related risks increasing in Central Ontario by mid-century.

Central Ontario has experienced the impacts of extreme precipitation events, with several areas vulnerable to riverine and overland flooding.

Top Climate Drivers for the Central Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	 Extreme Precipitation Events	 Winter Precipitation	 High and Extreme Temperatures	 Low Temperature
Mid-century	 High and Extreme Temperatures	 Extreme Precipitation Events	 Drought	 Temperature

When analysing all 'high' and 'very high' risks evaluated as part of this assessment, extreme precipitation events continue to be a key climate driver. However, high temperature-related risks are expected to increase in the future, with the number of Extreme Hot Days (maximum

daily temperatures exceed 30°C) expected to rise significantly across Central Ontario. Currently winter precipitation (Rain to Snow Ratio) and low temperatures (Extreme Cold Days) drive a portion of risks for this Region. It is expected that risks associated with drought conditions and warming seasonal temperatures will increase by mid-century.

Eastern Ontario

For the purpose of the PCCIA, Eastern Ontario is defined as all areas east of Central Ontario, from Kawartha Lakes to Prescott and Russel. Renfrew and Haliburton are the two counties further north included in this Region of the province. This Region also includes the City of Ottawa.

Agriculture is a regional economic driver.

Prime agricultural areas in the province are largely located south of the Canadian Shield, with Eastern Ontario contributing significantly to agricultural production in the province. The Region produces a high percentage of field crops, including corn, soybeans, and forage acreage, reporting 450,000, 500,000, and 520,000 acres in 2020 respectively[lxxxvi]. Fruit and vegetable and livestock production also contribute to the Region's agriculture economy.

Its communities face health care pressures.

Communities have grown significantly in Central, Eastern, and Southwest Ontario, where climate, economic conditions, cultural diversity, education and skills training, and health care investments are concentrated. With population expected to continue to grow, issues of health care equity and access, are expected to worsen under climate change without intervention and investment.

High temperatures and extreme precipitation events will continue to drive the highest risks in Eastern Ontario.

Similar to Central Ontario, the 'high' and 'very high' risks in Eastern Ontario are being driven by high temperature and extreme precipitation-related conditions. Historically, Eastern Ontario experiences a substantial amount of precipitation during winter, with winter precipitation driving a large portion of current risks.

Moving towards mid-century, extreme precipitation events will continue to drive risks. High and extreme temperatures are expected to drive more risks moving into the future. Risks associated with drought and warming seasonal temperatures are expected to increase by mid-century.

Top Climate Drivers for the Eastern Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	 Extreme Precipitation Events	 High and Extreme Temperatures	 Winter Precipitation	 Low Temperature
Mid-century	 High and Extreme Temperatures	 Extreme Precipitation Events	 Drought	 Temperature

Northeast Ontario

For the purposes of assessing climate change impacts, Northeast Ontario includes all areas north of Central and Eastern Ontario between Muskoka and Nipissing in the south up to Algoma and parts of Cochrane in the north.

Communities in this Region are primarily dependent on resource industries.

Communities within this Region are largely dependent on natural resource industries, including mining, agriculture and forestry, and supporting activities. Regionally, Northeast Ontario employs the greatest numbers of workers in the mining sector, with concentrations around the Sudbury and Timmins areas. Other prominent sectors in this Region include financial and business services, research and innovation, construction, shipping, and tourism.

The Region contains a large portion of the province's highway lines.

Highway networks in this Region provide important economic and social linkages between regions and communities. The Region is served by several branches of the Trans-Canada Highway, including Highway 11, Highway 17, Highway 66 and Highway 69.

Its infrastructure is aging.

Similar to other regions in northern Ontario, both rural and urban infrastructure systems are aging (e.g. stormwater management, transportation, buildings). A growing infrastructure deficit is expected to contribute to the Region's exposure to climate-related impacts (e.g. flooding).

It encompasses the Ontario Clay Belt.

The Clay Belt is described as a large swath of viable agricultural land that stretches across Cochrane and Timiskaming and beyond the border into Abitibi County in Quebec. Ontario's Northern Clay Belt region represents 9%, 50% and 68% of the province's Class 2, 3 and 4 lands, respectively[lxxxvii]. In the past, drainage and climate conditions have limited agricultural productivity in the Clay Belt. This has been amplified by deficits of infrastructure, market access, labour supply and supportive policy. With additional support in the form of increased capacity (e.g. investment in infrastructure, tile drainage etc.), these expansion barriers could be overcome and northern regions may be better positioned to seize opportunities associated with climate change defined by longer growing seasons and more available heat units.

High temperatures and extreme precipitation events will continue driving the highest risks in Northeast Ontario.

Risks associated with extreme heat, extreme precipitation and winter precipitation are currently driving the highest risks in the Northeast Region. Moving into the future, the Northeast Region is expected to experience extreme heat and high temperatures more frequently. Extreme precipitation is also a major driver of risk for this Region now and in the future. Risks associated with warming seasonal temperatures and drought conditions are expected to increase in the future, compared to those related to winter precipitation and low temperature.

Top Climate Drivers for the Northeast Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	 High and Extreme Temperatures	 Extreme Precipitation Events	 Winter Precipitation	 Low Temperature, Temperature, and Drought
Mid-century	 High and Extreme Temperatures	 Extreme Precipitation Events	 Temperature	 Drought

Northwest Ontario

For this assessment, Northwest Ontario is comprised of almost all of Thunder Bay, all of Rainy River, and portions of Kenora. Smaller areas farther north of Thunder Bay are included in the Far North Region of Ontario, along with larger swathes of Kenora.

This Region has a lower population density compared to southern areas of the province.

The Region is large with low population density and includes medium-sized municipalities of Thunder Bay and Kenora. In recent years, this Region has experienced declining population, which mirrored employment rates related to declining forestry-based industries. The Region is projected to grow slowly moving into the future, with between 3-4% growth expected by mid-century[lxxxviii]. The Region's Indigenous Population has been growing, with over 30 First Nation Communities and high proportions of Indigenous People living in Thunder Bay, Kenora and surrounding areas.

Resource-based industries are a primary economic driver for the Region.

The economy is primarily supported by resource-based industries including mining and lumber and wood industries. Gold production dominates a large portion of the mining industry in Northwest Ontario, with just over 10% of provincial industry employment[lxxxix]. The Region has a presence of significant critical mineral deposits including nickel, copper and platinum.

The Region encompasses boreal forest region.

This Region is covered mainly by boreal forest, which is largely dominated by coniferous and mixed-wood tree species (e.g. white spruce, jack pine, poplar). The boreal forest contains hundreds of species of plants (e.g. ferns, mosses, fungi) and is home to a wide range of wildlife (e.g. black bears, wolves, moose, great owl). The Northwest Region also is covered by Great Lakes–St. Lawrence forests, along the coast of Lake Superior, largely dominated by hardwood tree species such as maple, oak, red and white pine.

High temperatures and extreme precipitation events continue to be the greatest drivers of risk in Northwest Ontario, with drought-related risks expected to increase in the future.

Similar to the Northeast Region, the 'high' and 'very high' risks derived from the assessment are driven largely by high and extreme temperatures and extreme precipitation events.

In the Northwest Region, it is expected there will be a shift from risks driven by winter precipitation and low temperatures to drought conditions by the mid-century. Moving into the

future, Northwest Ontario is also expected to experience more risks driven by increasing seasonal temperatures.

Top Climate Drivers for the Northwest Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	 High and Extreme Temperatures	 Extreme Precipitation Events	 Winter Precipitation	 Low Temperature and Drought
Mid-century	 High and Extreme Temperatures	 Extreme Precipitation Events	 Drought	 Temperature

Far North Ontario

As it pertains to the assessment, the Far North Region is defined by the boundary established as part of the Far North Act by the Ontario Ministry of Natural Resources and Forestry (MNRF). This Region includes large parts of the Kenora district, northern sections of the Cochrane district and the farthest north areas of Thunder Bay. The area encompasses more than 450,000 square kilometers and is home to globally significant expanses of relatively untouched boreal forest.

It is Ontario's most unique and distinct Region.

Despite covering 42% of the land area of Ontario, this Region is the most sparsely populated area of Ontario, with a population density of 0.08 people per square kilometre[xc]. It is primarily populated by First Nation Communities that rely on subsistence practices and winter road access in order to acquire necessary resources. This Region is the most unique, sharing the least social, economic or ecosystem similarities with other Regions of the province.

Pristine natural environment in the Far North plays a vital role for biodiversity.

The Far North Region has two distinct ecological regions, bogs and fens of the Hudson Bay Lowlands and boreal forest of the Canadian Shield. These ecosystems provide critical habitat for more than 200 sensitive species, including species at risk like woodland caribou and wolverine. The Region also is home to Ontario's only populations of polar bears, beluga whales and snow geese. The Far North extends from the coasts of Hudson Bay and James Bay and includes areas with continuous and discontinuous permafrost and peatlands.

The Far North is home to the highest number of remote First Nation Communities in Canada.

Over one-quarter of Ontario First Nations Peoples live in remote communities of the Far North subregion, within more than 30 First Nations Communities[xci]. Many of these communities are only accessible by air or winter roads: two modes of travel that are highly dependent on weather and climate conditions.

Winter Roads are critical for the Far North.

Winter roads in the Far North provide connection to other areas of the province through highway and railway systems. Winter roads are critical for remote communities in the Far North, providing goods, services to residents. Winter roads also support the self-sufficiency and well-being of residents and enhance industry access to remote communities.

Climate drivers in the Far North remain consistent in the future.

High temperature, extreme precipitation events and drought conditions will continue driving the highest risks in Far North by mid-century. In comparison to other northern Regions, the Far North contains a high proportion of current risks already being driven by drought conditions. For the Far North particularly, extreme temperature, precipitation and moisture conditions are expected to drive the highest risks, compared to slower onset changes in seasonal temperature and precipitation patterns.

Top Climate Drivers for the Far North Region				
Rank	**#1**	**#2**	**#3**	**#4**
Current	High and Extreme Temperatures	Extreme Precipitation Events	Drought	Low Temperature, Temperature, and Winter Precipitation
Mid-century	High and Extreme Temperatures	Extreme Precipitation Events	Drought	Low Temperature and Temperature

Navigate back to the Launch Page

How prepared is Ontario to deal with climate change?

When assessing the impacts that climate change will have on Ontario, it is important to not only look at risk, but also the province's 'Adaptive Capacity'. **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**'[xcii].

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 was applied to all Areas of Focus and Regions.

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

Governance addresses how an organization/industry is prepared to adapt for, and respond to, climate change impacts 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, rights holders, 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.

What is Ontario's Capacity to Adapt?

The findings of the assessment suggest that Adaptive Capacity ('capacity') varies significantly across regions and sectors of Ontario. Levels of capacity vary considerably across Ontario, with higher levels of capacity identified in regions with large urban centres (e.g. the Central Region), where more resources exist. The northern regions of the province were found to have lower capacity levels in relation to technology and resource availability, but a higher capacity in relation to levels of complexity.

Levels of Adaptive Capacity are not uniformly distributed across Ontario.

Ontario has a relatively high capacity to adapt to climate change, however types of capacity (e.g. technology, governance etc.) and amounts or levels of capacity vary across Areas of Focus and more broadly across provincial Regions. Sub-sectors (Level 2 categories) within Business and Economy were found to have relatively higher levels of Adaptive Capacity in themes such as technology and resource availability, whereas categories of equity and resource availability ranked lower in the People and Communities Area of Focus. Other Areas of Focus had mid-scale rankings largely falling in the 'medium' category.

While many sectors in Ontario are positioned to address current climate risks, all sectors could benefit from strengthening and mobilizing their capacity to build climate resilience. To achieve this, barriers that impede progress on building capacity in Ontario will need to be overcome, including financial constraints, lack of expertise and access to data, support and mandate for action, and uncertainty associated with roles and responsibilities. Stronger coordination and governance among and across Ontario's sectors and regions will be required to effectively implement and scale up adaptation planning processes and help to expedite widespread capacity building[xciii].

Ontario has a relatively high capacity to adapt, but this capacity has not yet been mobilized widely nor sufficiently to build resilience.

What areas should be prioritized for adaptation action?

Based on the impact assessment risk scores, and corresponding levels of Adaptive Capacity, the following areas were identified as current adaptation priorities for Ontario.

- **Indigenous Communities** were assessed to have 'high' risk profiles, including **Population, Cultural Services**, and **Health Care** categories. This level of risk is coupled with a relatively 'low' Adaptive Capacity, given the lack of dedicated funding and resources and existing environmental injustices, highlighting the requirement for urgent adaptation action.

- **Unhoused Populations** represent one of the most climate vulnerable groups in the province, with heightened exposure and relatively lower capacity attributed to lack of coordinated programming and resource availability.

- Climate change is already a threat to Ontario's natural environment, and is expected to drive risks to species, habitats and ecosystem services even higher in the future. Considering significant human development pressures, risk scores for **aquatic ecosystems** (e.g. bogs and mudflats), **fauna** (e.g. fish and waterfowl species) and **regulating services** (e.g. pollination, carbon storage) are currently 'high' across select Regions of the province and exhibit lower levels of Adaptive Capacity.

- The risk profiles of **electrical and stormwater infrastructure** systems are 'high' under current climate conditions, with a 'medium' level of Adaptive Capacity, indicating additional measures are needed to minimize climate risk. Infrastructure should be strengthened and properly maintained or replaced with future climate conditions in mind, to effectively build capacity and minimize existing and future climate risks.

- While managing uncertainty is common within Ontario's food and agricultural sector, climate change is expected to amplify existing current risks and introduce new risks for food producers across the province. Several **field crop** and **fruit and vegetable** commodities have 'high' risk profiles under current climate conditions. Appropriate adaptation action should be taken to limit agricultural risks and support potential opportunities for Ontario's food and agriculture sector.

- Climate risk profiles for industries dependent on natural production systems (e.g. **fishing, hunting and trapping, forestry and logging**) are already considered 'high', with a 'medium' level of Adaptive Capacity. Local economies and businesses that subscribe to climate resilience as well as the transition to a low carbon future will have increased growth, prosperity and thrive in the context of climate change.

These findings are derived from the quantitative risk scores and therefore only reflect the **direct** impacts assessed under the PCCIA. This adaptation priority list does not include the qualitative analysis of **indirect, cascading and cross-sectoral impacts**, as outlined throughout this Report, nor the priorities that emerge under future timeframes (e.g. 2050s or 2080s).

The common and uniting theme that stretches across all the PCCIA work, is one of urgency that highlights the resilience gap in Ontario. There is an urgent need for increased levels of widespread adaptation as climate risks continue to be felt across the province. A more fulsome summary of emerging adaptation priorities and risk reducing measures for each Area of Focus is contained within the PCCIA Adaptation Best Practices Report.

Navigate back to the Launch Page

Selected References

The following summarizes references where quantitative or numeric citations were used throughout this Summary Report. It is not meant to be comprehensive or exhaustive.

[i] Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, 444 p.

[ii] Canadian Climate Institute. (2022). Damage Control: Reducing the costs of climate impacts in Canada.

[iii] Environment and Climate Change Canada (ECCC). (2022a). Canadian Gridded Temperature and Precipitation Anomalies (CANGRD).

[iv] International Organization for Standardization. (2019). ISO/DIS 14090 Adaptation to climate change — Principles, requirements and guidelines. Geneva.

[v] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2017). Field Crops.

[vi] Ibid.

[vii] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2021). Area, Yield, Production and Farm Value of Specified Field Crops (Imperial and Metric Units): 2015-2021 by year.

[viii] Statistics Canada. (2017). Cropland in Ontario grows despite fewer farms. Census of Agriculture, 95, 4.

[ix] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2021). Area, Yield, Production and Farm Value of Specified Field Crops (Imperial and Metric Units): 2015-2021 by year.

[x] Ontario Fruit & Vegetable Growers Association. (2022). Sector Overview.

[xi] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2019). Horticultural Crops Statistics.

[xii] Ibid.

[xiii] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2017). Frost damage evaluation on apple buds.

[xiv] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2019). Horticultural Crops Statistics.

[xv] Ibid.

[xvi] Statistics Canada. (2022). Table 32-10-0370-01. Cattle inventory on farms, Census of Agriculture, 2021

[xvii] Beef Farmers of Ontario. (2018). Quick Facts about Ontario's Beef Industry.

[xviii] Statistics Canada. (2022). Table 32-10-0370-01. Cattle inventory on farms, Census of Agriculture, 2021

[xix] Statistics Canada. (2022). Table 32-10-0371-01. Sheep inventory on farms, Census of Agriculture, 2021

[xx] Statistics Canada. (2022). Table 32-10-0372-01. Pig inventory on farms, Census of Agriculture, 2021

[xxi] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2017). Farm Cash Receipts from Farming Operations, Ontario, 2006-2016 ($'000).

[xxii] Statistics Canada. (2022). Table 32-10-0370-01. Cattle inventory on farms, Census of Agriculture, 2021

[xxiii] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (2016). Statistical Summary of Ontario Agriculture.

[xxiv] Statistics Canada. (2022). Table 32-10-0370-01. Cattle inventory on farms, Census of Agriculture, 2021

[xxv] Statistics Canada. (2022). Table 32-10-0374-01. Poultry inventories on farms, Census of Agriculture, 2021

[xxvi] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2017). Farm Cash Receipts from Farming Operations, Ontario, 2006-2016 ($'000).

[xxvii] Stiebert Consulting. (2022). Socio-Economic Projection Ontario Provincial Climate Change Impact Assessment Final Report.

[xxviii] Financial Accountability Office of Ontario (2020). Provincial Infrastructure: A Review of the Provinces Infrastructure and an Assessment of the State of Repair.

[xxix] Statistics Canada. (2022). Inventory of publicly owned social and affordable housing assets.

[xxx] Canadian Energy Centre (2021). $193 billion and 71,000 jobs: The impact of oil and gas (and Alberta) on Ontario's economy. Canadian Energy Centre Accessed.

[xxxi] Enbridge. (2022). Enbridge's Energy Infrastructure Assets.

[xxxii] Canadian Dam Association (2019). Dams in Canada.

[xxxiii] Monica, I (2019). The Implications of Impervious Surfaces for Flood Management in the GTA.

[xxxiv] Government of Ontario (2020). Connecting the North: A draft transportation plan for Northern Ontario.

[xxxv] Government of Ontario (2020). Connecting the Southwest A draft transportation plan for southwestern Ontario.

[xxxvi] Statistics Canada (2021). Airport Activity: Air Carrier Traffic at Canadian Airports, 2020.

[xxxvii] Ontario Waste Management Association (2021). State of Waste in Ontario: Landfill Report January 2021.

[xxxviii] Ibid.

[xxxix] Ontario Biodiversity Council. (2021). State of Ontario's Biodiversity 2020: Summary. A report of the Ontario Biodiversity Council, Peterborough, ON.

[xl] Dove-Thompson, D., Lewis, C., Gray, P. A., Chu, C., & Dunlop, W. I. (2011). A Summary of the Effects of Climate Change on Ontario's Aquatic Ecosystems. 68.

[xli] Smith et al. (2021). Ontario Lakes and Climate Change Database: A guide to projected changes in the thermal conditions of Ontario's inland lakes. Ministry of Northern Development, Mines, Natural Resources and Forestry

[xlii] Environment and Climate Change Canada [ECCC] (2015). Wild Species 2015: plant kingdom. Government of Canada.

[xliii] Ibid.

[xliv] Miller, E., Robinson, R., McMaster, M.-L., Holloway, E., and Kapoor, A. (2021). Ontario's Ecological Footprint and Biocapacity: Measures and trends from 2005 to 2015. Report submitted to the Ontario Ministry of Natural Resources and Forestry.

[xlv] Ibid.

[xlvi] Ibid.

[xlvii] Ibid.

[xlviii] Ibid.

[xlix] Ibid.

[l] Ibid.

[li] Ibid.

[lii] Ibid.

[liii] Financial Accountability Office of Ontario. (2021). Housing and Homelessness Programs in Ontario.

[liv] Kapoor, G.T. (2022). Doing More for Those with Less: How to Strengthen Benefits and Programs for Low-Income Individuals and Families In Ontario. Ontario 360 Transition Briefings 2022. Munk School of Global Affairs and Public Policy.

[lv] Laduzinsky, P. (2019). The Disproportionate Impact of Climate Change on Indigenous Communities.

[lvi] Belanger, R. J. (2021). Climate change impacts on the health and livelihoods of Indigenous Communities in Northern Ontario. Lakehead University.

[lvii] Furgal, C. and Seguin, J. (2006). Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities. Environmental Health Perspectives, 114(12), 1964-1970. 10.1289/ehp.8433

[lviii] National Collaborating Centre for Indigenous Health (NCCIH) (2022). Climate Change and Indigenous Peoples' Health in Canada. In P. Berry & R. Schnitter (Eds.), Health of Canadians in a Changing Climate: Advancing our Knowledge for Action. Ottawa, ON: Government of Canada.

[lix] Warren, S.K, Charles-Norris, K.A., Butler, A., et al., (2021). Two Approaches, One Shared Learning Journey to Support Climate-Health Adaptation Planning. Public Health Agency of Canada, Ontario Region (PHAC), the Simcoe Muskoka District Health Unit (SMDHU) and Cambium Indigenous Professional Services (CIPS).

[lx] Chakraborty, L., Thistlethwaite, J., Minano, A. et al., (2021). Leveraging Hazard, Exposure, and Social Vulnerability Data to Assess Flood Risk to Indigenous Communities in Canada. Int J Disaster Risk Sci 12, 821-838.

[lxi] Government of Canada. (2022). Gross Domestic Product – Canadian Industry Statistics.

[lxii] Sood, S. (2021). Impact of COVID-19 on food services and drinking places, first quarter of 2021. Statistics Canada.

[lxiii] Government of Canada. (2022a). Summary – Canadian Industry Statistics.

[lxiv] Build Force Canada. (2021). Ontario Highlights 2021 – 2030.

[lxv] Build Force Canada. (2021). Ontario Highlights 2021 – 2030.

[lxvi] Invest Ontario. (2019). Strategically located next to the world's largest market.

[lxvii] Berkow, J. (2021). Frustrated by Rising Home Insurance Premiums? Blame Climate Change. RatesDotCA.
[lxviii] Insurance Bureau of Canada (IBC). (2021). Canada's P&C insurance industry, all sectors.
[lxix] Government of Canada. (2022a). Summary – Canadian Industry Statistics.
[lxx] Government of Canada. (2022c). Gross Domestic Product – Canadian Industry Statistics.
[lxxi] Wilson, M., & Greco, A. (2018). Manufacturing Ontario's future: Leveraging Ontario's Manufacturing sector to drive Ontario's Economic success. CME.
[lxxii] Government of Canada. (2022a). Summary – Canadian Industry Statistics.
[lxxiii] Toronto Workforce Innovation Group (TWIG). (2021). Retail and Wholesale Trade.
[lxxiv] Ontario Energy Board. (2022). Overview of energy sector.
[lxxv] Intendent Electricity System Operator (IESO). (2022). Ontario's Energy Sector.
[lxxvi] Independent Electricity System Operator (IESO). 2022. Natural Gas Phase-Out Study.
[lxxvii] Clean Water Act. (2006). S.O. 2006, c. 22.
[lxxviii] Provincial Policy Statement (2020).
[lxxix] Ministry of the Environment, Conservation and Parks (MECP). (2022). Best practices for source water protection.
[lxxx] Conservation Ontario. (2020). Climate Change Vulnerability Assessment Tool.
[lxxxi] Statistics Canada. (2017). Cropland in Ontario grows despite fewer farms. Census of Agriculture, 95, 4.
[lxxxii] Ministry of Energy. (2017). Oil & Natural Gas. Government of Ontario.
[lxxxiii] Stiebert Consulting. (2022). Socio-Economic Projection Ontario Provincial Climate Change Impact Assessment Final Report.
[lxxxiv] Ibid.
[lxxxv] Toronto Pearson Airport. (2021).
[lxxxvi] Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). (2021a). Area, Yield, Production and Farm Value of Specified Field Crops (Imperial and Metric Units): 2015-2021 by year.
[lxxxvii] Chapagain, Tejendra. (2017). Farming in Northern Ontario: Untapped Potential for the Future. Agronomy 7, no. 3: 59.
[lxxxviii] Stiebert Consulting. (2022). Socio-Economic Projection Ontario Provincial Climate Change Impact Assessment Final Report.
[lxxxix] Ibid.
[xc] Ibid.
[xci] Ibid.
[xcii] International Organization for Standardization. (2019). ISO/DIS 14090 Adaptation to climate change — Principles, requirements and guidelines. Geneva.
[xciii] Douglas, A.G. and Pearson, D. (2022). Ontario; Chapter 4 in Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario.

Key Terms and Definitions

Adaptation: Process of adjustment to actual or expected climate events and their 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.

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

Cascading Impacts: A climate-related event or trend that triggers a chain of impacts across different Areas of Focus. Cascading impacts are often associated with interdependencies between systems where components may be intrinsically dependent, or rely upon, one another to provide a function. (e.g. critical infrastructure failures can cause cascading impacts across several different sectors).

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 Resilience: 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.

Climate Variable: A measurable aspect of weather that contributes to the characterization of weather conditions in a given area.

Climate Variable Group: Climate variable(s) grouped together based on commonalities such as temperature or precipitation and representing changes in climate (physical events or stressors) that have the potential to cause harm, damage, or losses.

Consequence Criteria: Criteria used to assess the level of impact (or damage) to human health and safety, environmental damage, disruption to services, and financial loss. Consequence of impacts are rated from 'very low' to 'very high' based on the given criteria.

Consequences: Negative impact that arises when a climate variable interacts with an Area of Focus.

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

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 interactions within each Area of Focus and have been quantitatively assessed following the PCCIA methodology and given risk scores.

Equity Lens: Within the context of the PCCIA, this is a term specifically used within the cross-sectoral analysis. 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.

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

Exposure: An interaction, either actual or expected, between the climate variable and the presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economy. Exposure was not explicitly assessed as a discrete element of vulnerability under the PCCIA methodology.

Frequency: The number of occurrences of a repeating climate variable 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 years 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". Frequency is also referred to as 'likelihood' within the report.

Impact: The effect of climate change variables on natural, built and human systems.

Impact Assessment: Process used to identify, analyze, and evaluate impacts, inclusive of risks and opportunities.

Indirect impacts: For the PCCIA, indirect impacts are secondary effects of changes in climate and are directly tied to (stem from) a primary impact within an Area of Focus. Indirect impacts were excluded from the quantitative assessment but are characterized qualitatively.

Individual Risk Score: The quantification of each interaction between a climate variable and area of impact as noted by a Level 1 or 2 category within each Area of Focus and region (e.g. interaction between extreme precipitation event (short term) and rail infrastructure in Central Ontario).

Interaction: The combination of a region and asset/service/operation with a climate variable that has the potential to impact the asset/service/operation in the given region.

Interconnected linkages: A term used to represent the inherent connectedness between Areas of Focus as part of cross-sectoral analyses. Interconnected linkages are defined as complex interactions among system components that are dependent, or rely upon, one another to provide a function. damage from climate change.

Likelihood: In the context of the PCCIA, likelihood is a measurement of the probability of consequence associated with an impact occurrence. Likelihood scales are characterized by the percent chance of an impact occurring, categorized as 'Improbable', 'Remote', 'Occasional', 'Probable', and 'Frequent' levels of occurrence.

Opportunities: Opportunities are cases where risk scores decrease over time or are described qualitatively where evidence suggests that a changing climate may lead to favourable effects under each Area of Focus.

Probability: Percentage chance of the occurrence of an event.

Risk: Risk is measured as the combination of the probability of an event, with its likelihood of impact and severity of consequences.

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

Risk Evaluation: Process of comparing the risk results with the risk tolerance criteria to determine the degree to which action is required.

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

Risk Scenario: A PCCIA risk scenario describes the interaction between a select climate variable, a Level 1 or 2 category and within an applicable region. For example, the risk scenario developed for extreme heat days (climate variable) and corn crops (Level 2 category) in Southwest Ontario (region) reads as: 'An extreme heat event (+32° C during day/+20°C at night) occurs during later reproductive phases (blister and maturity) of corn development, reduces crop productivity by impacting the grain fill period, lowering kernel weight, and resulting in yield losses of between 20 to 40%'.

Sensitivity: The degree to which a system is adversely or beneficially affected by the climate variable to which it is exposed. Sensitivity was not explicitly assessed as a discrete element of vulnerability under the PCCIA methodology.

Severity: The degree of impact of an event and related to consequence.

Threshold: Context-specific, a point beyond which a system is deemed to be no longer effective or efficiently functioning (economically, technologically, or environmentally). Thresholds define inflection points at which time declines in function occur. Threshold is also "The level of risk exposure above which risks are addressed and below which risks may be accepted." A threshold level is a level beyond which an organization does not want to tolerate the risk.

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.

Vulnerability: The extent to which a system or component is susceptible to damage from climate change. This is calculated based on the potential impact (exposure and sensitivity) and the Adaptive Capacity of the system or component. It is important to note that Ontario's PCCIA is an assessment of climate impacts, including risks and opportunities as a function of likelihood and consequence, and does not explicitly assess vulnerability.