Climate Change Adaptation and Agriculture:

Addressing Risks and Opportunities for Corn Production in Southwestern Ontario

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OCCIAR
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About this Document

The Ontario Climate and Agriculture Assessment Framework (OCAAF) is a decision-support tool for application at regional scales to assess baseline and future agroclimatic risks and opportunities. The goal of OCAAF is to inform policy, program and management choices of key stakeholders in Ontario's agri-food sector so as to maintain or enhance agricultural productivity in a changing climate.

As part of a pilot study, the OCAAF was applied to two different regions and production systems:

1) Forage-based beef production in Ontario's Great Clay Belt, specifically looking at timothy grass; and
2) Corn production in southwestern Ontario, specifically looking at eco-district 7E-1 (see Figure 1).

Application of the OCAAF provides insights into how attributes of climate change may affect agricultural opportunities and productivity in the 2020s, 2030s, 2040s and 2050s. Results can be used by decision-makers to:

- Reduce Ontario production systems' susceptibility to climate change-related hazards now and into the future;
- Realize the yield potential of Ontario production systems now and into the future;
- Equip producers for the adoption of novel crop species; and
- Consider the expansion of warm climate crops to more northerly regions.

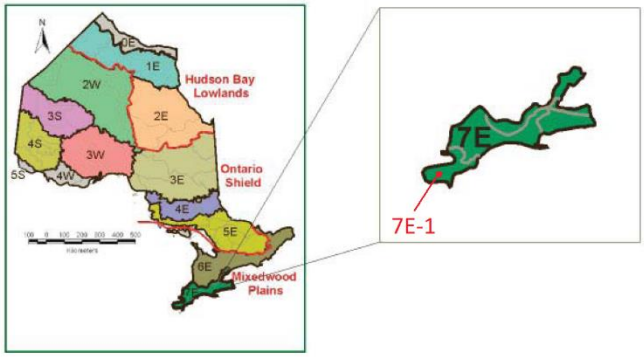

Figure 1: Eco-district 7E-1.

With improved knowledge of the impacts of climate change and other factors on productivity, adaptation options were developed to manage climate change-related risks and opportunities for corn in eco-district 7E-1. Consultation with project advisors and other stakeholders led to the identification of 12 adaptation options that promote increased resilience to climate change in the agriculture sector.

This document outlines these 12 adaptation options which are organized into the following objectives:

1. Encourage water management practices that mitigate the impacts of climate change
2. Improve soil management practices and build soil health
3. Support agriculture research, innovation and knowledge exchange
4. Encourage the implementation of adaptive measures

Several adaptation options are interconnected and build on each other; therefore, some sequencing of options might be necessary. Please see Appendix 1 for a summary of the 12 adaptation options.

Developing the Adaptation Options

Development of the adaptation options involved the following steps:

1. **Identify key management issues**. Results of the OCAAF assessment in southwestern Ontario highlighted the various risks and opportunities that climate change will bring for corn production (see Page 3). With these results, key management issues that target future policy options were identified.
2. **Conduct research**. Research was conducted into the current state of agriculture in southwestern Ontario and on possible adaptation options that would either reduce the risks that climate change presents, or take advantage of opportunities. This involved extensive online research, creating a compendium of adaptation options, and discussions with project advisors and stakeholders.
3. **Develop adaptation options**. Using the compendium of adaptation options and key management issues as a guide, adaptation options were drafted. Smit and Skinner[1] suggest that agricultural adaptation can fall under four categories: technological developments, government programs and insurance, farm production practices, and farm financial management. The adaptation options presented in this document were developed with these four categories in mind.
4. **Validate adaptation options**. The adaptation options were presented to regional advisors and representatives of agricultural organizations in a workshop setting. The objective was to receive feedback and validation that the adaptation options would be useful and practical for agricultural stakeholders in the eco-district 7E-1 region.
5. **Revise adaptation options**. Based on feedback from stakeholders, the adaptation options were revised (if necessary) and finalized.

Who Is This Document For?

The main audience for the adaptation options in this document are provincial policy advisors and program managers from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), as well as other ministries dealing with natural resource management (e.g. Ontario Ministry of Natural Resources and Forestry).

It is expected that the adaptation options will broker dialogue with other government agencies, agricultural organizations, farmers and local communities, thus further extending the goal of adaptation. The options presented here mainly address the goal of adapting agriculture to climate change. Other considerations would factor into evaluating alternative options, such as environmental benefits/costs and the potential to increase greenhouse gas emissions or enhance carbon sinks.

[1] Smit, B and M.W. Skinner. (2002). Adaptation Options in Agriculture to Climate Change: A Typology. *Mitigation and Adaptation Strategies for Global Change* 7: 85-114, 2002.

Overview of OCAAF Results

The following presents a summary of the key results from the application of OCAAF to corn in southwestern Ontario:

- **It will be warmer**. Historical temperatures have been increasing and this trend will continue into the future. Temperature projections for southwestern Ontario in the 2050s, relative to a 1981-2010 baseline, are as follows:
  - Annual: +3.3°C
  - Winter: +3.6°C
  - Spring: +2.8°C
  - Summer: +3.2°C
  - Autumn: +3.1°C

- **It will be wetter**. Historical precipitation has been increasing and this trend will continue into the future. Precipitation projections for southwestern Ontario in the 2050s, relative to a 1981-2010 baseline, are as follows:
  - Annual: +6%
  - Winter: +13%
  - Spring: +13%
  - Summer: no change
  - Autumn: +3%

- **The growing season will be longer**. Growing season length will increase from approximately 182 days (current season length) to approximately 210 days by the 2050s.

- **Crop Heat Units will increase**. Crop Heat Units (CHU) will increase from 3943 to 4923, which is an increase of 25%.

- **Yield will increase**. Currently, the relationship between average corn grain yield and CHU is 8,000 kg/ha. As a result of climate change, this number could increase by 41% by the 2050s to 11,300 kg/ha (see Figure 2).

- **There will be more evaporation**. Between May and September, the region will see an increase in potential evaporation from 552mm to 640mm (an increase of 16%) which could lead to more moisture stress.

- **Better land suitability scores**. The Land Suitability Rating System (LSRS) is an existing tool developed by Agriculture and Agri-food Canada. It is a well-established system that assesses the suitability of land for crop production, based on measurable qualities of three key factors: climate, soil and landscape. OCAAF was designed around the LSRS and results show that southwestern Ontario will see a decreasing LSRS score from Class 1 (no limitations) to Class 2 (slight limitations). This decrease in LSRS score is attributed to moisture stress during the summer months.

For a full summary of the OCAAF results, please visit: www.climateontario.ca/p_OCAAF.php.

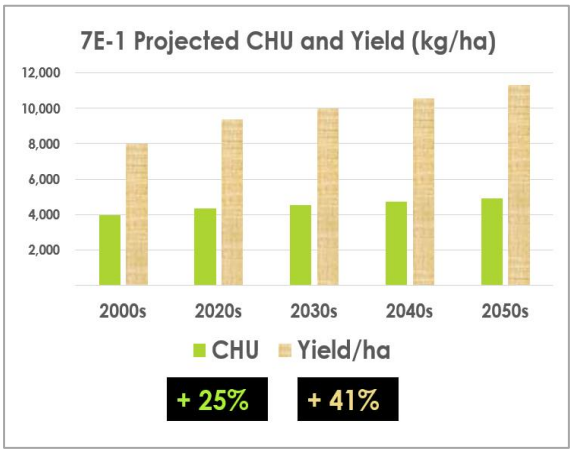

Figure 2: Projections for Crop Heat Units and corn yield for eco-district 7E-1.

Adaptation Options for Grain Corn in Southwestern Ontario

Often times, what are considered 'best management practices' in agriculture also help to combat the risks posed by a changing climate. Many of the adaptation options listed here are not necessarily new; adapting to climate change simply presents an additional reason why these management practices are of immense value to the agriculture sector.

Objective I: Encourage Water Management Practices that Mitigate the Impacts of Climate Change

OCAAF results show that by the 2050s, southern Ontario will be wetter, particularly during the winter and spring, while the summer months are likely to experience dryer conditions when compared to the 1981-2010 baseline. These results indicate that moisture stress will be an issue for corn in eco-district 7E-1; therefore it will be important that farmers are managing water appropriately to handle both periods of wet and drought conditions during the growing season. The following five adaptation options aim to encourage water management practices that will help to mitigate some of the impacts of climate change.

Figure 3: Heavy precipitation in June 2015 near Windsor, Ontario resulted in flooded corn fields (Photo credit: Dax Melmer/The Windsor Star)

Adaptation Option 1

Sustain/increase financial support for farmers to install tile drainage.

Due to the projected increase in winter and spring precipitation in the area, and the risk of more frequent and intense rain events during the growing season, installing tile drainage in southwestern Ontario is an adaptive strategy to improve drainage of excess water from fields. The practice offers a number of benefits such as higher yields and improved crop quality, earlier planting, reduced nitrogen loss, and reduced soil erosion. Tile drainage is already quite common in southwestern Ontario (approximately 70% of agricultural land is tile drained); therefore, it is important to sustain or increase financial support to offset tile drainage installation costs for farmers who do not have tile drainage installed, as this is a practice that comes at a high cost (approximately $1000/acre or more). For example, this support could be delivered through OMAFRA's Tile Loan Program[2] which helps farmers finance the installation of tile drainage. However, finance might not be the only reason why some farmers have not yet installed tile drainage

[2] www.omafra.gov.on.ca/english/engineer/facts/07-061.htm

(see Adaptation Option 3). Further investigation into the constraints or barriers of installing tile drainage in the area would be beneficial.

Adaptation Option 2

Promote the installation of controlled drainage systems on non-tile drained farmland.

Climate change is expected to increase the variability of weather in southwestern Ontario, including periods of extremely wet conditions in the spring, and periods of very dry conditions in the summer. In order to adapt water management at the farm-level for times of both high and low water conditions, controlled drainage systems could be installed where appropriate (i.e. in fields with slopes of less than 1%). These systems are characterized by a metal bar that adjusts an underground box containing a series of dams that control the water level underneath fields. With this controlled system, farmers can adjust the water table under fields, making swings from flood to drought less of a factor (see Figure 4). Controlled drainage systems have been proven to be effective water management systems for corn by increasing yields[3], conserving water and reducing nutrient loss.

Although most of the existing tile drainage systems in southwestern Ontario are too shallow to function with control structures, there are opportunities to promote and install these systems on farmland that has not been tile drained. Thus, new tile drainage systems in areas that are suitable for controlled drainage should consider the specific depth requirements for drains and other design specifications in order to accommodate a controlled system.

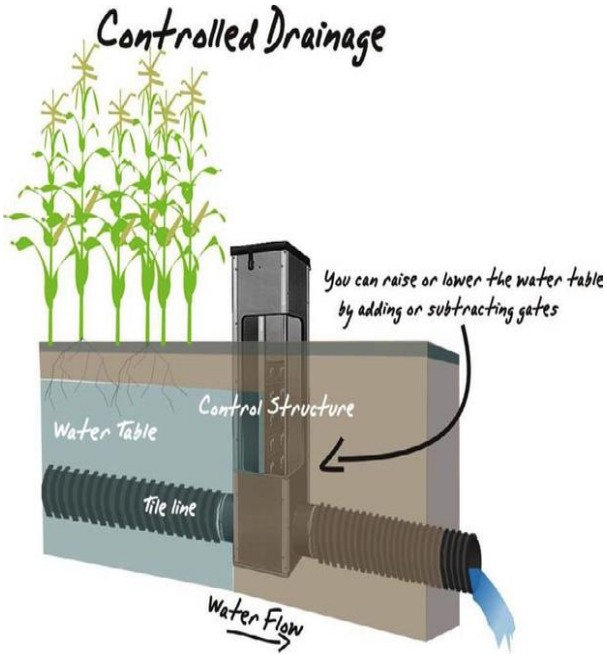

Figure 4: Depiction of a controlled drainage system (Photo credit: Agricultural Drainage Management Coalition)

Adaptation Option 3

Ensure there is sufficient availability of licensed tile drainage contractors in the area.

Since tile drainage is an important practice for managing water at the farm level that will help mitigate the impacts of climate change, it is vital that there are enough licensed tile drainage contractors to meet the needs of farmers. In southwestern Ontario, there is more demand for tile drainage than there is supply of licensed contractors (e.g. some farmers have to book a licensed contractor 2

[3] http://publicentrale-ext.agr.gc.ca/pub_view-pub_affichage-eng.cfm?publication_id=10485E

years in advance[4]). Implementing measures to avoid these long wait times would be beneficial. This could include expanding the tile drainage contractor certification program[5] or reducing licensing restrictions.

Adaptation Option 4

Provide incentives for the installation of on-farm water harvesting and storage infrastructure.

In southwestern Ontario, increasing summer temperatures coupled with minimal changes in average summer precipitation will lead to more evaporation, increasing the risk of drought conditions. Providing incentives for the installation of on-farm water harvesting and storage infrastructure will help to conserve water, maintain a more constant water supply, and help farmers adapt to potential water shortages associated with climate change.

Water storage involves capturing and holding water on the farm that might ordinarily be lost as runoff or in-stream flow, making it available for later use in agricultural production. This can include the capture and storage of water from tile-drained lands into holding ponds, which could then be used to help irrigate fields during dry summers, resulting in water reuse and conservation, and prevention of nutrient loading in local waterways. It can also include the capture and storage of water falling on farm buildings. For example, farmers can add eavestroughs to the roofs of buildings and collect water in rain barrels, small-scale earth-banked water reservoirs, or direct the water to natural wetlands.

Although the water captured on-farm may not be enough to supply irrigation water for an entire growing season, it can be stored and applied to crops during critical growth periods where sufficient moisture levels are essential (e.g. tasseling, silking).

Adaptation Option 5

Create a program to fund on-farm demonstration projects showcasing the benefits of subsurface drip irrigation.

With drought conditions more likely to occur during the growing season as a result of climate change, irrigating corn fields will become more commonplace in the coming decades (currently in Ontario, less than 5,000 acres of corn are irrigated[6]). Overhead systems are a common form of irrigation for corn; however, subsurface drip irrigation is gaining attention as a more efficient system. These low-pressure systems involve burying drip tubes or tape which supply water directly to plant roots, all of which is controlled by the farmer. Some of the benefits of subsurface drip irrigation include: eliminating surface runoff and soil erosion; reducing water loss due to evaporation; providing more efficient water and fertilizer application; preventing weed germination; improving field access; and automation for precise irrigation management. A few demonstration projects have taken place in the province with positive

[4] Personal communication with representative from the Ontario Soil and Crop Improvement Association (June 9, 2017).
[5] www.omafra.gov.on.ca/english/engineer/facts/01-063.htm
[6] www.aginnovationontario.ca/en/ontario-farmers-put-environment-first-in-crop-irrigation

results for corn[7]; however the costs of installing subsurface drip irrigation are often a deterrent from its uptake and can run in the range of $1400/acre. A program to fund demonstration projects throughout the area and communicate the results to farmers would help to build a case for subsurface drip irrigation as an efficient way to manage water at the farm-level and mitigate the fluctuations in moisture availability that are expected as a result of climate change.

For example, something similar to the Water Resource Adaptation and Management Initiative (WRAMI)[8] would be beneficial. This program took place in 2013/14 and allocated approximately $1M to various demonstration and pilot scale projects that showcased innovative technologies and solutions to water conservation and water use efficiency problems within agriculture.

Objective II: Improve Soil Management Practices and Build Soil Health

OCAAF results suggest that both temperature and precipitation will continue to increase into the future. Along with these changes in climate, variability in weather extremes are also expected to increase, leading to longer periods of drought mixed with more heavy precipitation events. Healthy soils can help to adapt to some of these impacts. For example, healthy soils retain water and nutrients that might otherwise be lost due to runoff; reduce soil erosion from fields; and improve water quality downstream. Healthy soils also sequester carbon from the atmosphere and contribute to climate change mitigation. The following two adaptation options represent ways to help improve soil management practices to build soil health.

Adaptation Option 6

Continue to research and promote best management practices that increase soil organic matter at the farm level.

With projections for increasing winter and spring precipitation, the risk of more frequent and intense rainfall events, and the possibility of more drought conditions in the summer, maintaining healthy soils and increasing soil organic matter will be one of the best defences producers have to increase the resilience of their crops to the impacts of climate change. For example, planting cover crops and rotating crops not only increase soil organic matter, but also reduce soil erosion, improve soil structure, reduce the spread of weeds, improve nitrogen and phosphorus levels, and store carbon.

Additionally, farming practices that leave the soil undisturbed can increase the residue on the land surface and improve soil health. By leaving soil undisturbed, soil structure is maintained, fungal networks and microbes are conserved, organic matter is increased, carbon is stored, and yields are also increased. This results in many benefits to farmers, such as: better water infiltration, reduced runoff, reduced soil erosion, and improved soil quality.

[7] www.realagriculture.com/2016/09/corn-school-doing-the-math-on-subsurface-drip-irrigation
[8] www.farmfoodcareon.org/water-resource-adaptation-and-management-initiative

Thus, there is value in continuing to invest in research into best management practices for improving soil quality and soil organic matter at the farm-level and promoting their awareness and use.

Adaptation Option 7

Encourage the protection or creation of natural features such as shelterbelts, hedgerows, wetlands and woodlands.

Natural features such as shelterbelts, hedgerows, wetlands and woodlands help to lessen some of the impacts of climate change on agriculture while minimizing losses in biological diversity, ecological processes and functions, as well as storing carbon. For example, shelterbelts help to protect crops from wind and heat, create wildlife habitat and biodiversity retention, offer fence-line erosion control, reduction of evaporation of water storage ponds, and retention of soil moisture. Wetlands and woodlands provide water management functions and help to filter and retain tile drained water, while hedgerows are an exceptional habitat for pollinators. It will be beneficial for farmers to conserve natural features or create new ones that not only provide adaptive benefits but also help to sequester carbon.

Objective III: Support Agricultural Research, Innovation and Knowledge Exchange

As a result of climate change, southwestern Ontario could see an average annual temperature increase of 3.3°C by the 2050s. With this warming, further research will be needed to identify the types and varieties of crops with the potential to grow well in the area. The following two adaptation options are focused on supporting agricultural research for corn in the region and disseminating that information to those who will use it for their long-term decision making.

Adaptation Option 8

Continue to support applied research into different crops that are well-suited in the context of a changing climate.

Southwestern Ontario will experience greater heat and drought conditions in the summer. In order to continue to produce high crop yields with these more challenging weather conditions, farmers may have to adopt improved cultivars that are more suitable for these new climatic conditions. In order to do this, there is a need for continued provincial support for public and private research and development programs focused on new corn hybrids that are better adapted to climate change.

For example, further research could be conducted on developing corn hybrids that are more tolerant to heat and drought through conventional breeding and genetic engineering, or looking to climate analogues to see what corn varieties are being grown in climates similar to what is being projected for southwestern Ontario (i.e. the Corn Belt in the USA). Additionally, a changing climate could mean looking towards researching new and potentially more profitable crops altogether.

Adaptation Option 9

Improve access and dissemination of information related to climate change impacts and adaptation.

Climate change adaptation in the agriculture sector will be more effective if decision-makers have the knowledge and information they need to manage climate risk effectively. Increasing technical scientific knowledge on climate change forecasts and expected

impacts on the sector will help to inform short- and long-term decision-making by various agri-food stakeholders. Thus, there is a need to improve access to critical climate change data and information on adaptation for agri-food organizations, businesses, government departments and producers to help increase the adaptive capacity of the region.

An important piece for improving access to information is disseminating information to the right people. An information/education outreach program could be developed to disseminate information on future climate change to farmers to encourage adaptation at the farm level. Communication methods could include workshops, site-visits, websites, newsletters, listservs, or an online Community of Practice where members can log on, share information with one another, and participate in online discussions about climate change and implications for corn production in southwestern Ontario.

Objective IV: Encourage the Implementation of Adaptive Measures

OCAAF results show that southwestern Ontario will experience improved corn yields as we move into the 2050s if water stresses are managed appropriately. There are opportunities for farmers to implement adaption options that will not only take advantage of the better growing conditions, but also reduce the risks associated with a changing climate, such as increasing floods and droughts. The following three adaptation options will help to promote and encourage adaptive action at the farm-level.

Adaptation Option 10

Create a program to encourage adaptation in the agriculture sector and reward early adopters.

To encourage implementation of adaptive measures in the agriculture sector, a program could be created that rewards early adopters of adaptive actions that reduce their vulnerability to climate risks. One such program has been launched by the Government of British Columbia, called the Farm Adaptation Innovator Program[9] with funding from Growing Forward 2[10]. It provides direct financial assistance (between 80 and 100% of the project costs) to projects that promote innovation in farm practices, approaches and technologies that support climate change adaptation; demonstrate farm practices that reduce weather related production risks; and develop information and knowledge sharing resources to support adaptation.

These projects could include applied research, pilots and demonstrations that specifically increase the capacity of farmers to adapt to climate change and weather-related production risks and impacts. Applied in Ontario, a similar program could encourage the implementation of measures to increase adaptive capacity of corn producers throughout southwestern Ontario.

[9] www.bcagclimateaction.ca/farm-level/adaptation-innovator-program
[10] www.agr.gc.ca/eng/about-us/key-departmental-initiatives/growing-forward-2

Adaptation Option 11

Promote and encourage farmer uptake in income stabilization and crop insurance programs.

Increasing climate variability, along with more frequent and intense extreme weather events, will lead to more situations where insurance is called upon to help farmers recover from damaged crops. Thus, there is a need to promote and encourage farmer uptake in income stabilization and crop insurance programs. For example, farmers could participate in income stabilization programs such as Agricorp's AgriStability program, which is a whole-farm, margin-based program that protects farmers when their net farming income falls below 70% of their recent average. As well, farmers could participate in established subsidized crop insurance programs such as Agricorp's Production Insurance, which protects producers from yield reductions and crop losses caused by factors beyond their control (e.g. adverse weather, insect infestations).

Adaptation Option 12

Recognize the importance of achieving greenhouse gas emission reduction goals alongside or through adaptation.

With Ontario's new Cap and Trade system, it will be important for the agriculture sector to ensure that agricultural lands are managed in a way that is efficient, sustainable, and will enhance the removal or storage of carbon from the atmosphere. Thus, measures to adapt the agriculture sector to climate change in southwestern Ontario should also work towards climate change mitigation objectives and carbon storage opportunities.

Conclusion

The future success of Ontario's agri-food sector depends on knowledge of future weather and climate implications. The OCAAF was developed to help address this need, as it is a spatially explicit and adaptable risk-opportunity assessment framework incorporating the most recent climate science.

The results of the application of OCAAF to corn production in southwestern Ontario has expanded the knowledge of climate risks and opportunities for the area. Warmer temperatures, longer growing seasons, increasing crop heat units and a potential increase in yield of 41% by 2050 indicate that growing conditions will continue to improve. However, a decreasing LSRS score provides evidence that there will also be agricultural risks in the region as a result of a warming climate (e.g. water stress through potential flood and drought conditions).

With this information, the agriculture sector can make more effective policy and program decisions that increase its resilience to climate change and effectively manage impacts. The 12 adaptation options listed in this document are meant to inform policy, program and management choices of key stakeholders in Ontario's agri-food sector so as to maintain or enhance agricultural productivity under a changing climate. This list of adaptation options is not exhaustive, but represent a selection of adaptation options that could be developed and implemented.

Provincial policy advisors and program managers dealing specifically with agriculturally-related policies and programs should consider climate change adaptation in order to:

- Reduce the susceptibility of corn production systems in southwestern Ontario to weather and climate change-related hazards now and into the future; and
- Maintain or enhance agricultural yield potential for corn in southwestern Ontario under the influence of climate change.

Appendix 1: Summary of Adaptation Options

Table 1: Summary of the 12 adaptation options to manage risks and opportunities for grain corn production in southwestern Ontario as a result of climate change.

Objective I: Encourage Water Management Practices that Mitigate the Impacts of Climate Change	1) Sustain/increase financial support for farmers to install tile drainage.
	2) Promote the installation of controlled drainage systems on non-tile drained farmland.
	3) Ensure there is sufficient availability of licensed tile drainage contractors in the area.
	4) Provide incentives for the installation of on-farm water harvesting and storage infrastructure.
	5) Create a program to fund on-farm demonstration projects showcasing the benefits of subsurface drip irrigation.
Objective II: Improve Soil Management Practices and Build Soil Health	6) Continue to research and promote best management practices that increase soil organic matter at the farm level.
	7) Encourage the protection or creation of natural features such as shelterbelts, hedgerows, wetlands and woodlands.
Objective III: Support Agricultural Research, Innovation and Knowledge Exchange	8) Continue to support applied research into different crops that are well-suited in the context of a changing climate.
	9) Improve access and dissemination of information related to climate change impacts and adaptation.
Objective IV: Encourage the Implementation of Adaptive Measures	10) Create a program to encourage adaptation in the agriculture sector and reward early adopters.
	11) Promote and encourage farmer uptake in income stabilization and crop insurance programs.
	12) Recognize the importance of achieving greenhouse gas emission reduction goals alongside or through adaptation.

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