VULNERABILITY ASSESSMENT SUMMARY

Agricultural Systems in Peel Region

Prepared for:

Region of Peel working with you

Prepared by:

Toronto and Region Conservation for The Living City

ONTARIO CLIMATE CONSORTIUM

RSI RISK SCIENCES INTERNATIONAL

Action on Climate Change in Peel Region

The Region of Peel recognizes that working together with regional municipalities, Conservation Authorities, and local citizens is paramount to addressing the challenge of climate change. In 2011, the Region developed the Peel Climate Change Strategy in partnership with lower tier municipalities (Brampton, Mississauga and Caledon) and local Conservation Authorities (Credit Valley Conservation and Toronto and Region Conservation) to build resilience and adaptive capacity to climate change.

The Strategy serves as a road map for addressing climate change impacts locally through the following:

- Proactive and responsive planning and leadership
- Actions to reduce greenhouse gas emissions
- Targeted and proactive adaptation actions
- Shifting to a green economy
- Increasing awareness of, and engagement in, climate issues in Peel
- Ongoing research and adaptive risk management

Peel commissioned the development of vulnerability assessments to investigate the impacts of climate change on a variety of systems. The information gained in these assessments will help identify opportunities for adaptation to climate change and reduction of its negative effects.

In 2016, this vulnerability assessment was completed, which studies the impacts of climate change on agricultural systems in the Region, with a focus on oil seed and grain crops. The following summary of that assessment was prepared by Hutchinson Environmental Sciences Ltd. and Shared Value Solutions Ltd., in collaboration with the Toronto and Region Conservation Authority, the Ontario Climate Consortium and the Region of Peel.

The full technical report for this and other assessments is available at climateconnections.ca.

Note: Please refer to the full technical report for all source material used in the assessment and this summary. Statistics were derived mainly from the 2011 Agricultural Census, with some comparisons to the 2006 Agricultural Census.

Suggested citation for the full technical report:

Harris, S., Hazen, S., Fausto, E., Zhang, J., Kundurpi, A., Saunders-Hastings, P. 2016. **Climate Change Effects on Agricultural Production in the Region of Peel.** An Assessment of Vulnerabilities and Potential Opportunities. Toronto, Ontario: Toronto and Region Conservation Authority and Ontario Climate Consortium Secretariat.

Preparing for the Future

Climate change is one of the greatest challenges humans face in the 21st century. As the planet warms, we are witnessing more extreme and variable climate patterns, which are leading to unprecedented impacts for society and natural environments worldwide. Efforts are underway to address the problem at all scales, from local to global. While reducing greenhouse gas emissions is clearly an essential part of this strategy, we also need to plan for how we adapt to the impacts of climate change which are already happening and forecasted to get worse in the future. Adaptation to climate change will play a critical role in minimizing negative climate impacts on our society, economy and the natural world.

The purpose of the vulnerability assessment is to understand the impacts of climate change on agriculture within Peel Region.

Calls to Action

The results of this vulnerability assessment, summarized over the following pages, make it clear that we must act now:

- ✓ Start or continue adaptation planning, leveraging this and other community assessments and datasets to increase adoption of farming best management practices (BMPs).
- ✓ Be proactive by working with farmers to minimize harmful impacts of climate change.
- ✓ Protect ecosystem services (such as flood and erosion control, habitat diversity, water quality) as well as farming infrastructure, technologies and inputs so that natural and built resources can better cope with variable and extreme weather.
- ✓ Enable investment in new technologies and innovative approaches that consider flexibility to changing conditions (such as climate change and urbanization).
- ✓ Promote collaboration of government, farmers, community interest groups and agricultural suppliers to prioritize best adaptation approaches, seize opportunities, and avoid top down regulations.
- ✓ Encourage a holistic conversation and knowledge transfer among suppliers, farmers, markets and consumers on the future impact of climate change on the Region's agricultural systems.

DEFINING RESILIENCE AND ADAPTIVE CAPACITY TO CLIMATE CHANGE

Agriculture, by nature, is sensitive to climate and weather. The degree to which farming is vulnerable to changes in temperature, precipitation or extreme weather events will depend on its **adaptive capacity**: the ability to adjust to changing conditions over time. This in turn will result in **resilience**: the ability to cope and remain productive under a range of different and highly variable conditions. Both resilience and adaptive capacity are influenced by the ability to mobilize resources and learn from experience.

DEFINING AGRICULTURAL VULNERABILITY TO CLIMATE CHANGE

Many definitions of vulnerability to climate change exist. For the purposes of this assessment the definition from the Intergovernmental Panel on Climate Change was used:

"Vulnerability encompasses... sensitivity or susceptibility to harm and lack of capacity to cope and adapt."

How Does Climate Change Affect Agriculture?

Climate plays a significant role in agriculture. Among other things, it influences the suitability of land for farming, what crops can grow, the availability of water for crops and livestock, and how smoothly farm operations run (such as irrigation systems and pest management approaches).

Farmers have always depended on predictable weather patterns to plan and manage their farming activities. Climate change will lead to increasingly variable and unpredictable conditions, making it difficult to forecast how long the growing season will be, or when to plant and harvest. At the same time, extreme weather, such as flooding and drought, is expected to become more frequent and severe, leading to numerous potential impacts such as the following:

- Water-logging of fields
- Soil erosion
- Pest infestations
- Leaching of nutrients
- Water scarcity

The frequency and severity of extreme weather events, such as flooding and drought, is projected to increase.

Peel's Agricultural Profile

Farming is already under pressure in Peel Region because of urban development and rising human population. Climate change will bring additional threats to the sector. It is crucial that farmers and agricultural decision-makers have the information they need both to envision the impacts of climate change on their livelihoods, and to plan effective responses to those impacts.

- Peel has some of the most productive agricultural land in Canada.
- Of the Region's farmland, 62% is considered prime, and only 25% is considered marginal.
- Based on the 2012 MPAC assessment, approximately 45% of the Region's total land base is used for farming, most within the Town of Caledon.
- Between 2006 and 2011, the number of farms in the Region declined by 8.5% and the area of land used for agriculture declined by 1.5%.
- Agricultural sectors that declined most were dairy cattle (-40%), beef cattle (-32%), and greenhouse production (-20%), while oil seed and grain farming increased the most (+42%).

- Peel farmers benefit from their proximity to a large consumer market in the Greater Toronto Area (GTA), but also face threats from urban development and high population growth.
- Peel's population is rapidly increasing, with currently 1.3 million people living in the Region, putting pressure on natural areas and farmland.
- In addition to land development pressures associated with urban sprawl, farming in the GTA faces challenges related to high capital costs, decreasing commodity prices, and fewer people choosing to farm. These factors are expected to worsen the effects of climate change on farming in the future.
- As of July 1, 2017, amendments to the Ontario Growth Plan for the Greater Golden Horseshoe (GGH) take effect and include new policies to better manage and protect farmland in GGH growth areas. These policies should be implemented as part of the response to reducing Peel's agricultural systems vulnerability to climate change impacts described in this assessment.

Possible Futures Under Climate Change

Climate Trends in Peel Region

Predicting future climate is not an exact science, but trends can be forecasted based on a range of future greenhouse gas emission scenarios. Assuming we continue business as usual, Peel Region is expected to be hotter at all times of year, with changes to seasonal rainfall patterns, more rainstorms and more heat waves. Winter, spring and fall will likely be wetter, while summer will be drier, but punctuated by heavy rainfall events.

Climate change will directly affect farming in several ways within Peel Region. The growing season will likely extend by between 34 and 54 days on average over the next 60 years, but unseasonal frost may become more frequent both early and late in the season. While a longer growing season and some other changes could boost crop yield and present other opportunities, more frequent heat waves and drought during the summer will be damaging for many types of crops.

Impacts on Ecosystem Services

Healthy farmland does not exist in isolation. It needs to be nested within a broader landscape that features a variety of healthy, thriving natural

FUTURE CLIMATE TRENDS IN PEEL REGION

A study of predicted climate trends for Peel Region found that

By 2050

- Annual mean temperature will rise by 2°C

- The number of extreme heat days (over 30°C) will more than double (from 12 days/year now to 26 days/year)

- The intensity of extreme storms will increase by 28-51%

- The growing season will be 20% longer than today (from 169 days currently to 203 days)

By 2080

- Annual mean temperature will rise as much as 5°C from current levels

- There will be up to five times more extreme heat days (62 days/year)

- The intensity of extreme storms will increase by 46-90%

- The growing season will be 30% longer than today (up to 223 days/year)

STAKEHOLDER ENGAGEMENT

Farmers and agricultural decision-makers are the ones directly experiencing the effects of climate change on agriculture, and thus their input for this vulnerability assessment was critical. Stakeholder engagement was a key component of the assessment process and occurred at every step to ensure that stakeholders' perspectives, experiences and knowledge were considered and incorporated.

A broad cross-section of agricultural stakeholder groups was consulted for the report:

- The Town of Caledon
- The City of Brampton
- The City of Mississauga
- The Peel Agricultural Advisory Working Group
- The Peel Federation of Agriculture
- The Peel Soil and Crop Improvement Association
- The Greater Toronto Area Agricultural Action Committee
- The Golden Horseshoe Food and Farming Alliance
- The Ontario Soil and Crop Improvement Association
- The Ontario Climate Consortium
- Conservation Authorities
- Agricultural input supply companies
- Commodity groups
- Private sector businesses
- The Ontario Ministry of Agriculture, Food and Rural Affairs
- The Ontario Federation of Agriculture
- Agriculture and Agri-Food Canada

environments, such as forests, wetlands, rivers and lakes. These natural systems provide a number of ecosystem services that benefit farming, such as habitat for crop pollinators, regulation of water quality and quantity, and control of soil erosion. However, climate change threatens the normal functioning of the natural environment, which will have cascading effects on farming. In Peel Region, this could mean that there will be shifts in the types of crops that can grow, and changes in when and how much water is available for crops and livestock.

New Challenges Ahead

Climate change will bring fundamental changes to farming in Peel Region and farmers will face many new challenges. To maximize farming success under these new unpredictable conditions, farmers will need to rethink a number of important issues:

- What land to farm
- What crops and livestock to produce
- What farming practices to follow
- What infrastructure to invest in

In Peel Region, for instance, rising temperatures, more variable rainfall, and a longer growing season will likely put significant pressures on water supply. New approaches to water management may be needed to control the availability of water for farming. Farmers are on the front lines of dealing with climate change. The innovative ways in which they adapt and respond can be a powerful example for the rest of society.

What the Storylines Tell Us

The agricultural vulnerability assessment focused on four potential impacts of climate change on farming in Peel Region, which are presented in a series of storylines. The storylines link research on climate change impacts with current conditions in Peel, to illustrate potential vulnerabilities and highlight potential ways farmers can adapt.

Storyline 1: Extreme Precipitation

Storyline 3: Extreme Heat

Storyline 2: Drought

Storyline 4: Changes to the Timing of Growing Conditions

Storyline 1: Extreme Precipitation

Climate change is expected to produce stronger storms with heavier rainfall, which will affect oil seed and grain farming in a number of ways:

- Water logging and flooding of soils
- Soil erosion and changes to the availability of nutrients
- Outbreaks of pests and disease

The severity of impacts from severe storms will depend largely on when they occur during the growing season, and on the type of crops affected.

Winter, spring and fall will likely be wetter, while summer will be drier on average, but punctuated by heavy rainfall events.

Water Logging and Flooding

Water logging of fields is a particular concern if it occurs during planting or harvest periods, as it can delay farming activities. The longer farmers have to wait to sow seeds, the greater the chance that crops won't mature in time. Water logging during harvest, meanwhile, can lead to rust and fungal infections of grain, as well as sprouting of grain before it can be harvested.

The extent of damage to crops from water logging and flooding varies by plant type and stage of development. Corn, soybeans and wheat, for example, are most sensitive to adverse weather during early growth, flowering and grain filling stages. Corn yield can drop by more than 40% if prolonged flooding happens at the start of flowering or kernel development. Soybeans can tolerate floods lasting up to two days during their reproductive stages (i.e., blooming through full maturity) without any serious decline in yield. Different plant varieties also differ in their tolerance of extreme weather. Soybean types that are sensitive to flooding, for instance, experience a 77% reduction in yield compared with a 39% reduction for flood-tolerant types during the blooming period.

Low-lying lands are most susceptible to water logging and flooding, especially if drainage is poor. In Peel Region, these areas are mainly located in the northwest and south of the Niagara Escarpment, comprising roughly 1/3 of all farmland. Peel has only a small portion of farmland with poorly drained soil (2.5%), made up of clay and clay-loam, and this mainly occurs below the escarpment. Thus, vulnerable areas to water logging and flooding are generally concentrated south of the escarpment.

Tile drainage is an important management measure to reduce the risk of water logging and flooding in poorly drained areas. Currently 5.8% of Peel farmland has tile drains, mainly in fields used for cash crops or mixed farming south of the escarpment.

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Soil Erosion and Changes to Nutrient Availability

The more rain that falls during a storm, the greater the amount of soil that washes away, taking with it valuable nutrients needed by plants. Physical factors, such as slope and soil type, influence the vulnerability of soil to erosion and leaching. For example, steep terrain is more prone to erosion than flat land. Loamy soils tend to let water drain through without erosion, while clay soils resist being swept away by water flow. Most farms in Peel Region are not very vulnerable to soil erosion, but those that are generally occur in the northeast on the escarpment.

Farming practices can play a major role in determining the overall vulnerability of land to erosion and nutrient loss. The less physical disturbance of the soil the better. For example, conservation tillage (which leaves crop residues on the soil surface) is a proven technique to retain moisture and nutrients in the soil. Approximately 35% of Peel farms currently use no-till farming as a conservation tillage practice. Hay and pasture practices are least susceptible to soil erosion and leaching.

Pests and Disease

Climate change is expected to benefit existing agricultural pests and diseases and to lead to the introduction of new ones. Increased rainfall may help spread plant pathogens, such as rusts and bacteria, as well as insect pests, such as aphids and psyllids. At the same time, excess moisture could cause some weeds to flourish and out-compete crops for light and nutrients.

Farmers will need to adapt their Integrated Pest Management Strategies to deal with the increase in pest and disease outbreaks in crops.

Storyline 2: Drought

The frequency and duration of drought events will likely increase under climate change. Prolonged lack of water during the growing season can have serious impacts on crops including the following:

- Limiting growth and development
- Increasing pest and disease outbreaks
- Exposing plants to extreme heat

Drought reduces yield in soybean, corn and grains and can increase seedling death in maize. Dry soil conditions make it more difficult for plants to receive adequate supplies of nutrients during the growing season. Some agricultural pests and disease thrive when crops are stressed from lack of water.

Aphids, for example, proliferate during drought years, while some weeds can out-compete crops under dry conditions.

Crops vary in their vulnerability to drought depending on plant type and development stage. The table below illustrates the number of days two common crops can tolerate drought conditions. Similar information is needed for other crop types to determine management options and needs (such as irrigation and alternative drought tolerant cropping systems).

Farmers will need to adapt their farming practices to cope with more frequent and severe drought in the future. One way may be through increased reliance on irrigation, which accomplishes the following:

- Provides crops with the water they need when rainfall is scarce during critical growth stages
- Increases the opportunity for double cropping in a season
- Improves the overall quality and quantity of crops produced

Irrigation, which is currently used by only 12% of farms in Peel, may become an increasingly important practice across the Region in the future. However, this practice has its drawbacks. Irrigation is expensive and can put a strain on local water supplies. In Peel Region very few water taking permits currently exist for agriculture. There are many permits already issued for other uses in the area north of the escarpment, which may mean that water is not available for agriculture under climate change.

Farmers can mitigate the negative effects of drought in other ways as well. For example, type of cultivar, tillage practices, and pest and nutrient management strategies all play a role in determining the vulnerability of crops to drought.

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Thresholds at Which Wheat and Soybeans Show Negative Impacts of Drought

Crop Stage of Development	Wheat Threshold	Soybean Threshold
Initial stage	30 days of reduced rain (< 9 mm)	10 days of reduced rain (< 8 mm)
Developmental stage	30 days of reduced rain (< 34mm)	20 days of reduced rain (< 35 mm)
Middle stage	40 days of reduced rain (< 119 mm)	40 days of reduced rain (< 131 mm)
Late stage	40 days of reduced rain (< 85 mm)	20 days of reduced rain (< 33 mm)
All stages	More than 8 consecutive days without rain	

Storyline 3: Extreme Heat

The frequency, intensity and duration of heat waves is expected to increase in Peel Region under climate change. Heat stress affects plants in a variety of ways:

- Reduced photosynthesis
- Scorched leaves and stems
- Dead leaves and seeds
- Reduced pollen production and viability
- Reduced grain number and weight

Most plants are more vulnerable to extreme temperatures when they are in their reproductive stage, and even short spikes of heat (a few hours long) can dramatically reduce crop productivity and yield. Farmers may need to switch to crops and cultivars that are bred to withstand higher temperatures. They may also rely increasingly on irrigation, which cools plants and reduces heat stress. Drought and extreme heat will interact under climate change to amplify damage to crops.

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Storyline 4: Changes to the Timing of Growing Conditions

Climate change will alter temperature and rainfall patterns, affecting both growing conditions and length of growing season.

Climate change will alter temperature and rainfall patterns, affecting both growing conditions and length of growing season. Farmers will likely be able to plant and harvest crops earlier than they have in the past, which will be beneficial as long conditions remain favourable for crops throughout the season. For example, if frost occurs during the earlier planting period this may damage crops early on in the season. Similarly, extreme rainfall or heat waves over the course of the summer could reduce any gains in yield from a longer growing season.

Crops respond differently to changes in conditions depending on their type and stage of development. In southwestern Ontario, precipitation in January and April could mean lower corn and soybean yields, but higher wheat yield. Precipitation in July, meanwhile, could lead to higher yields of corn and winter wheat. While drought is expected to become more common, heavy rainstorms will also be more frequent in summer. Even a modest increase in total summer rainfall (50 mm more in a season) could help counteract the damaging effects of increased heat on crops, with potential increases in yield of 5-10% for wheat and soybeans.

An extended growing season and warming temperatures could have positive impacts initially on corn and soybean yields. Climate projections suggest, however, that after a certain threshold these crops could collapse.

Where Do We Go From Here?

Climate change is real and it's happening now. This vulnerability assessment has shown that there are many potential negative impacts of climate change on farming in Peel Region. However, by taking a proactive approach to the problem, farmers and agricultural decision-makers can minimize harmful effects on the agricultural sector, while at the same time taking advantage of new opportunities of a changing climate.

Adaptive Management Considerations

Agricultural adaptation to climate change will need to occur across multiple scales, both on and off the farm. Specific approaches may differ throughout the Region, since the extent and nature of climate change impacts is expected to vary geographically based on soil type. A wide array of farming best management practices, technologies and strategies already exist that could form part of an adaptation plan for farming in Peel Region.

Farms within Peel Region have a higher rate of adoption of BMPs relating to soil conservation and environmental protection compared with other Ontario farms. However, most of these practices are used in fewer than 30% of farms in the Region, showing that there is considerable opportunity to expand their benefits. These BMPs represent a critical way to address many of the vulnerabilities highlighted in the storylines. They also provide additional benefits for farms, by conserving soil and water resources while lessening reliance on artificial farm inputs. Advancing the use of these and other innovative approaches to farming will position Peel at the leading edge of agricultural adaptation.

Select Best Management Practices and Potential Benefits for Reducing Vulnerability

On-farm Practice	Climate Resiliency Benefits
Conservation tillage/no till/intercropping	Minimize soil erosion and runoff; retain soil moisture; retain nutrients, pest management, frost protection
New rotations, harvesting schedules and varieties	Take advantage of new climate regimes by double cropping, staggering crops, and planting crops adapted to the different growing conditions
Drainage	Reduce flooding
Water reuse	Mitigate drought
Ongoing monitoring	Test field practices (timing, techniques) and climate resilient crop types to optimize best approaches under climate change
Off-farm Practice	
Funding	Provide financial support for testing of new field practices and crop types
Communication	Promote transfer of knowledge and success stories within the farming community

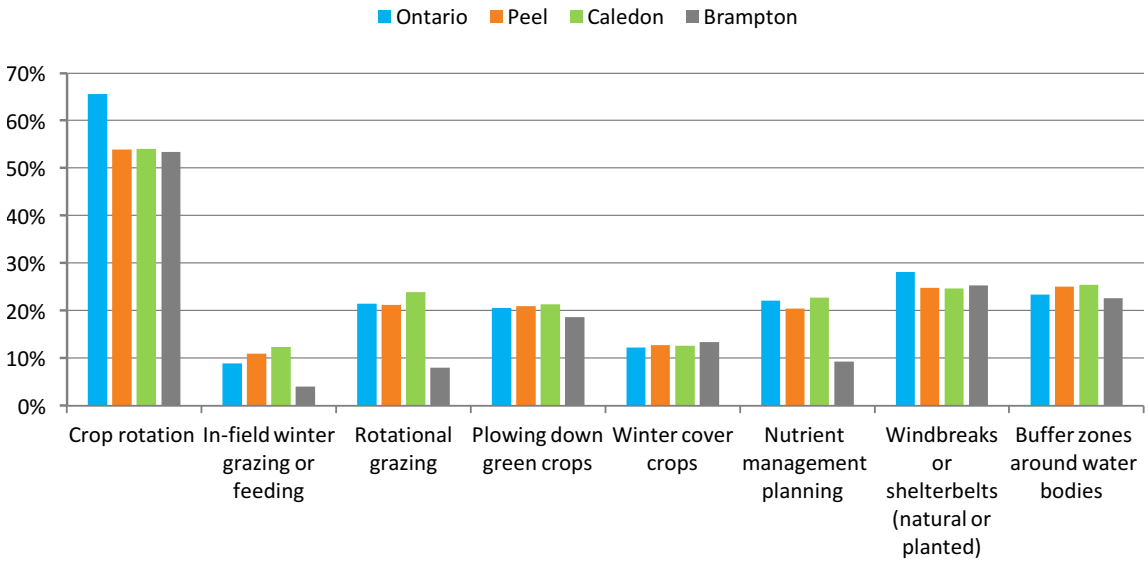
WHAT THIS VULNERABILITY ASSESSMENT IS

- Part of the research phase of the adaptive management process Peel is undertaking to respond to climate change
- Technical assessment to understand how agricultural systems in Peel respond to climate change
- Characterizes current climate vulnerability and how this might change in the future under climate change
- Provides evidence and information needed to inform adaptation
- Precursor to developing an adaptation strategy for protecting agricultural systems
- Provides background information that could be used in future risk assessments
- Developed through widespread consultation with local stakeholders (farmers and agricultural decision-makers)

WHAT THIS VULNERABILITY ASSESSMENT IS *NOT*

- Not a prescriptive plan for addressing vulnerabilities and impacts
- Does not rank the relative significance of different climate change effects on agricultural systems
- Does not evaluate resources or programs available in Peel Region to support adaptation planning and implementation

Adoption Rate of Agricultural Best Management Practices by Farms Within Peel Region and Ontario (From the 2011 Census).



Strengthening Adaptive Capacity

Climate change will bring considerable uncertainty and variability to agricultural systems. As a result, business as usual may no longer be effective. Farmers and decision-makers will need to be flexible and responsive to build resiliency under these new conditions.

Many potential approaches exist for building adaptive capacity, and it can be challenging to assess and prioritize the best way forward. At a systems scale, Agriculture and Agri-Food Canada has developed Envision, an integrated decision support tool based on scenario testing to enable adaptation planning on a landscape scale: <https://www.iisd.org/sites/default/files/publications/mainstreaming-climate-change-toolkit-briefing-note.pdf>

Farmers will need to actively engage with stakeholders beyond their farms for adaptation to be truly successful. The cooperation, knowledge and support of both upstream and downstream players will be essential. Upstream, companies that supply farmers will need to understand how to adapt to climate change, so that this information and associated products can be passed along to farmers. Downstream, farmers will need to consider the preferences of wholesalers, exporters, retailers, and consumers when they make their choices on crops, technologies and practices best suited for climate change. Also, farmers should plan to communicate with other downstream markets to let them know what climate change means for farming, and how this may affect product selection, availability and price as a result.