OMAFRA Consolidated Research Priorities (Updated in 2018)

Ontario Ministry of Agriculture, Food and Rural Affairs

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FINAL

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1: Purpose of this Document

Research and innovation is key to helping the ministry achieve its objectives and support the agri-food sector and rural communities. The OMAFRA-University of Guelph (UofG) Agreement is a critical means to address the research needs of the ministry and its stakeholders, and to support OMAFRA's three core business areas: Economic Development, Stewardship, and Protection and Assurance.

The purpose of the *OMAFRA Consolidated Research Priorities* document is to communicate annual updated research priorities for use directly in the OMAFRA-UofG Agreement Research Program call, and to inform calls for proposals under other OMAFRA-funded research programs in seven theme areas:

- Agri-Food and Rural Policy
- Bioeconomy-Industrial Uses
- Emergency Management
- Environmental Sustainability
- Food for Health
- Products and Value Chains
- Production Systems (plants and animals)

Note to Researchers: Tools and contacts are available to assist with communicating the value, and where relevant, the market opportunity of your research. These resources are particularly important if developing a product, technology or service with the intent of commercialization, but may be useful for all research areas. The tools and contacts focus on components such as identifying the problem your research will solve, identifying future market opportunities, important questions to consider in the early stages of the product/technology/service development process, et cetera. Tools and contacts are available on the University of Guelph web site.

2: Agri-Food and Rural Policy

2.1 Alignment with Ministry Core Business Areas

This research theme focuses on all three core business areas to support the sustainable development and long-term success of the agri-food and rural sectors.

2.2 Definition and Scope of the Theme

Ontario's agri-food sector and rural regions are significant contributors to regional economies and to the province. A key policy concern for OMAFRA is how to facilitate the sustainable development and long-term success of the agri-food sector and rural regions while ensuring that the public interest is served.

The research priorities in this theme are focused on the ministry's three core business areas to help build expertise and support evidence-based policy development to facilitate the sustainable development and long-term success of the agri-food sector and rural regions. They are outlined below:

A. ECONOMIC GROWTH

This theme will examine economic development opportunities for the agri-food sector, as well as rural regions. Specific areas of focus in relation to economic development opportunities are:

- Trade and competitiveness
- Business risk management
- New and clean technologies
- Labour attraction and retention
- Trade policies and sustainability
- Innovation and place-based rural economic development

B. STEWARDSHIP

For this theme, research will explore policy tools and evidence to inform the development of policies that will enable and/or facilitate producers and agri-food businesses to sustainably manage natural capital for continued competitiveness and sustainable growth.

Issues for research in this core theme will also include farmland protection, resource and energy conservation, soil heath, and water management.

C. PROTECTION AND ASSURANCE

Research under this theme will examine the role of industry, government and others in enhancing public trust in all aspects of Ontario's agri-food sector production practices.

D. OVERARCHING

Research will examine how to facilitate access to information.

For each of the Agri-Food and Rural Policy research priorities below, policy issue statements and questions are provided. These questions provide context and are intended to guide researchers in the development of appropriate approaches to fulfill the overarching policy objective.

2.3 Agri-Food and Rural Policy Research Priorities

A. ECONOMIC GROWTH

A1. TRADE AND COMPETITIVENESS

Policy Objective:

Provide support to Ontario's agri-businesses to remain competitive in domestic and global markets in response to change and challenge in international trade relations and international markets.

Policy Issue Statement and Questions:

Canada and Ontario maintain trade relations with most countries in the world, either through free trade agreements (FTAs), or bilateral trade relations. One of the goals of trade is to increase Canada's competitiveness by expanding exports through new FTAs. Even in countries where Canada already has an FTA it may be challenging to increase exports if there are already well-established supply chains between the target countries and Canada's competitors, such as the U.S. and E.U. New FTAs will help Canada to be on an equal footing with its main competitors, who benefit from tariff rate reductions from earlier FTAs. In order to provide sound, evidence-based policy advice, it is necessary to gain a deeper understanding of new potential markets in terms of consumer tastes and preferences, regulatory environment, business culture, transaction costs and logistics, and level of readiness of Ontario food processing business to successfully expand to these markets.

Ontario works closely with the federal government and provincial counterparts to ensure Ontario's interests are front and centre in trade discussions. This year, the policy research priorities will be focused on assessing the readiness of small and medium food processing companies to expand exports to niche markets in the U.S. and other growing markets, looking at potential scenarios over the next 5 to 15 years. The research related to trade and competitiveness should address at least one of the following policy problems and research questions:

A1.1 Current and potential new Free Trade Agreements

Research problem: To inform policy development and to help the food processing industry to identify strategic trade opportunities, it is important to have a clear understanding of how potential changes in international trade agreements could impact Ontario's agriculture and food system.

What are the wider market opportunities (e.g. India, China, Europe, and South America), market development and market access challenges to successfully engaging the agrifood sector outside of established export markets?

- What can we learn from other jurisdictions with FTAs with these countries?
- What does an FTA with these countries look like for Canada/Ontario in terms of export volumes, regulatory harmonization, logistics, new product development, volume and type of import requirements, etc. for the next five to 10 years from now?
- Given the province's factor endowments and production potential, what types of agri-food products are more likely to be exported to and imported from these countries and how will the agri-food industry be affected in terms of competitiveness and survival when exporting or facing import competition from these countries?

- How has the evolution of trade agreements during the last decade impacted our national trade policy? How will they affect national and provincial policies during the next 10 years?

A1.2 Small and medium size (SMEs) food processing companies' level of readiness for exporting

Research problem: To achieve the goal of facilitating market expansion, the Ontario government should look beyond current traditional export markets. This is particularly important for helping small and medium size food processing companies, with limited production volumes, to be able to export to niche markets. Ontario agri-food businesses could focus on catering to niche markets, product differentiation, and leveraging Canada's reputation for safe, high-quality agri-food products. To be able to provide evidence-based policy advice, we need to know the level of readiness of these type of businesses, as well as, what types of constraints/barriers these companies could face, especially when exporting beyond the U.S.

- To what extent are Ontario food processing SMEs ready to take advantage of these new market opportunities?
- What types of indicators could be developed for assessing the level of readiness of food processing SMEs to engage in new export activities in niche markets?
- What is the process, and what types of physical, financial, human and regulatory resources are needed to establish a competitive edge in these potential niche markets?
- What resources are available to the sector to support product differentiation and export development?
- Why do some individual businesses with export potential not scale up to pursue trade? What type of incentives do they need to engage in exports?

A1.3 Niche ethnic food export markets

Research problem: Empirical observations indicate that some food processing companies which have successfully expanded to niche markets in the U.S. and other countries have started the process by serving ethnic markets in Canada first. This has allowed them to tailor food products and marketing mix according to the tastes and preferences of these local ethnic communities which has helped them to be ready for exporting to niche ethnic markets with similar tastes and preferences. In addition to this particular factor, there may be other idiosyncratic elements that play an important role in the export success of these companies. Understanding these success factors, as well as the constraints and barriers these companies have faced when exporting, is very important to help the government orient its advice and support to the sector about how to take advantage of new potential export opportunities.

- What are the key success factors that have facilitated small and medium Canadian food processing companies to successfully expand into new niche ethnic food markets in the U.S. and other jurisdictions?
- What are the key characteristics of small and medium companies that have successfully captured niche food markets in the U.S. and other jurisdictions? Is there a successful model that could be followed by new exporters into niche food markets?
- What are the most important challenges faced by SMEs in the food processing sector willing to export to niche ethnic markets? To what extent do size, labelling, packaging, product formulation and differentiation, logistics and regulation requirements become obstacles to accessing niche markets?

A1.4 Regulatory Co-operation/Harmonization

Research problem: There is limited understanding of the extent of regulatory harmonization/cooperation between Canadian and Ontario export/import regulations and regulations in countries with which Canada already has FTAs and those with which the country is pursuing new deals. In particular, it is crucial to understand how and when a lack of regulatory cooperation/harmonization could become a trade irritant and how to deal with it.

- In the case of the U.S., what are the trade regulations that have become trade irritants? How big is the problem? How have these problems have been handled to date and with what level of success?
- Are there any success stories in other national jurisdictions from which we could derive best practices?

A1.5 Subnational governmental role in trade negotiations

Research problem: When dealing with trade negotiations the federal government sets trade priorities that affect the whole nation. However, national priorities do not always correspond with provincial priorities. Hence, trade initiatives that may be crucial at the provincial level may be of lesser importance at the national level and may not get the support needed to gain traction. To provide strategic advice about how to handle these types of situations for the benefit of Ontario's food processing sector, it is important to understand how can Ontario discover and maximize its distinct position vis-à-vis other provinces; for example, by looking for best practices in agri-food trade from other subnational jurisdictions.

- How effective are sub-national government interventions in trade negotiations at affecting the outcome of trade agreements and at advancing sub-national trade interests? Is it worth the effort? What can we learn from past experience?

- What can we learn from trade-related coordination between subnational and national governments, in Canada and abroad?
- Where is Ontario specific competitive edge? In which cases, will it be advantageous to pool interests/forces with other provinces when trying to advance the provincial trade agenda? To what extent, and in which areas is Ontario an influencer? How can we use this to our advantage when negotiating with the federal government?
- Have other provinces successfully employed specific models when negotiating with the federal government? Could some of these models be adapted to the Ontario-Canada relationship?
- How do national and sub-national governments in other parts of the world collaborate to improve trade? What types of sub-national interventions in trade have proven to be effective?

A1.6 Consumer and industry trends

Research Problem: Consumer tastes and preferences are constantly changing, some of these changes are temporary, but others become lasting shifts in demand for products or product attributes (e.g. non-GMO, organic, animal welfare, etc.) It is critical for the industry to be able to identify the market trends that are going to strengthen in the future in order to make the strategic changes in production and marketing needed to respond, locally and abroad.

- Over the next 5 to 15 years, what are the major trends in consumer taste and preferences that will impact the competitiveness of Ontario's agri-food industry globally and locally?
- How would those trends differ between the developed and developing world?
- What are the main strengths and weakness of the Ontario food industry to address these potential changes?

Expected Outcome:

The research will enrich the evidence base needed to help ensure that appropriate government strategies, policies and initiatives are in place to support strong trade relations and competitiveness in international markets.

A2. BUSINESS RISK MANAGEMENT (BRM) PAYMENTS AND PRODUCER INVESTMENTS

Policy Objective:

Provide appropriate risk management programs that are comprehensive in scope and effective in helping manage the impacts of production losses, severe market volatility, extreme events and disasters. The intent is to give producers confidence to invest in their farm businesses to manage risks that are less severe, and to contribute to making the sector competitive, innovative and resilient.

Policy Issue Statement and Questions:

One intended benefit of BRM programs is to encourage investment in Ontario's farm operations to innovate and increase competitiveness within a highly volatile sector that is significantly impacted by weather, and by world markets.

- Do Ontario's BRM programs provide a suitable business climate where producers can manage risk and have confidence to invest?
- How effective are BRM programs in encouraging agricultural producers to make long-term investments impacting productivity or profitability in their operations?
- How would one assess the optimal level of government involvement in BRM tools that provides producers with the ability to manage risks, and the confidence to make long-term investments in their operations?
- In addition to managing risk, how would we assess the effectiveness of BRM programs in encouraging agricultural producers to make investments in public goods in their operations, such as environmentally sustainable management practices?
- How do we measure the complex impact of BRM programs over time? For example, by using or developing tools such as business analytics?

For additional questions related to Business Risk Management, please see Section B5.

Expected Outcome:

Provide evidence to show the impact of BRM programs and long-term investment tendencies of producers.

A3. AGRI-FOOD VALUE CHAINS

Policy Objective:

To foster the development of fully-functioning agri-food sector value chains within both Ontario and Canada, and to foster the entry of these value chains into global value chains.

Policy Issue Statement and Questions:

Ontario has the largest agri-food sector in Canada. In 2016, the sector generated $37.6 billion in GDP, exported $14.8 billion in products and employed 11.5% of the province's labour force. Globally, demand for food is rising with population growth and an expanding middle class. Ontario has abundant resources such as land and water to increase output and serve global market demands. But there are barriers to development of efficient, fully-functioning value chains and to the entry of domestic value chains into global value chains.

Research should address the following:

- Determine the factors that create barriers to the formation of effective value chains and the role that they play in entry to global value chains and global markets.
- Where strong, effective value chains exist, what are the factors that lead to benefits from having close ties to a family of suppliers and related businesses?

- As one member of a value chain grows, how does growth get mirrored in other segments of the chain? From a sectoral perspective, how does growth cascade from increased consumer demand along a value chain? What are the factors defining how scale up and growth can be coordinated along a value chain?

Expected Outcome:

The resulting information would enable OMAFRA to develop options for decision makers on how best to encourage the development of fully functioning sector value chains and their entry into global value chains.

Note to Researchers: Researchers seeking help in identifying potential priorities and collaborators may contact Barb Alves by email at Barb.Alves@ontario.ca or by phone at 519-826-4479.

A4. NEW TECHNOLOGIES

Policy Objective:

To position Ontario as a centre of research and commercialization in agriculture and food processing technology.

Policy Issue Statement and Questions:

Ontario benefits from the development, adoption, and diffusion of new technologies to improve agriculture and food processing. It is expected these innovations will improve the competitive position of Ontario agriculture and food producers, or at least prevent them from falling behind other competitive jurisdictions. Given the rapid pace of advanced technology development, there is interest in ensuring that Ontario does not lag behind in rolling out new technology to the industry but rather fully benefits from the commercialization of the technologies. How can Ontario's agri-food sector be best positioned to adopt and take advantage of these new technologies? Are there legislative or regulatory barriers that are discouraging adoption?

Expected Outcome:

The research will provide information that will assist the ministry in developing policies and programs to encourage the research and commercialization of innovative new technologies in Ontario.

Note to Researchers: Researchers seeking help in identifying potential priorities and collaborators may contact Kevin Ferraro by email at Kevin.Ferraro@ontario.ca or by phone at 519-826-3875.

A5. LABOUR ATTRACTION AND RETENTION

Policy Objective:

To understand what efforts are needed to maintain the provision of adequate and suitably skilled labour to Ontario's agri-food sector.

Policy Issue Statement and Questions:

Demographic changes in Ontario/Canada and the introduction of advanced technologies are expected to greatly impact the domestic labour market. How will the supply of workers, their skillset and their

interest in the agri-food sector as a career path affect labour supply? How can provincial policy adapt to ensure that evolving labour needs and employer skill requirements can be met best?

Expected Outcome:

The research will provide information that will assist the ministry in devising strategies to ensure that economic development in the agri-food sector is supported by adequate access to labour.

Note to Researchers: Researchers seeking help in identifying potential priorities and collaborators may contact Jill Melo-Graydon by email at Jill.MeloGraydon@ontario.ca or by phone at 519-826-3467.

A6. DRIVERS TO ACHIEVE SUSTAINABLE SECTOR DEVELOPMENT THROUGH CLEAN TECHNOLOGY

Policy Objective:

Derive insights that would impact clean technology program design to ensure maximum effectiveness and efficiency for both adopters and producers of clean technology.

Policy Issue Statement and Questions:

Improving environmental sustainability, decreasing costs and improving competitiveness are all related in that they tend to deal with improved efficiency and the reduction of waste.

Clean technology is any process, product, or service that achieves all of these things through:

1. Resource management activities that result in a more efficient use of natural resources and inputs;
2. The use of goods that have been modified or adapted to be significantly less energy or resource intensive than the industry standard; or,
3. Environmental protection activities that prevent, reduce, or eliminate pollution or any other degradation of the environment.

The federal definition of "clean technology" is very similar. Both federal and provincial clean technology initiatives demonstrate a commitment to use the transition to a low-carbon economy as a lever for economic development through the development and adoption of clean technology economy-wide. For example, in the 2017 federal budget, the federal government committed at least $2.2B of funding to this sector.

Research should address the following:

1. Many observers have described the conflict between environmental goals and firm profitability as a false debate. How could a discourse analysis of clean technology program adoption, promotion and clean technology uptake in businesses be used to inform best practices in program design and promotion to ensure that the funding and services that governments intend to provide is effective in accomplishing objectives?
2. What type of investments would bring the most benefits to the agri-food sector (e.g. energy productivity technologies, bio-based packaging, automated production line systems coupled

with on-the-line monitoring tools for temperature, PH, and humidity, or contaminants to reduce food recalls, and food waste) that could in turn be used to incent adoption?

3. Which sectors/subsectors could benefit the most from new or continued investments in clean technology that could inform targets in programming?
4. Which emerging local and national markets provide the greatest potential for new agri-clean technology product development (e.g. biofertillizers, and agri bio-based products, water, energy and waste reduction technologies) that could inform targets in programming?

Expected Outcome:

Insights to inform effective and efficient clean technology program design to meet Ontario's sustainable economic development goals.

A7. RURAL ECONOMIC DEVELOPMENT

A7.1 Place-Based Economic Development for Rural Ontario

Policy Objective:

Understand the role place-based economic development can play to improve rural prosperity in Ontario.

Policy Issue Statement and Questions:

There is increasing recognition that prosperous rural communities and regions have a few things in common: they took initiative and control for economic development; strategic planning was done at the community and regional level; and cooperation was sought with other communities. "Place-based economic development" focuses on the unique features of particular places and regions, building on existing assets, and using them to attract new investment and strengthen existing businesses. It entails targeting investments to particular parts of the local and regional economy that offer the greatest potential.

Research is needed to address the following questions:

- What role has place-based economic development played with community and regional prosperity in rural Ontario?
- What are the factors that contribute to successful place-based rural economic development and which factors contribute to failure? Do these factors differ based on the type of rural community/region, including: rural/remote; rural urban adjacent; and rural indigenous?
- What do existing evaluations and research show that place-based approaches have (or have not) achieved?
    - What conclusions have been drawn about the effectiveness of place-based approaches versus other development strategies?
    - What is known about the cost effectiveness of place-based approaches compared with other development approaches?

- How does this evidence inform when and where place-based approaches should be used, and the contextual success factors?

- What are the most effective place-based economic development strategies for rural communities and regions? Do these strategies differ based on the type of rural community/region, including: rural/remote; rural urban adjacent; and rural indigenous?

Expected Outcome:

Provide evidence to OMAFRA and the Province on the role place-based economic development can play to improve rural prosperity in Ontario.

Research will also identify effective place-based economic development strategies for rural communities and regions in Ontario.

A7.2 Innovation and Rural Economic Development

Policy Objective:

To better understand the future impacts of innovation on rural economic development and how to enhance the innovative capacity of rural areas in Ontario at the community and regional level.

Policy Issue Statement and Questions:

It is widely understood that innovation is a key competitive factor to sustain or gain regional, provincial and national wealth. Businesses that develop and successfully implement innovations permit themselves and, in the process, regional, provincial, and national economies, to achieve higher levels of production and development, as opposed to areas with little or no innovative capacity. This implies that a key way to promote economic growth and regional development is through the development and implementation of innovations by firms (e.g. agri-tech and agri-innovation). Innovation in this sense encompasses knowledge in all forms, from simple and routine procedures of everyday life, to the methods of organization and management in enterprises large and small, from the machines that produce enormous quantities which formally required many workers, to the complex scientific investigations that create new inventions and products.

Given the association between innovation and increased economic development, innovation is a logical direction for local, regional, provincial and national economic development efforts. However, innovation is also creating uncertainty for economic development in the future. From 3D printers and the “Internet of Things” to artificial intelligence and automation, new and emerging technologies are radically changing the way we work and the types of jobs we will do in the years ahead.

Research should focus on understanding the uncertainty and future impacts of innovation on rural economic development and strategies to promote innovation in rural areas at the community and regional levels.

- What lessons can be learned and applied from a review of the research findings into place-based innovation policy in Ontario and similar jurisdictions in the developed world?

- What approaches have other jurisdictions utilized to successfully encourage innovation in rural areas at the community and regional levels? How have these initiatives contributed to rural economic development?
- How will disruptive technologies such as 3D printing, automation and artificial intelligence impact rural economic development, and what strategies should rural communities adopt to cope with and capitalize on these emerging trends?
- How can local and regional economic development policy and programming best encourage innovation in rural areas at the community and regional levels?

Expected Outcome:

This research will provide essential information about how to encourage economic development in Ontario's rural municipalities and regions.

Research will also identify strategies that rural Ontario communities can use to build their innovation capacity and manage technological disruption.

B. STEWARDSHIP

Ensuring the long-term capacity of Ontario to produce food through farmland protection, soil health, environmentally sustainable agriculture and food processing, and proactive risk management is a priority.

Ontario is home to some of Canada's most productive farmland. However, much of the province's best farmland is under pressure from urban development and other non-agricultural uses, compromising Ontario's natural capital.

Soil, water, energy and other resource use throughout the agri-food value chain has a number of environmental consequences. Agri-food's impacts on the environment include: soil erosion and degradation; declining water quality (including algae blooms in Lake Erie); greenhouse gas (GHG) emissions; loss of biodiversity, such as pollinators; and resource depletion.

In addition to environmental impacts, inefficient and unsustainable practices often impact agri-food productivity and profitability.

The public expects the agri-food sector to operate safely and in a sustainable manner, while providing economic benefits for all Ontarians, as part of its social license.

With increasing pressures on natural resources in a changing climate, the need to maintain the productive capacity of Ontario's agri-food system through sustainable management is greater than ever.

Sound stewardship of our resources will provide fertile conditions for economic growth and enable the continued viability of agriculture now and for future generations.

While Ontario is well-positioned to become a global leader in sustainably produced food, fuel and fibre, research is required to better inform policy and program development to understand how best to support sustainable economic growth, that enhances competitiveness and efficient use of resources.

B1. FARMLAND PROTECTION

Policy Objective:

To better understand the effectiveness of existing farmland protection policies and identify and assess practical policy responses that address key land use issues affecting the economic viability of the agri-food sector.

Policy Issue Statement and Questions:

As part of the province's commitment to fostering a thriving agri-food sector, Ontario has introduced several policy changes to strengthen farmland protection and support the social and economic viability of the agri-food sector. Under the farmland protection theme, research is required in a number of key areas to assess the effectiveness of existing policy and provide information to support the development of future provincial policy and guidance.

Research Questions:

- Beginning and next generation farmers are expressing concerns about their ability to either access land or remain on the family farm. How can Ontario's land use planning system support beginning and next generation farmers? What approaches are other jurisdictions taking to address this issue?
- OMAFRA's Guidelines on Permitted Uses in Ontario's Prime Agricultural Areas provide guidance to support implementation of the Provincial Policy Statement (2014) with regards to agricultural, agriculture-related and on-farm diversified uses in prime agricultural areas. Research is needed to assess the effectiveness of these guidelines including measures of their performance in terms of supporting farmland protection, assessing if the policy/guideline have increased the numbers of new businesses, and economic benefits and costs for farmers and municipalities. Research should also identify and evaluate best practices for land use planners to achieve policy objectives for agriculture-related and on-farm diversified uses in prime agricultural areas.
- Ontario has existing land use policies requiring the protection of specialty crop areas. Research is need to better understand the unique microclimatic and/or biophysical factors that can be used to identify specialty crop areas. How can these areas with microclimatic and/or biophysical conditions be defined either locally, regionally or at a provincial level?
- The Provincial Policy Statement (2014) includes lot creation policies that are intended to reduce the loss of farmland to non-agricultural uses, reduce fragmentation of the land base, and facilitate the consolidation and expansion of farm operations. These policies have not substantively changed since 2005. Are these policies being consistently implemented across the province and are they achieving their intended outcomes? Are these policies leading to unintended outcomes or placing certain agricultural sectors or rural communities at a disadvantage? What policy changes might be required to ensure that farmland remains available for commercial agricultural operations in the future? What other mechanisms, besides lot creation, might address concerns that smaller land holdings need to be provided for niche farming and beginning farmers?

- Existing provincial Minimum Distance Separation Guidelines and Formula address setback requirements between livestock operation and other non-agricultural land uses. A similar guideline/formula does not exist to address odour and other nuisance issues associated with non-livestock agricultural operations. What are appropriate measures (i.e. setbacks, buffers and other best management practices, mitigation measures) to avoid, minimize and mitigate odour impacts and other nuisance issues from non-livestock agricultural production (e.g. cannabis production, mushroom production, etc.) on surrounding agricultural operations and rural landowners?

Expected Outcome:

The research will provide essential information to OMAFRA and the Province to assess the effectiveness of existing land use policies and additional information that can inform future policy responses to emerging land use issues impacting the economic viability of the agri-food sector.

B2. SOIL HEALTH AND CONSERVATION

Policy Objective:

Healthy soil is the foundation of our food system. Declining soil quality (e.g. decrease in organic matter and nutrient content) and quantity (e.g. soil erosion) is putting the productive capacity and agri-food system at increased risk. Improving soil health can contribute to reduced greenhouse gas emissions and make agriculture more resilient to climate change.

Policy Issue Statement and Questions:

OMAFRA has worked with industry stakeholders and partners and developed a strategy to address shared concerns over the long-term health of Ontario's agricultural soils. Several factors are believed to have contributed to observed declines in soil health, including long-term reductions in forage and pasture, simplification of crop rotations, and increased spring and fall tillage. Research priorities have been identified to help reverse the decline in soil health and support the long-term viability of the agri-food sector.

Research Questions:

- What is the current status of on-farm soil management practices in Ontario? This research would build on existing analysis of soil related agri-environmental indicators, assemble and analyze existing data (e.g. census, farm management survey, best management practice adoption data) to broaden the analysis of trends and identify gaps in information, establish comprehensive baseline measures and inform decision-making related to soil health.
- Three soil indicators (soil organic carbon change, erosion risk, and soil cover) are currently used by Agriculture and Agri-Food Canada to chart changes in soil at a broad scale. How can these indicators be modified to provide additional detail at finer scales to support implementation of the soil strategy? What additional data would assist in adaptation of these indicators?
- What are the economic impacts of soil degradation and different land management practices (i.e. crop rotation, tillage, crop residues, cover crops, compaction and other practices)? Conversely, what is the return on investment in terms of time and money for farmers adopting

soil health practices (e.g. conservation tillage, cover cropping, and soil amendments)? What economic modeling tools and approaches are best to estimate economic effects?

- What are the co-benefits of soil health management practices for farmers (i.e. pest control, reduced input costs) and the environment (greenhouse gas emissions and water quality)?
- Focusing on reluctant and/or non-adopters, what types of tools, incentives, learning approaches or strategies would be the most effective in encouraging farmers to make changes to their soil health management practices?

Expected Outcome:

Effective evidence to be used in the development of policies to support improvements to soil health as well as all policy/program work related to the effective implementation of on-farm best management practices.

B3. ENVIRONMENTAL SUSTAINABILITY AND PERFORMANCE

Environmental sustainability is critical to maintaining Ontario's capacity to produce food. Broader public concerns and global demands for environmental sustainability present new opportunities to increase resource use efficiencies. Innovative agricultural products and services (e.g. plant-based packaging, renewable fuels, nutrient recovery and reuse, offsets) can achieve environmental objectives while reducing costs or creating value added for businesses. Demonstrating good environmental performance is imperative to demonstrating the sector's social responsibility and a key driver of public trust in farmers and agri-food producers. It also provides an economic advantage in some markets, in addition to the quantifiable ecological goods and services that benefit the Ontario economy as a whole from a healthy and resilient agriculture landscape.

This section focuses on: (1) identifying opportunities to drive adoption of sustainability practices in the agri-food sector, building on recent advances in behavioural insights and social network analysis methodologies to help the ministry better target stewardship policies and programs, (2) exploring policy frameworks and tools to help the sector adopt new technologies and practices to reduce waste and increase efficiencies (e.g., nutrients, water, waste, energy); and (3) exploring opportunities for traditional ecological knowledge to support Indigenous agri-food production.

B3.1. Driving Adoption of Sustainability Practices in the Agri-Food Sector

Policy Objective:

To better understand the range of policy tools available to increase adoption of best management practices that improve the agri-food sector's environmental performance, support competitiveness, enable long term economic profitability and help to uphold the sector's social responsibility.

Policy Issue Statement:

Governments around the world are looking to new ways to incent producers and agri-food businesses to integrate environmental stewardship into mainstream business decisions. Research is needed to better understand the drivers and determinants of adopting environmentally responsible management practices and to explore the range of non-regulatory policy tools (e.g., market based tools, information on economic and financial benefits) available to promote/support increased adoption.

Research Questions:

- What new policy tools are being used by other jurisdictions to incent producers to integrate environmental stewardship practices into their operational decisions, and how could they be applied in Ontario (e.g. market based tools, social capital incentives, land-tenure agreements, business risk management)?
- What factors influence farmers' management choices in cropping and soil management (e. g. short or long term economics, social norms, family and social relationships, convenience, management experience, perceptions, beliefs, impulses, etc.)? Sociology, psychology, neuroscience, social marketing, and behavioural economics can reveal key factors influencing soil management decisions by farmers.
- What are the differences in needs and barriers among farmers regarding BMP adoption (e.g. commodity, part-time/full-time, off-farm income, learning styles, age, farm size and type, social factors, etc.)? What types of strategies (tools, incentives, communication and learning approaches) are most effective at encouraging adoption for different segments?
- What types of communication and learning approaches best support adopting a system of practices to benefit ecosystem health?
- Are there specific individuals groups or organizations considered leaders on stewardship practices? How can these social networks be connected and leveraged to improve learning across the agri-food sector and motivate adoption of BMPs?

Expected Outcome:

A set of recommendations on how to motivate desirable changes in agriculture sector practices and increased permanent adoption of environmentally beneficial management practices.

B3.2. Efficient Use of Resources (water, nutrients, energy, reduced waste)

Policy Objective:

Evaluate the range of policy tools and approaches to incentivize and enable resource use efficiencies and sustainable use of natural capital as it applies to the agri-food sector; and understand the policy tools required to enable the agri-food sector and rural communities to take advantage of sustainable growth opportunities (e.g., environmental offsets, carbon neutral farming) and improved productivity and profitability.

Policy Issue Statement:

A key challenge for the agri-food sector and rural communities is to achieve continued productivity, competitiveness and growth whilst increasing efficient use of resources (e.g., water, nutrients, and land) and reducing greenhouse gas emissions. Understanding new and emerging innovative technologies, practices and services for the sector to improve resource use efficiencies as well as ways to measure and demonstrate efficiency outcomes, are needed to inform policy and program development (especially non-regulatory) that supports the sector to implement stewardship innovation and leverage economic opportunities.

Research Questions:

- Nutrient/Phosphorus Circular Economy
    - What are the opportunities and barriers for nutrient/phosphorus trading on a lake basin scale (e.g. Lake Erie basin), including opportunities for recovery and reuse technologies, in the agriculture and agri-food sector in Ontario?
    - How can blockchain-type technologies enhance sustainable production, traceability and public trust in agriculture and agri-food production?
- Rural Green Infrastructure
    - What is the current impact of rural green infrastructure (constructed and natural) on management of water quality and quantity in Ontario?
    - What would be the most effective policies to enhance the use of rural green infrastructure on public and private land for water quality/quantity, pollinator habitat, and carbon storage? What are the costs and benefits of expanding the use of rural green infrastructure, and what are the economic and social drivers for change?
    - What new techniques and/or technologies exist to further enhance the use and effectiveness of rural green infrastructure?
- Food Waste in Agri-Food Systems
    - What barriers exist to increasing the amount of surplus, edible food that is recovered in Ontario (including infrastructure gaps and social attitudes, such as misconceptions about perishability and stigma associated with recovered food) and how can food recovery be further promoted as a means of reducing food waste in Ontario?
    - What compostable packaging options can the food and beverage processing sector rely on to successfully reduce waste? What are the barriers to ensuring certified compostable products and packaging are diverted from disposal and how can they be overcome? To what extent are consumers willing to pay a premium to acquire a compostable version of a product (or the packaging used for a product) versus a conventional one made from non-compostable materials?
    - What kinds of incentives, disincentives or other policy tools are most likely to prompt a change in customer behaviour (e.g. a financial or other incentive) to reduce the amount of green bin waste that is generated at food service establishments?
    - What opportunities exist to up-cycle organic waste materials that are currently being sent for composting or anaerobic digestion? What barriers (including infrastructure gaps and social attitudes/misconceptions) exist to segregating these materials and commingling them for efficient supply to a firm that can make use of them in a value-added application?
    - How can agricultural producers and processors of packaging materials benefit from increased use of compostable packaging materials?

- What barriers affect the recovery, processing and distribution of organic food waste for use as an organic amendment on farms? Food and organic wastes are often distant from many farms needing soil amendments. Such soil amendments are often not widely available, or are available at prices too high for widespread use. How can transportation costs and other challenges be overcome? What organizational approaches can allow efficient acquisition of organic amendments by many individual farmers without high transaction costs?
- Can pyrolysis or gasification technology be implemented as a cost-effective means to process organic and other waste materials in Ontario that may not be suitable for current waste diversion methods (e.g., packaged food waste)? Is the resulting biochar suitable for agronomic uses in Ontario?

- Energy Efficiency and Greenhouse Gas Emissions
  - What are the policy barriers and opportunities for Ontario's rural communities and agricultural stakeholders to transition toward resource use efficiency, such as energy self-sufficiency (e.g., waste free production systems, carbon neutral farms)?

B3.3. Indigenous Traditional Knowledge

Policy Objective:

Better understand the ways in which traditional knowledge can inform agriculture and food production approaches and how it can support economic development and stewardship objectives for indigenous communities.

Policy Issue Statement and Questions:

Indigenous communities have engaged in sustainable land management and food harvesting practices in Ontario for thousands of years based on traditional knowledge. There are opportunities for Indigenous cultural revitalization, increased food security and enhanced economic opportunities for Indigenous communities by engaging in the growth of the agriculture and agri-food sector, which will benefit the cultural landscape, environment and economy of Ontario as a whole.

Research Questions:

- How is Indigenous traditional ecological knowledge currently being used in agriculture and agri-food production?
- What are the barriers and opportunities to share and learn from traditional knowledge to:
  - Supporting Indigenous food security;
  - Developing new Indigenous economic opportunities through traditional foods and other products; and
  - Enhancing environmental sustainability practices in the broader agriculture and agri-food sector?

B4. SUSTAINABLE GROWTH: NEW MARKETS AND TRADE

Policy Objective:

To better understand market trends related to sustainability (from local to global) and the implications for Ontario's policies and programs associated with market access, trade and economic expansion.

Policy Issue Statement and Questions:

OMAFRA, Ontario and Canada have an ambitious export agenda to drive economic growth, and is well-positioned to be a global leader in sustainably produced food. As the global demand for sustainably produced food, fibre and fuel increases and becomes a stronger driver of market access/competitiveness, there is a need to understand how Ontario's market development policies and programs can support the sector to take advantage of these emerging growth opportunities, and promote the long term sustainability of Ontario's food production capacity, food system, and rural communities. In addition, it is important to better understand Ontario's relative position related to sustainable farming/production practices and how this influences Ontario's competiveness domestically and globally.

Research Questions:

- What are the growth opportunities and challenges for domestic and export markets under future climate conditions (e.g. will food supply security issues globally provide future export opportunities for Ontario?) and what are the policy tools required to support these opportunities?
- How and where can Ontario's agri-food sector be competitive in the global market place by differentiating its products and/or production practices based on environmental sustainability? What are the appropriate target markets?
- What environmentally sustainable farming or manufacturing practices/production systems will be required in order to compete globally over the next 3-4 years?
- What are the market trends on sustainability standards in Ontario and other jurisdictions? How are agri-food companies and retailers responding to these trends, which standards are emerging as leaders, and what are the implications for policies and programs that could support Ontario's agriculture and agri-food sector to be competitive globally based on environmental sustainable products and production practices?
- What are the barriers and opportunities for Ontario to retain, expand or access new domestic and international business opportunities and markets through environmental stewardship?
- What are the opportunities for Ontario's agri-food sector to participate in voluntary (non-compliance) offset markets (e.g., carbon markets, environmental goods and services)?
- Does the sector have the capacity to participate, and what might be required to further support efforts to participate? What are the incentives and barriers that influence participation?
- What non-regulatory policy tools and approaches have been effective in other jurisdictions to achieve economic and environmental objectives in the agri-food sector; and what approaches

would be most effective within Ontario's agri-food sector (e.g. offsets markets, industry certification standards)?

Expected Outcome:

The research will provide essential information to OMAFRA and the province on emerging market trends related to sustainability (e.g. international retail markets), and the policy tools available to support the sector in retaining market access, and taking advantage of new growth opportunities.

B5. REDUCING RISK AND BUILDING RESILIENCE IN THE FOOD PRODUCTION SYSTEM

Policy Objective:

Increase our understanding of the risks of climate change and variability and opportunities over time, to guide policies that will build resilient food systems and support food security for future generations.

Policy Issue Statement and Questions:

Agricultural productivity is particularly sensitive to the effects of climate change and variability. The Intergovernmental Panel on Climate Change, a scientific and intergovernmental body under the auspices of the United Nations, has concluded that dramatic global environmental changes are already affecting food production, health and ecosystems, and that the world is ill-prepared for future risks. There is a need to assess the broad economic risks and opportunities for Ontario's agriculture and food processing sectors.

Research Questions:

- What capacity is required to make climate-smart adaptive decisions across the agri-food sector? What is the readiness/capacity of the sector (especially small/medium operations) to adapt (i.e., to take actions that build resilience and contribute to a resource efficient economy), and what policy tools are required to support maintaining or improving adaptive capacity and participation in resource efficient operations (e.g. energy efficient/carbon-neutral farms)?
- What are the tools, programs, systems required to enhance the sector's capacity to anticipate risks (e.g., pest and disease outbreaks for animals and plants) under future climate change conditions? Do our current systems help us anticipate our response needs under climate conditions? Do we have a surveillance system for plants, and if not, can one be developed?
- Does participation in business risk management (BRM) programs influence farm-level decisions toward long-term investments that support building resilience to adapt to climate variability (i.e., climate adaptive action)? How has climate variability impacted BRM and income stability?
- How is climate change/variability impacting government liability in providing BRM programs?

Expected Outcome:

Evidence to inform development of policies and approaches to manage risk and improve sector resilience to climate and other risks.

C. PROTECTION AND ASSURANCE

C1. FOOD SAFETY AND ANTI-MICROBIAL RESISTANCE

Policy Objective:

To support efforts to ensure food safety protection and assurance in the agri-food sector. Current policy objectives are to:

- Translate knowledge concerning antimicrobial resistance to support adoption of stewardship practices using methods that are appropriate to the targeted sector (e.g., swine, poultry, etc.).
- Improve awareness and understanding of antimicrobial resistance in agriculture and food-producing sectors through identifying and establishing innovative and effective outreach, education and training that elicits measurable improvements in producer and veterinary behaviour.
- Improve livestock producer and veterinary understanding of effective practices (e.g., alternative products, husbandry practices, etc.) that improve animal health and reduce the need for antibiotics.
- Develop knowledge and support innovations in food safety, animal health and welfare and plant health practices, policies and programs.

Policy Issue Statement and Questions:

Antimicrobials are an important tool for producers to protect animal health and welfare, however, antimicrobials used for routine prevention or growth promotion can encourage resistance. There is increasing concern over the potential impacts of a changing climate and antimicrobial resistance (AMR) on human and animal health in many parts of the world, including Canada. A shift is needed in practices to support protection and assurance in the agri-food sector, including more prudent use of antimicrobials in agriculture.

Food safety, animal health and welfare and plant health continue to be complex issues that would benefit from examining new policy approaches to achieve economic and public protection/trust outcomes.

Research is needed in the following areas:

- What are the economic implications of a shift in use of antimicrobials, including limiting usage to treatment and use of alternative prevention practices?
- From a cost and sustainability perspective, what policy tools (e.g., education, incentives, legislation, etc.) would be most effective to support behavioral and cultural change within specific commodity sectors or industries in the agri-food sector? E.g., reduced use of antimicrobials (animal health); for employee behavior in food processing facilities (food safety); adoption of a formal integrated pest management program (plant health); reduced number of non-ambulatory animals or dead animals at sales barns (animal welfare); etc.
- What are the emerging food safety risks in Ontario caused by a changing climate?

Expected Outcome:

Prioritize risk management options, provide information and support for evidence-based decisions and animal health policy.

D. OVERARCHING

D1. DATA

D1.1 DATA SHARING AND ACCESSIBILITY

Policy Objective:

To support evidence-based decision-making in food safety and environmental policy by supporting the development of tools, strategies and/or mechanisms to facilitate access to information, and creating incentives for researchers to share and provide access to relevant sources of information.

Policy Issue Statement and Questions:

A wide range of governmental, academic, non-governmental and business organizations are involved in the collection and analysis of data relevant to food safety and environmental protection in the agri-food sector in Ontario. However, it is sometimes difficult for policymakers to gain access to appropriate sources of information to support evidence-based decision-making and performance measurement in a fast-paced and technically challenging environment. As a result there is a large and growing need to better understand how we can support evidence-based decision-making and performance measurement through the development of tools, strategies and mechanisms that will enhance sharing and accessibility of data.

Research should seek to address one or more of the following questions with specific reference to issues in environmental stewardship (i.e. soil health, phosphorus, best management practices), land use planning (i.e. farmland protection, agri-food network and/or protection and assurance):

- What strategies, tools or approaches are used by government to access data to support evidence-based policy making and performance measurement? Which of these approaches are most effective, and how can programs be developed to encourage broader adoption of effective strategies?
- What data currently exists and is regularly maintained by external organizations (i.e. AAFC's crop inventory) that could support evidence-based decision-making and/or performance measurement for food safety and environmental protection in the agri-food sector in Ontario? How can the ministry best support efforts to enhance the accessibility of this information?
- What are the major gaps in terms of publicly-available data on food safety and environmental protection issues within the agri-food sector in Ontario? To what extent is this data available in private or proprietary datasets, and what value might it hold to support cost-effective evidence-based decision-making and performance measurement?
- Which policy tools, strategies or approaches are most effective for encouraging academic researchers, businesses and individuals to share information with OMAFRA to support

evidence-based decision-making, and performance measurement related to food safety and environmental protection in the agri-food sector?

Expected Outcome:

Better understanding of the barriers and challenges related to data sharing and accessibility; identification of existing sources of data that could support evidence-based making; identification of strategies to support sharing of data.

D1.2 IMPACT OF EMERGING INTERNET TECHNOLOGIES ON AVAILABILITY AND USE OF DATA FROM THE AGRI-FOOD SECTOR

Policy Objective:

To develop policy instruments that allow the Ontario agri-food sector to take advantage of emerging tools that extract and utilize large amounts of data is a major opportunity for agri-food producers and processors.

Policy Issue Statement and Questions:

Research problem: With the widespread societal use internet-based technology, there is an increasing trend towards using the data generated to improve business decision making. The use of big data and block chain, for example, is expected to have a large impact on smart farming and in the broader supply chain. Opportunities for big data applications by the agri-food sector include, data sharing along the value chain, inventory management in real time, benchmarking, sensor deployment and analytics, predictive modelling for better management, and for reinvent business processes for faster, innovative action and game-changing business models. Likewise, governments around the world are increasing their capabilities to take advantage of big data for improving the effectiveness, efficiency and quality of decision-making in the public sector. The USDA, for example, is investing in big open data projects to harness the power of agricultural data points created by connected farming equipment, drones, and even satellites, to enable precision agriculture for policy objectives like food security and sustainability. Other leading jurisdictions such as the UK are developing synthetic biology roadmaps and strategies to capitalize these opportunities. Some sectors of Canadian agriculture are already digitalized mainly through the use of precision agrifood technologies and the Internet of Things (CPAF, 2017). However, there is still a vast sub utilization of the value of data generated across the agrifood value chain.

From a public policy perspective, it is important to have a better understanding how big data and similar applications could be useful for informing evidence-based public policy development and for establishing benchmarks and performance measures for the agri-food sector. In order to provide policy guidance and advise to stakeholders about use of these tools in agriculture and in food processing companies, it is necessary to develop exploratory research focused on assessing the agri-food industry's current state of affairs on this issue; the potential benefits and negative effects that use of big data and other related tools may entail for stakeholders in the long run, as well what the role of government should be in regulating, facilitating, or promoting these type of initiatives.

- What are the potential benefits of using big data and similar tools by for farmers and the food processing sector? Which are other benefits?

- Are there successful business models in big data usage for agriculture and food processing that could be adapted to the Ontario context?
- Could these the use of these tools, under the current regulatory environment, cause major shifts in roles and power relations among different players in the food supply chain networks now and in the future? Who will be the winners and losers?
- How will governance, the formal and informal arrangements that govern cooperation within the stakeholder network, will look like in terms of agreements on data availability; data access and quality, security, responsibility, liability, data ownership, privacy and distribution of costs?
- What best practices are available, from other jurisdictions, in the use of these tools for improving evidence-based public policy making, e.g. through policy modelling, monitoring, simulation, testing, analysis, and policy compliance?
    - What types of methodological instruments have been developed for examining the extent to which policy-making structures and systems are ready to absorb and analyse the data generated?
    - How could big data and similar tools be used in evaluating the impact of past policy decisions and to simulate potential impact of current or future policies?
    - What the role of government should be in promoting, regulating or facilitating usage of these tools?
- To what extent could big data and similar tools be useful for addressing public policy questions related to competitiveness, trade, and sustainable growth of the agrifood sector? For example:
    - Developing benchmarks and performance measures for monitoring competiveness and productivity;
    - Monitoring import displacement and domestic market growth;
    - Removing barriers and incenting technology adoption and IP development in the agrifood sector;
    - Leveraging natural capital sustainably and preserving reputation for quality and safety.

Expected Outcome:

The research will provide an assessment of the current use of big data and other applications for extracting and sharing data by the agrifood industry, as well as, the physical, technological, and regulatory constraints impeding the sector to incorporate in their business the use tools for extracting and utilizing large amounts of data. It will also provide policy recommendations about the potential role of government in regulating, facilitating, or promoting these types of initiatives.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- **Animal Production Systems** and **Emergency Management** also includes priorities related to antimicrobial/drug and pesticide resistance.
- **Products and Value Chains** also includes priorities related to value chain development and assessment, trade and rural development.
- **Food for Health** also includes priorities related to labour attraction and retention as it relates to food processing.
- **Environmental Sustainability** also includes priorities related to soil and environment health and sustainability.
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

3: Bioeconomy - Industrial Uses

3.1 Alignment with Ministry Core Business Areas

The Bioeconomy-Industrial Uses research theme is aligned with OMAFRA's priorities for economic development by promoting higher value agricultural products and businesses that are based on renewable resources from Ontario's agri-food sector. This theme also supports OMAFRA's stewardship priorities by promoting eco-friendly products and alternatives to petroleum products (biofuels, biochemicals and biomaterials). Agricultural bioproducts also provide opportunities for new innovation and business opportunities for Ontario thus helping Ontario to transition to a low-carbon economy.

3.2 Definition and Scope of the Theme

The **Bioeconomy-Industrial Uses** theme encompasses three major areas of focus, all of which involve use of agriculturally-derived biomass (including food processing residue) to produce some type of bioproduct. The three major product categories considered are:

Biomaterials - includes bioplastics, biobased blends, natural fibre composites, biobased nanocomposites, biofoams, biorubber, biobased paints and coatings, bioadhesives and bioinks, and natural fibres, as well as the resulting end products (e.g. textiles, carpets, mats), rigid components (e.g. tiles, panels, beams and posts, tubes/pipes, casings, or other formed products), or granulated products (e.g. chips, pellets, dust).

Biochemicals – includes industrial chemicals (e.g. cleaners, lubricants, sealants, solvents, intermediate biochemicals (e.g. ethylene), chemical inputs/feedstocks for production of other products (e.g. oils, phenols, resins) and biotech products where at least part of the product is a biological organism, or a component thereof (e.g. enzymes, molecular probes, microbes, yeast, bacteria). Biopharmaceuticals and cosmetics are considered in the Bioeconomy-Industrial Uses research theme, whereas nutraceuticals and functional foods are excluded, as they are considered under the Food for Health theme.

Bioenergy – includes energy feedstocks and biofuels (e.g. ethanol, methanol, butanol, biodiesel, bio-oil, biogas, pellets, hog fuel) as well as the end products (e.g. electricity, thermal energy).

3.3 Bioeconomy – Industrial Uses Research Priorities

3.3.1. FEEDSTOCK RELATED RESEARCH

"Feedstock-Related Research" is defined as research to create unique, sustainable, and/or more robust bio-based/organic feedstocks with the aim of long-term market viability, environmental (e.g. GHG reduction) and societal benefit. This includes research on organic waste streams and research into logistics/delivery of feedstocks, farm gate processing, storage, and transportation.

Priority areas for research are:

a) Utilization of agricultural crop-based residue and by-product streams to create value-added bioproducts such as low or negative value by-products (e.g. glycerol and lignin from biofuel industries), or medium value residues such as Distillers' Dried Grains with Solubles (DDGS) from corn ethanol industries, CO2, and food processing waste streams. For example, research into the economic utilization of residue and byproduct streams at the site where residue is generated could be considered. Such research should also include aspects of environmental sustainability.

b) Development of new or improved crops beyond traditional or existing commodity crops. Examples include:

    i. Agronomy (yield and agro-climatic suitability), selection, breeding and use of biotechnology to improve current or develop emerging crop plants with identity preserved traits for specific industrial chemicals/products/applications, stress tolerance, value-added feedstock for advanced manufacturing like biopharmaceuticals;

    ii. New crops or cultivars of existing crops for biofuel and other industrial applications, such as paints, coatings, lubricants and solvents applications;

    iii. Algae and agroforestry (e.g., use in bioproducts or processes linking benefit to agri-food sector and rural communities);

    iv. Development of new or improved crops beyond traditional or existing commodity crops.

c) Feedstock development, quality development, production optimization, feasibility of storage and supply chain logistics of biobased feedstocks for biomaterials, biochemicals, and bioenergy.

3.3.2. PROCESSING TECHNOLOGIES RESEARCH

"Processing Technologies Research" is defined as research into methods and processes for converting/refining feedstocks to enable cost-competitive products for a variety of industrial uses. This type of research should work towards an integrated approach that may consider multidisciplinary skills, or multiple feedstocks, or multiple products or different technologies. Processing technologies that lead to novel or more efficient uses of biobased feedstock are desirable. The ultimate outcome of

this type of research is increased value (economic and environmental), either of a single component or across products. This type of research includes development of processing technologies that meet market needs, and the pursuit of commercially viable deployment. OMAFRA in particular seeks research outcomes focused on the agri- technology side of this component.

Priority areas for research are:

a) In support of a circular economy, processing technologies research considers total utilization and integrated production of food/feed/specialty crops and high value/added value co-products (e.g. biorefinery, processing strategies for reuse of biobased industrial residues; fractionation of processed food/feed/specialty crops to capture high value co-products which remain after processing and conversion technologies have been utilized).

b) Biological (including genomic, enzymatic, yeast), thermal, chemical and/or mechanical (on and off-farm) processing including nanotechnology-based approaches of the optimized plant biomass to yield bioproducts and enhancement of processes for economic and environmental benefits. For example: cost-effective methods and efficient processes for conversion of agricultural feedstock and development of enhanced quality parameters.

c) Integration of biobased inputs with existing manufacturing industries (e.g., understanding of fossil-based processes and other biobased replacement opportunities).

d) Computer-based models in bioproduct processing for input/output costs (gas, waste heat, feedstock preprocess to end products).

e) Processing technologies for use of biobased feedstock that are responsive to manufacturing issues; this could span all areas of bioenergy, biofibre/biocomposites, or biochemical.

3.3.3. BIOPRODUCT DEVELOPMENT RESEARCH

"Bioproduct Development Research" is defined as scientific research undertaken with the objective of incorporating the results (if successful) into particular product applications based on feedstock from the agri-food sector. The product may be entirely bio-based, an ingredient substitution, or biomass used in combination with fossil fuels. This includes products made from Ontario woodlots, but not boreal forests. Forest products/residuals may be a component or part of a blend, but a product which is 100 per cent from the boreal forest is not included in this definition. OMAFRA would benefit from collaborative research with other ministries and universities in Ontario which are recognized leaders in this research area.

Priority areas for research are value added bioproducts (e.g., plastics, complex chemicals, high-end bio-materials, enzymes, veterinary/pharmaceutical drugs, cosmetics/ personal care products, latex, biopesticides, enabling biotechnology such as microbial tools/products for bioremediation and to drive bioprocesses), particularly those that have Canadian feedstock inputs, immediate processing opportunities and market applications. Examples include:

a) Advanced biofuels, higher-chain alcohols, drop-in fuels, biocrude, biochemicals for platform chemicals and bioalcohol from ligno-cellulosics;

b) Development of biochemicals and biomaterials from corn, soybeans, algae, other crops, and agricultural residue streams, as equal or superior (e.g., performance, environmental and health benefits) substitutes/supplement for petrochemicals;

c) High-performance micro-fibres, nano-fibres, nanoparticles, nano coatings and carbon fibres for light-weight, structural composite applications; biobased lubricants, durability;

d) Bio fillers, composite reinforcement fibres, and biochemicals from agricultural residues and biofuel, agriculture and food processing co-products streams;

e) Carbonization, graphitization, pyrolysis of biomass for advanced biocomposites; advanced carbon material for green materials (e.g., supercapacitors for battery applications);

f) 3D printing and bioproducts development and manufacturing for biomedical and automotive applications, mold design;

g) Sustainable packaging for consumer products like toys and food packaging (recyclable, compostable, high barrier), and waste utilization for value-added bioproducts applications to support a circular economy.

3.3.4. BIOECONOMY – INDUSTRIAL USES POLICY RESEARCH

"Bioeconomy policy research" is defined as research undertaken to help inform government decision-making. Research can include both economic and environmental impacts of the bioproducts sector, as well as identify areas where government initiatives or other tools may help stimulate further development of the sector to enable a successful bioeconomy in Ontario.

The areas of interest for Bioeconomy policy research include:

a) Economic research on bioproducts (e.g., biochemicals/biomaterials/bioenergy). Specific examples include:

   i. Feasibility of transitioning from conventional manufacturing to biobased or hybrid production using agricultural sources;

   ii. Economic viability of the development of bioproducts (biochemicals, biomaterials, bioenergy) including the biorefinery concept (e.g. several streams of value addition for the same feedstock), full utilization concept, or implications of public policies for bioproducts development;

   iii. Barriers to scaling up of biochemical/biomaterial industries;

   iv. Economic and other related impacts (e.g., impacts to other sectors, improved health, land use changes) of biochemical/biomaterial value chain development, including economic returns to primary producers;

   v. Identification of gaps (economic, technology and infrastructure, intellectual property protection) in bioproduct value chains;

   vi. Economics and barriers of using waste stream materials and other feedstock; competitive advantage of integrating waste (e.g., food processing waste), agricultural,

and forestry feedstock supply chains in attracting platform biochemical firms to Ontario;

vii. Scan and inventory of regulatory requirements for any bioproducts or process to reach commercial viability.

b) Research into sustainability (e.g. indirect land use changes, specifically intensification; soil and water impacts) and life cycle impacts, which can be integrated into planning stages of research projects. This research would consider the short and long-term implications of biochemical/biomaterial development with a view to enhancing their competitiveness. Specific examples include:

   i. Life cycle analysis of bioproducts versus conventional petroleum-based products (e.g. quantifying the environmental impacts, including assessment of GHG emissions reductions) and economic benefits associated with different feedstocks, processing technologies, processes and products);

   ii. Development of standards and performance indicators for bioproducts (quality standards of feedstocks and bioproducts to meet industry requirements, as well as environmental, human health and food safety standards);

   iii. Demonstration of co-benefits from agricultural feedstock or bioproducts.

c) Identification of incentives and disincentives that are or are not working in North America or other jurisdictions, related to the adoption and utilization of feedstocks for biochemicals and biomaterials. Specific examples include: research on risk mitigation to be an early adopter of greener products or new crop/market switching; risk management for new crops; procurement; the role of financial sectors/structures.

d) Study on consumer awareness/perceptions/demand on bioproducts (e.g., retail market trends and demand for bioproducts).

e) Study on the infrastructure, and regulatory/policy barriers (municipal, provincial, and federal) to organic waste use.

f) Study on the cumulative impact of multiple policies (e.g., clean technology, GHG mitigation) on feedstock use in the province for biofuels and bioproducts.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- The **Products and Value Chains** research theme has priorities related to **product and value chain development and assessment** that may be relevant to bioeconomy projects.
- The **Plant Production System** theme also has priorities related to the development of new bioproducts (e.g. **product diversification** priority).
- Biopharmaceuticals and cosmetics are considered in the Bioeconomy-Industrial Uses research theme whereas nutraceuticals and functional foods are considered under the **Food for Health** theme.

- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

4: Emergency Management

4.1 Alignment with Ministry Core Business Areas

This theme aligns with the Protection and Assurance core business area by fostering research which focuses on understanding and managing threats and hazards to decrease the frequency or impact of agri-food emergencies. Ontario's agricultural industries are vulnerable to threats associated with globalization including the increased movement of people, plants and animals, new emerging pests and diseases, some of which are associated with a climate that is changing, and the increased urbanization of agriculture. Research undertaken in this theme is necessary to place the ministry and industry partners in better position to respond to and recover from significant threats that negatively impact production systems. The research outcomes provide information to the ministry that supports risk assessment and decision making and the development of tools to support prevention, response and recovery from agri-food emergencies.

4.2 Definition and Scope of the Theme

The Emergency Management research theme focuses on emerging, re-emerging or endemic pathogens and pests in livestock and crops that require (or may require) an immediate and comprehensive response for containment that cannot be handled with typical resources. The theme is rooted in "One Health" at the interface of livestock, ecosystem and human health, with a focus on agriculture. The Emergency Management research theme has an emphasis on evaluating and mitigating the impact of emergencies on Ontario's agricultural sector and related public health, through the lens of the core components of emergency management: prevention, preparedness, mitigation, response and recovery.

Note: Research related to food safety is funded outside of the OMAFRA-UofG Agreement, through the OMAFRA Food Safety Research Program. Applicants interested in applying for funding for food safety projects should apply to that program.

4.3 Emergency Management Research Priorities

The research priority areas for the Emergency Management Research Theme are:

- Threat Identification, Prioritization and Pathway Analysis
- Detection and Surveillance
- Prevention and Control

Successful research proposals will align strongly with at least one of the specific research needs identified in the following priority areas.

4.3.1. THREAT IDENTIFICATION, PRIORITIZATION AND PATHWAY ANALYSIS

There is a need to identify and prioritize emerging, re-emerging or endemic pathogens and pests that require (or may require) an immediate and comprehensive response for containment that cannot be handled with typical resources. It is also important to understand the conditions under which these pathogens and pests may become a threat (e.g. due to changes in the environment). Results of this research will contribute to the ministry's leading role in prevention of, response to and recovery from agricultural related emergencies, help fulfill the Ministry's legislative responsibilities and fulfill commitments to our federal, provincial and industry partners in emergency management.

Specific research needs:

1. Identify, quantify and prioritize the impact of changing environmental factors (including changes in the climate) and the increase of production of food in urban areas on the distribution and spread of pathogens and pests in Ontario.
2. Identify and describe the effect of policy decisions, production and management practices on threats to agriculture and related public health within the scope of this theme (see Section 4.2).
3. Identify and quantify the risks of new or expanding transmission pathways or distribution patterns of pathogens and pests.

4.3.2. DETECTION AND SURVEILLANCE

Preventing the introduction of a pathogen or pest is the most effective means to avoid or minimize risk, and can be considered the most cost-effective approach to emergency management. Effective prevention and control strategies that are affordable and can be broadly implemented are required. Research is required to support the development of innovative products and approaches, including best management practices.

Specific research needs:

1. Define and collect baseline data about pathogens and pests within the definition and scope of this theme (see 4.2).
2. Identify and evaluate efficient and effective risk-based detection and surveillance methods and technologies.
3. Detection and surveillance for resistance to veterinary drugs and pesticide resistance within the scope of this theme (see 4.2).

4.3.3. PREVENTION AND CONTROL

Preventing the introduction of a pathogen or pest is the most effective means to avoid or minimize risk, and can be considered the most cost-effective approach to emergency management. Effective prevention and control strategies that are affordable and can be broadly implemented are required. Research is required to support the development of new products, new approaches and best management practices.

Specific research needs:

1. Develop effective prevention and control measures for pathogens and pests within the definition and scope of this theme (see 4.2).
2. Assess barriers/facilitators to the adoption of prevention and control methods within the scope of this theme (see 4.2).
3. Research and development of efficacious strategies to support emergency response.
4. Development and evaluation of large-scale destruction methods and disposal of livestock which minimizes the impact on animal welfare, the environment and on the people involved.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- Please refer to the **Production Systems** priorities for research needs relating to animal health, plant protection and antimicrobial resistance.
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

5: Environmental Sustainability

5.1 Alignment with Ministry Core Business Areas

OMAFRA's Environmental Sustainability research theme priorities are strongly aligned with stewardship goals of the ministry by providing scientific knowledge and expertise to address agri-food sector's agri-environmental issues like soil health, water quality, nutrient management and changes in the climate.

5.2 Definition and Scope of the Theme

The Environmental Sustainability (ES) research theme focuses on maintaining the ability of natural resources (soil, air, water and biodiversity) to support and strengthen agriculture, food and bioproduct sectors and rural communities by evaluating environmental, economic, and social perspectives. In order to support long-term sustainability of the agri-food sector (agro-ecosystem and food system) and address the concerns of society, OMAFRA invests in this research theme to:

1. Understand the agriculture and food sector's potential risks and benefits to soil, water, air and biodiversity resources;
2. Provide science for the development of credible and evidence-based government policies, programs, new technologies and practices;
3. Assess the effect of environmental policies on the agri-environment, agri-food sector's economics and rural society; and
4. Identify opportunities for agriculture, food and bioproducts sectors, and rural communities to provide solutions for environmental challenges.

5.3 Environmental Sustainability Research Priorities

The Environmental Sustainability research theme is focused on three main priority areas as given below.

- Understanding the science how drivers and stressors influencing the agri-food system's interaction with the natural environment.
- Managing effects of the agri-food system using best management practices (BMPs) that consider economic, environmental and social implications.
- Defining optimum agri-food production system and measuring their provincial impact.

The above three priorities are built on a continuous improvement approach to address ES research needs that support a sustainable agri-food system. Figure 1 describes the ES research continuum showing the linkages between ES research priority areas in moving towards a sustainable agri-food system. The basic and applied research related to agri-environmental drivers and stressors will inform development or improvement and implementation of best practices to achieve desired agri-environmental outcomes. Assessing performance will help to understand if we are able to make any improvement through the adoption of agri-environmental best practices and also to inform what new knowledge or continuous improvements in best practices is needed.

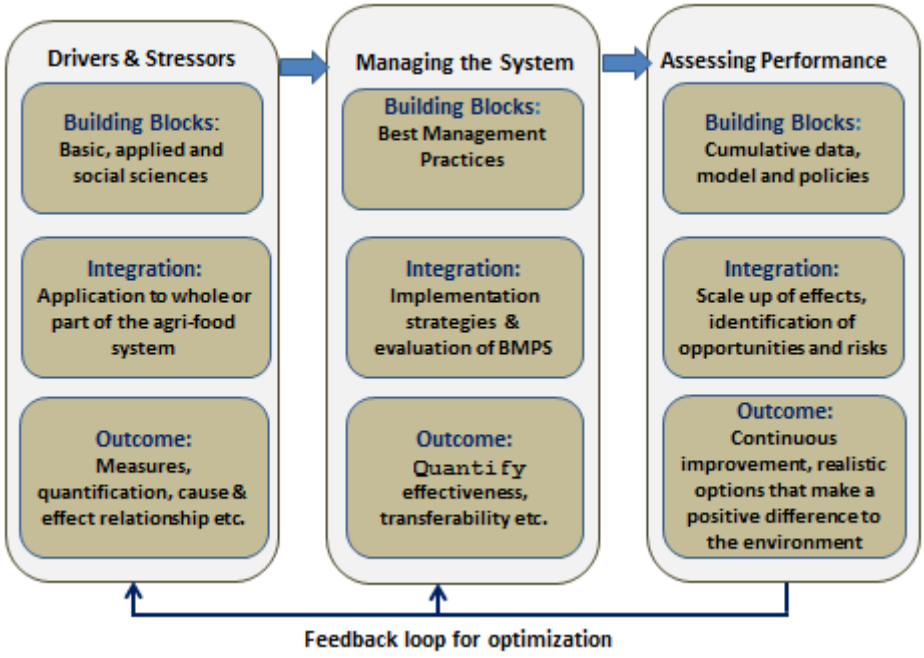

Figure 1: Environmental Sustainability Research Continuum

The three research priority areas are described below with key deliverables. Research proposals should clearly describe how they address one or more of the following priorities.

5.3.1. UNDERSTANDING THE SCIENCE HOW DRIVERS AND STRESSORS INFLUENCE THE AGRI-FOOD SYSTEM'S INTERACTION WITH THE NATURAL ENVIRONMENT (DRIVERS AND STRESSORS)

The agri-food system is both influenced by and influences the natural environment (climate, soil, water, air and biodiversity) and related biophysical processes. A thorough understanding of the science in biological, chemical and physical processes is required to support the measurement of soil health and agro-ecosystem resiliency. Therefore, a detailed analysis and assessment of these relationships allows for more effective management strategies to sustain a resilient and viable agri-food system. The effect of various land use and agri-food practices on the quantity, fate and pathway of contaminants, and soil health needs to be understood and quantified. Concerns for water quantity and quality span many scales from farm to municipality to watershed to the Great Lakes basin. The implications of climate change for water management and other elements of agri-food production in Ontario, such as opportunities for expanding agriculture to the northern Ontario, carbon sequestration and soil health, need to be anticipated and understood. This research area seeks to provide scientific understanding to assist with response options by the agri-food system due to different drivers and stressors in the context of the environment. Research projects need to consider linkages and collection of holistic and integrated datasets for soil, air, water, biodiversity, land management and economics, facilitating understanding of cumulative effects.

This research area will:

- Provide scientific understanding how drivers and stressors influence various biophysical processes of the agri-food production system. The examples of drivers and stressors include: changing production practices, land use, changing climate and extreme weather events, energy, drainage, farm enterprise composition and ownership, increased market competition, end-consumer influence, technologies like precision technology, biotechnology, and Great Lakes water quality (particularly as it relates to phosphorus).
- Understand the science to quantify the impacts (benefits and risks) of agri-food production practices on soil, water, air and biodiversity. The topics of research include: impacts on soil health, soil degradation and loss, soil carbon sequestration, water quality and quantity, GHG emission, wild pollinators, and long-term economic impact.
- Develop and deliver cost-effective and efficient methods to measure the changes in the biophysical processes due to drivers and stressors on the agro-ecosystem. Research projects with life cycle approach can describe and quantify soil health, air emissions, water use and water quality, economics of impacts and rate of behavioural adaptation.

5.3.2. MANAGING EFFECTS OF THE AGRI-FOOD SYSTEM USING BEST MANAGEMENT PRACTICES (BMP) THAT MEASURE ECONOMIC, ENVIRONMENTAL AND SOCIAL IMPLICATIONS (MANAGING AGRI-FOOD SYSTEM WITH BMPS)

This research area supports the development of scientifically credible and cost-effective BMPs, including recommendations for their transferability, prioritization and placement. The goal of BMPs is to reduce adverse effects or accrue benefits of agri-food production. Evaluation and validation projects are desirable even though a practice may not be considered "new or innovative". On-farm or model farm research should be used as much as possible to assess practicality, determine potential

implications and/or synergies (including cost and benefit) between BMPs. Integrated systems analysis should be used to consider the intersection of BMPs in consideration of biophysical, economic and behavioural considerations. Investigation of the link between field scale and watershed scale effectiveness of BMPs is required to assess water quality.

This research area also focuses on demonstration and evaluation of BMPs in the agro-ecosystem management in providing public benefits, in addition to the goods resulting from agricultural production (e.g. food and fibre production). Continued development, evaluation and validation of BMPs are important to quantify trade-offs between soil/water/air/biodiversity impacts and environmental/economic/social/behavioral aspects of a practice.

This research area will:

- Develop new (or improve existing) methods, practices, farm-level decision support tools, and technologies to reduce environmental risks and capture opportunities from economically sustainable agri-food production.
- Identify indicators or metrics to measure environmental, economic, social and biodiversity benefits or consequences of agri-food system management.
- Evaluate potential cumulative impacts (environmental and economic) of multiple BMPs towards meeting multiple agri-environmental goals across Ontario soil types and whole farm production systems.
- Analyze producer behaviour and willingness to adopt BMPs.
- Assess the impact of various environmental policies, practices and technologies in Ontario for agricultural production and food processing.
- Understand the impact of BMPs/changes on the whole farm system including economics, practices, biodiversity, market opportunities, social license etc.
- Analyze and provide foresight on market opportunities for agricultural production that pertain specifically to environmental stewardship and sustainability.

5.3.3. DEFINING OPTIMUM AGRI-FOOD PRODUCTION SYSTEMS AND MEASURING THEIR PROVINCIAL IMPACT

Once we understand and quantify the underlying biophysical processes and adopt best practices to manage the agri-food system, it is important to measure agriculture and food's ability to affect changes that meet social, economic and environmental goals. There is a need to confirm that environmental improvements expected through BMP adoption are being achieved at different scales and in different combinations. This research uses risk/benefit assessment to define realistic options and develop what level of BMP adoption is required. This answers the questions "So what" by defining agri-environmental targets and the additional value or consequences for practices outside this range. Quantification of the benefits and risks of sustainable/resilient agri-ecosystems is an objective of this research area that considers foresight or scenario development, from the farm to sector to provincial scale.

This research area will:

- Develop an integrated model/approach to estimate the likelihood impact, magnitude and potential trade-offs related to the adoption of BMPs to achieve a number of agro-environmental goals (e.g. nutrient reduction, soil health, biodiversity (i.e. pollinators) health and GHG reduction). This model / approach should be considered at different scales (i.e. the farm, regional and/or provincial scale).
- Use scenarios to assess the likelihood, impact, magnitude and potential trade-off of impacts of individual BMP adoption for nutrient reduction, soil health, biodiversity (i.e. pollinators) health and GHG reduction. Scenarios would help to inform options for achieving specific targets, including Lake Erie and climate change targets.
- Identify barriers (motivation and influencers) faced by farmers to the adoption of practices that improve soil health, reduce nutrient loss, biodiversity, and GHG.
- Explore innovative technologies, tools and processes that could be used to efficiently collect and assess data for monitoring progress towards environmental agricultural outcomes on farms, regional and provincial scales.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- **Environmental Ecosystem Impact** is a priority area under **Production Systems**.
- **Agri-Food and Rural Policy** also includes priorities related to soil and environment health and sustainability.
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

6: Food for Health

6.1 Alignment with Ministry Core Business Areas

The Food for Health research theme focuses on fostering economic development in rural areas and the agri-food and agri-products sectors across Ontario by supporting the local food system and improving market opportunities related to value-added food production and healthy eating.

6.2 Definition and Scope of the Theme

The Food for Health research theme focuses on enabling:

- Improved health for Ontarians through agri-food products; and
- Increased competitiveness of the Ontario agri-food sector through identifying market opportunities related to health, for agri-food products.

Research into food production, processing, distribution, retailing, access, and skills should be undertaken to improve Ontarians' health and improve market opportunities for Ontario growers, manufacturers and related businesses.

Proposals should demonstrate:

1. **Targeted benefits to Ontario** (i.e. economic, social, environmental, competitive);
2. **Collaboration** (e.g. with industry, grower groups, Ontario food for health initiatives, researchers in diverse fields/locations, with the target population for the research);
3. **Demand-driven research** (i.e. have an established audience for the research outcomes).

6.3 Food for Health Research Priorities

6.3.1 BIOACTIVES, FUNCTIONAL FOODS AND NEW HEALTHFUL FOOD INGREDIENTS

Bioactives, functional foods and new healthful food ingredients represent an opportunity for Ontario producers and processors to gain value for products.

Proposals for this priority should focus on one of the following:

- Evaluate the efficacy of and demand for alternative proteins. Three priority outcomes are:
    1. Evaluate consumer perceptions of plant, insect and/or lab (in vitro/synthetic) based protein in comparison to traditional animal based proteins.
    2. Distinguish the qualities of plant, insect and/or lab (in vitro/synthetic) based proteins in comparison to traditional animal based proteins.
    3. Evaluate health attributes of plant, insect and/or lab (in vitro/synthetic) based protein in comparison to traditional animal based proteins.
- Food processing and healthful food products. New thresholds are being considered for sodium, sugar and saturated fat content in processed foods, yet there may be functional and consumer acceptance challenges. What needs to be done to support success in the marketplace? Consideration could be given to building on relationships between industry and health professionals.
- A top global healthy food trend identified by SIAL in 2018 is 44% of Asia/Pacific consumers prefer food with "no artificial colors". Compare artificial colour alternatives used in Chinese and Ontario markets and identify if industry opportunities exist for Ontario foods with no artificial colours to profitably expand into provincial, domestic or international markets.

6.3.2. POLICY, REGULATIONS, INVESTMENT, AND THE ECONOMY

This priority focuses on research that increases competitiveness for Ontario's agri-food sectors related to food for health and improves Ontarians' health through food.

Proposals should focus on one or more of the following:

- Evaluate the impact (economic, social, environmental, competitive, etc.) to Ontario of serving freshly-prepared meals made from fresh or minimally-processed locally-available foods in broader public institutions such as colleges and universities, schools, and municipalities (e.g. daycare, recreation centres).
    - Consideration should be given to multiple outcome measures, such as but not limited to: seasonality, cost of locally-available food, nutrition, institutional budgets for food, health outcomes, user satisfaction, food waste and environmental footprint.
- Evaluate and analyze what Ontario jobs exist now, and what jobs may exist in the future of the food for health processing industry. What is forecast for the future of this industry's job market, including opportunities and gaps for advanced skills positions? Some examples of products in this industry include many Ontario-grown foods (which the project would need to specify), value-added foods, emerging protein markets, wellness food products, consumable natural health products, allergen-free foods, et cetera. Consideration should be given to existing and future skills development programs (agriculture, business, dietetics, food science, government, investor organizations, naturopathic medicine, medicine, nutritional science, pharmacy, regulatory affairs, etc.).
- Examine how government-implemented policies, programs, regulations and behaviour change theories to improve health (e.g. nutrition labelling, menu labelling, front-of-package labelling, advertising to children, trans fat-, sodium- and sugar-reduction approaches) have influenced Ontario's food and beverage industry to innovate and improve consumers' options for making healthier choices.
- Food access for health:
    - Explore access for reaching remote rural communities with Ontario-grown or produced food. Consideration could be given to cultural relevance in the community.
    - Consumers are eating more often and looking for food convenience. Are there feasible market and infrastructure opportunities and gaps to support healthy, sustainable, convenient food options for consumers in urban and rural Ontario? Consideration should be given to e-commerce impact and to cultural relevance.
- Explore how technologies (e.g. QR Codes, smart phones, retail video displays, websites) and additional information and logos on packaging influence product credibility, public trust and consumer behaviour:
    - How does each type of information "compete" for consumer attention? How do consumers reconcile the information? What is important to influence decisions? Do additional messages change awareness of mandatory on-label health messages (e.g. allergen warnings, nutrition facts table, health claims)? Is there a point of consumer saturation?
    - Are third-party endorsement systems (e.g. better-for-you, fair trade, animal welfare, GMO-free, vegan, etc.) perceived as trustworthy and credible? How relevant are they compared to other information on food packages?

6.3.3. CONSUMERS AND HEALTHY CHOICES

What opportunities and challenges face Ontario consumers when choosing and utilizing healthful foods?

Local food literacy[1]: The scope of food literacy focuses on understanding why local food is important, knowing what local food is available and when, knowing how to prepare local food and knowing where local food comes from, to support local economy and healthcare. Three food literacy goals are:

1. Increase the number of Ontarians who know what local foods are available.
2. Increase the number of Ontarians who know how and where to obtain local foods.
3. Increase the number of Ontarians who prepare local food meals for family and friends, and make local food more available through food service providers.

Proposals should focus on one or more of the following:

- Generate tools to measure attributes of food literacy and food skills[2] within the contexts of local food and public health in order to reach consensus about the level of food literacy and food skills held by Ontarians. Consumer motivation to apply food literacy and food skills should also be a consideration.
    - Attributes of food literacy should include:
        - Food knowledge (awareness of the type and/or varieties of foods, understanding of where food comes from, ability to make informed food choices);
        - Food and other systems (understanding of growing, manufacturing, transportation, preparation, consumption and disposal of food products);
        - Food attitude (developing a positive attitude and healthy relationship towards food or motivation to learn how to prepare food);
        - Food techniques (ability to perform basic kitchen skills like chop/mix/stir/measure ingredients, prepare meals, dispose of food);
        - Food self-efficacy (understanding how to select and purchase nutritious foods and meals within a budget in a complex food environment with a diverse number of choices);

[1] *Food literacy* is the ability of an individual to understand food in a way that they develop a positive relationship with it, including food skills and practices across the lifespan in order to navigate, engage, and participate within a complex food system. It's the ability to make decisions to support the achievement of personal health and a sustainable food system considering environmental, social, economic, cultural and political components. *Reference – Cullen, T. et al.* Food Literacy: Definition and Framework for Action. *Canadian Journal of Dietetic Practice and Research*, 2015, 76(3): 140-145. http://dcjournal.ca/doi/abs/10.3148/cjdpr-2015-010

[2] "At an individual and household level, *food skills* are a complex, inter-related, person-centred, set of skills that are necessary to provide and prepare safe, nutritious, and culturally acceptable meals for all members of one's household." *Reference - Vanderkooy, P. Food skills of Waterloo Region adults. Fireside Chat Presentation. 1-20-2010.* Online: http://www.chnet-works.ca

        - Cooking self-efficacy (confidence to prepare a good-tasting meal from whatever is available and belief in one's ability to use cooking implements and styles such as frying, grilling).

- Explore cultural relevance in local food literacy in Ontario. Cultural relevance could include, but is not limited to, ethnic or world food choices, traditional foods and food practices, including those used by Indigenous communities.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- Research on labour attraction and retention is included in **Agri-Food and Rural Policy** priorities.
- Product quality improvement priorities in **Production Systems – Plant** focus on the introduction of traits for human health.
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

7: Products and Value Chains

7.1 Alignment with Ministry Core Business Areas

This research theme focuses on fostering economic development in rural regions and the agri-food, and agri-products sectors across Ontario.

7.2 Definition and Scope of the Theme

This research theme's aim is to fund product and value chain development that anticipates market opportunities, encourages innovation, creates a strong and resilient regional economy, and supports profitability and job creation.

Prior to commercialization, products and value chains face challenges. This theme hopes to address these issues.

Within this theme, "product" refers to:

- Physical products or technologies in/for the marketplace (e.g. food products, enhanced agricultural commodities, retail technologies, processing technologies, robotics, etc.);
- Services, on their own or as a part of a physical product or technology; and
- Organizational processes or collaborative initiatives.

A "value chain" in this theme is defined as a strategic partnership among inter-dependent businesses, and potentially other organizations, that collaborate to create value, resulting in improved competitive advantage for all members in the value chain. The result is market-focused collaboration. A value chain can be niche or link a large network of partners.

The definition of "value" in this theme includes:

- Market value, derived from the sale of products, services and technology solutions;
- Competitive advantage through improving efficiency, reliability, quality, customer responsiveness and innovation, that benefits businesses;
- Improved economic performance of Ontario's agriculture, food and rural sectors; and
- Socio-economic value, including improved environmental sustainability, enhanced corporate social responsibility, and regional economic development.

The strongest proposals will be collaborative, drawing on more than one researcher's strengths in a multi-disciplinary approach. Researchers will engage early with collaborators to increase the likelihood the product or value chain will enter the marketplace and be valuable to Ontario industry. Successful projects will demonstrate that appropriate links have been made between the laboratory and the marketplace.

Research projects funded under this theme must address an opportunity or solve a problem in a manner that creates value.

Note to Researchers: Tools and contacts are available to assist with communicating the value, and where relevant, the market opportunity of your research. These resources are particularly important if developing a product, technology or service with the intent of commercialization, but may be useful for all research areas. The tools and contacts focus on components such as identifying the problem your research will solve, identifying future market opportunities, important questions to consider in the early stages of the product/technology/service development process, et cetera. Tools and contacts are available [on the University of Guelph web site https://www.uoguelph.ca/omafra_partnership/priority-driven-programs-support-world-class-research-and-training

7.3 Products and Value Chains Research Priorities

7.3.1 PRODUCT DEVELOPMENT AND ASSESSMENT

Product development and assessment projects can include any aspect of product development research. This can range from initial concept to prototype development or inbound and outbound logistics and services, to create value at any point(s) in the value chain. Proposals should explain market opportunities/gaps being addressed (what is the problem being solved?) and future commercialization considerations, including but not limited to possible barriers to user adoption (this program funds pre-commercial research). Make connections or partnerships to increase the potential of the research to have a beneficial impact for Ontario and beyond.

Proposals should focus on one or more of the following:

- Research on a product or value chain, outlining the economic feasibility and profitability for Ontario agriculture, food and rural sectors. Aspects of your work might include:
    - Intellectual property analysis;

- Product development or adding value to a product (see product definition above);
- Technical feasibility study on commercial ingredient supply and availability, equipment, process, packaging, transportation, shelf-life, labour and productivity solutions, automation and robotics, etc.

- Research to address obstacles to commercialization in the food and beverage industry, such as developing innovative technology solutions.
- Investigate environmental sustainability related to an Ontario product. For example: product development of clean technologies for agriculture and food processing that reduce energy or water usage; improve waste water management, greenhouse gases, etc.; opportunities to use low value products (e.g. by-products, waste streams).
- Investigate potential technology solutions to improve transparency of food supply chains, such as distributed transaction ledgers (blockchain applications).

7.3.2 VALUE CHAIN DEVELOPMENT AND ASSESSMENT

The value chain development and assessment priority focuses on the effective development of specialized value chains for Ontario-based entrepreneurs of all sizes. Value chains can be built to develop and market a new product, improve competitive advantage, and create other socio-economic or regional development benefits. Research should provide results that will help the development of a new value chain for Ontario and/or guide companies and/or other organizations to viable, value-added opportunities.

Proposals should focus on one or more of the following:

- Agri-Food and Packaging Waste
  - Research an approach to reducing agri-food organic or packaging waste in Ontario. The approach must consider strategic partnerships among inter-dependent businesses, and potentially other organizations, that collaborate to improve competitive advantage for all partners (a value chain). For example: reduce economic loss by diverting costly agriculture or food product waste into animal feed or packaging; improve social license and sector sustainability by mitigating plastic waste entering water systems; improve process inefficiencies to improve sector profitability.
- Regional Economic Development
  - Evaluate sustainable opportunities and engage with partners to research how to develop regional agriculture and food value chains (e.g. in Northern Ontario, Eastern Ontario, rural Ontario).
    - e.g. New and Specialty Crops: The specialty crops sector consists of over 100 different commodities that are typically grown on small acreages in Ontario. These include, but are not limited to: sweet potatoes, edamame, and other non-traditional vegetables, specialty fruit, medicinal herbs, culinary herbs, lavender, hops and tree nuts. Develop the market and grow the sector for new and specialty crops by assessing a value chain to identify market requirements;

consumer education gaps; production needs; cost of production information; access to processing facilities; value added opportunities; and implementation recommendations.

        - e.g. Aquaculture Genetics and Reproduction: Develop and assess a value chain for Ontario-produced rainbow trout eggs genetically optimized for Ontario growing conditions.
        - e.g. alternative protein, goat, greenhouse, hazelnuts, aquaculture.
    - Economic development strategies require effective collaboration between a myriad of stakeholders in the private and public sectors, including multiple levels of government, regional organizations, non-government organizations, investors, investment organizations, individual businesses and industry associations. This sub-priority is focused on research to improve economic outcomes for rural Ontario through strategic partnerships among inter-dependent businesses, and potentially other organizations, that collaborate to improve competitive advantage for all partners (a value chain). For example, develop and assess a value chain to build capacity in rural Ontario beyond infrastructure needs; research the true cost of monoculture, and the value chain economics of diversification in agriculture.

- Consumer Research
    - Ontario's marketplaces and export food marketplaces are becoming less homogeneous, with a greater diversity of products demanded by consumers with specific product attributes (e.g. alternative proteins, organic, local, no added hormones, no antibiotics, gluten-free, et cetera). These markets offer opportunities for Ontario firms and products. Research is required to determine market premiums associated with specific product attributes or bundles of attributes across commercial relationships with customers and suppliers (the value chain). Determine which product attributes are critical to success in a diversifying market.
    - Social license can drive market trends.
        - Research how to optimize social license for members of a value chain (e.g. engage industry to champion food integrity in the supply chain).
- Increase Market Access
    - The provincial and global marketplaces demand a large quantity and variety of foods that can be produced within Ontario. This sub-priority seeks to identify, realize, and implement:
        i. Partnerships with the private sector to identify one or more increased market access gaps/opportunities;
        ii. Research on how Ontario’s agri-food sector could successfully **realize** this opportunity with Ontario-produced or -processed foods using Ontario ingredients; and
        iii. Through collaboration and partnership, **implement** opportunities identified.

- Research areas might include regulatory or other challenges at the municipal, provincial, and federal level. Potential solutions to these challenges might include new technologies, accessing existing resources, partnering with business and/or government. Impact of implementation should include increased profitability and market access for Ontario products domestically or internationally.
    - e.g. Berries: How to capitalize on the "Buy Local" movement; Development of more environmentally acceptable packaging.

- Benchmark an Ontario Value Chain
    - Benchmark Ontario producers who have increased their profitability through establishing innovative commercial relationships with customers and suppliers. Based on best practices and lessons learned from the research, develop a framework for other producers to increase profitability.
- Environmental Sustainability
    - Investigate the economics (e.g. cost/benefit) of establishing increased sustainability along an agri-food or -products sector supply chain.
    - Determine opportunities and challenges of a sustainable urban agri-food value chain and its economic impacts for Ontario.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- **Agri-Food and Rural Policy** also includes priorities on value chains, new and clean technologies, niche and global markets and food waste.
- **Animal and Plant Production Systems** theme also includes priorities on product diversification and product quality improvement research priorities.
- **Bioeconomy** theme includes a bioproduct development research priority. Bioproduct development/value chain research may fit under the Products and Value Chains theme.
- **Food for Health** theme includes development of a food for health product.
- **Gryphon's LAAIR** is a program designed to support the commercialization of research findings. To know more, visit the UofG web site: https://www.uoguelph.ca/omafra_partnership/funding-programs/moving-research-innovations-marketplace.
- Researchers seeking help in identifying potential priorities and collaborators from OMAFRA and other organizations may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

8: Production Systems

8.1 Alignment with Ministry Core Business Areas

The Production Systems research theme supports the stability and economic growth of Ontario's largest and most diverse agriculture sectors: crops and livestock. The research priorities have been shaped with the Ontario producer in mind, the challenges/opportunities the sectors are facing, as well as the need for research to support future government policies and stewardship practices. Collective support in these priority areas could help transform or inform the ministry's work in areas such as economic development (i.e. production efficiency, management strategies), protection and assurance (i.e. pesticide use, plant and animal health, antimicrobial use) and stewardship (i.e. soil health, Great Lakes nutrients) and more broadly, sustainability.

8.2 Definition and Scope of the Theme

First and foremost, Production Systems research must focus on production research and profitable agriculture. Secondly, the Production Systems research capacity can be employed to incorporate the needs of other themes into profitable systems.

The Production Systems theme encompasses the development of innovative agricultural production systems that will enhance profitability of agricultural production, while incorporating issues, opportunities and advances arising from related research areas that address the greater societal environment within which production agriculture operates, including environmental sustainability, emergency preparedness, end product expectations with regard to food (healthy eating) and non-food (industrial) uses, value chain opportunities and agriculture and economic development policy directions.

PRODUCTION SYSTEMS – KEY RESEARCH AREAS

Plant Protection – Research needed in this area includes improving Integrated Pest Management (IPM), understanding the biology, ecology and management of current and emerging pests. This includes identification, tracking and monitoring, identifying biosecurity practices and protocols (especially related to maintenance of trade) and improving diagnostics and surveillance techniques to improve pest management and manage herbicide resistance.

Animal Health and Welfare – Research needed in this area includes management programs /tools to reduce risk of production-limiting diseases and mortality, animal welfare/behaviour (including housing systems, pain mitigation and reduction of stress), antimicrobial resistance and the use of non-antibiotic therapeutics, .

Production Efficiency – Research needed in this area includes profit enhancement and optimization of production efficiencies, reductions in labour costs, energy-saving technologies and processes, management strategies for young stock and crop production, reduced input costs, more efficient use of land, labour, energy, alternative feeds, etc.

Environmental/Ecosystem Impact – Research in this area includes resource use, including water management, environmental impacts on natural and man-made environments, and mitigation of potential impacts of changes in the climate, cover crops, soil health and efficient use of nutrients.

Product Quality Improvement – Research needed in this area includes studies focusing on producing cost effective, high quality products that meet consumer demands (e.g. malting barley, protein quality and sugar levels of soybeans, etc.), improving shelf life, storage and marketability, the introduction of traits for human health (e.g. omega-3, lycopene, Vitamin E), the introduction of traits to enhance value (higher oil content), new markets or new products, storability and post-harvest extension/shelf life.

Product Diversification – Research in this area includes new product development and associated production systems, response to changes in the climate (e.g. different crops), or different production strategies, or expansion of crop production to different land, market research to determine market demand, and/or consumer preferences for new products and/or uses.

Genetic Technologies and Reproductive Technologies – This research area focuses on genetic and reproductive technologies necessary to develop research in new products and specialty crops, enhance the marketability of existing products, improve productivity in pest management, environmental and end-use quality traits and to maintain our gene pool.

These descriptions of the broad key research areas above will be used to evaluate Tier II proposals for the Plant and Animal Production Systems theme for 2018-2019.

8.3 Plant Production Systems Research Priorities

The research priority areas for the Plant Production Systems Research theme to support the development of innovative products, approaches and best management practices are:

- Product quality improvement
- Plant protection
- Production efficiency
- Environmental ecosystem impact
- Product diversification
- Genetic technologies

Note to Researchers: Proposals must clearly identify which specific priority is being addressed, as well as how the proposed research will address a specific priority. Proposals that do not address the specific priority areas indicated below will not be eligible for Tier I funding and may be better suited for Tier II funding.

All research areas apply to both conventional and organic production systems.

Field Crops apply to soybean, corn, wheat, barley, oats, dry edible beans, canola and forages.

Edible Horticulture includes medicinal herbs.

8.3.1. PRODUCT QUALITY IMPROVEMENT

Edible Horticulture:

- Improve product quality and shelf-life of berries through the entire value chain (i.e. crop management, postharvest management, packaging, storage, insect damage).
- Develop an easy-to-use test to identify buddy sap prior to processing into maple syrup.
- Identify the causes and develop solutions to skin diseases and disorders that affect the marketability of ginseng roots.
- Improve product quality of fruiting vegetables specifically around harvest and along the entire fruit and vegetable value chain.

Ornamental Horticulture:

- Understand and improve plant establishment and survival in challenging environments, especially with regards to root growth in container nursery production and compacted soils.

Field crops:

- Identify production practices that improve barley (malting barley), oat (Beta-glucan), soy (protein quality, sugar levels: sucrose soy milk, dessert tofu, and isoflavones), wheat (protein levels and health benefits) and edible bean quality for specific end uses leading to value-added markets.
- Investigate conditions causing brown seed and increased free fatty acids in canola, including genetic-environment (G×E) interactions to improve quality and marketability.
- Investigate harvest and storage technology for forages to reduce losses, improve quality and marketability.

8.3.2 PLANT PROTECTION

All Horticulture, Ornamental and Field Crops:

- Develop integrated pest management including efficacy studies that incorporate pesticides, alternative control measures, host resistance and/or take a systems approach to controlling pests, disease and weeds. In greenhouse floriculture, the primary focus should be on biocontrol strategies.
- Develop integrated weed management strategies that consider management of herbicide resistance, and/or biology and ecology of specific weed species.

Field Crops:

- Resistance identification and management strategies for fungicides, effective management of *Fusarium* pathogens and associated mycotoxin accumulation, soybean cyst nematode (SCN), soybean sudden death syndrome (SDS), foliar diseases, oat crown rust, seedling diseases, root rots, alternaria, sclerotinia and club root.

- Research chemical and biological control options for pests of canola, as well as control thresholds, reproductive biology, scouting practices, and agronomic practices that mitigate damage by pests. In order of priority, this includes: swede midge, striped flea beetle, and crucifer flea beetle.
- Develop effective management strategies that consider resistance identification, and root and leaf disease management for pests and pathogens in edible bean production.
- Develop management strategies (for insect pests and/or define early-season soil insect thresholds).

8.3.3 PRODUCTION EFFICIENCY

All Horticulture:

- Develop and evaluate automation systems or other strategies to improve high labour costs and availability of labour in all horticulture crops and specifically in mushroom and apple production.
- Develop or evaluate crop management systems to improve production efficiencies at the whole farm level.

Edible Horticulture:

- Develop soil health and/or nutrient management strategies that improve crop quality and/or environmental sustainability in bulb and root vegetables.
- Develop strategies to improve long term profitability of leafy and crucifer vegetables that improve production efficiency and market diversification.
- Develop agronomic practices and efficiencies for new and speciality crops. Examples include: propagation and establishment, fertility and water requirements, season extension, harvesting methods, and post-harvest handling and storage issues.
- Viticulture research to improve grapevine health and winter survival.

Ornamental Horticulture:

- Utilize water more efficiently in ornamental plant production with strategies that are economically viable and commercially practical.
- Develop strategies to optimize the use of nutrients in plant production in order to reduce input costs, promote plant health and manage water runoff.
- Develop strategies to improve irrigation water quality by optimizing source water, irrigation systems and/or storage and recirculation systems.
- Improve energy efficiency in greenhouse production. Strategies to reduce energy use that are economically viable and commercially practical.
- Strategies to improve plant production with supplemental lighting.

Field Crops:

- Develop strategies to optimize the use of nutrients in field crops, particularly nitrogen, phosphorus, sulphur (including developing a test for sulphur) and potassium.
- Validate precision agriculture technologies for use as agronomy research tools that improve efficiency and accuracy of data generation to better address experimental variables and offer opportunities for economic gain.

8.3.4 ENVIRONMENTAL ECOSYSTEM IMPACT

- Develop strategies to improve environmental sustainability in greenhouse production through reducing carbon emissions per unit produced (e.g. renewable energy, breeding for low light and temperature varieties, more insulated greenhouse coverings, et cetera); and/or improved management of fruit and vegetable wash water and waste.
- Effectively integrate cover crops into field crop cropping systems (including identifying crop, soil, and/or environment benefits and detriments).
- Identify soil health parameters (i.e. soil organic matter, soil carbon, soil structure, water holding capacity, pH, etc.) including soil ecology and practices affecting crop resilience under various stresses.
- Identify the impacts of various tillage systems on phosphorous and nitrogen best management practices in various major soil types that would ensure productive crops and mitigate nutrient losses (considering both short-term and long-term effects of phosphorus use).
- Identify and validate best management practices and risk assessment tools for phosphorous in terms of both crop productivity and potential for phosphorous loss (in soluble and particulate forms) throughout a year, including consideration of soil type and weather.
- Investigate production practices for their efficiency and effectiveness at sequestering carbon, along with the practicality and profitability of these practices.
- Assess the function of soil biology and microbiology populations, their effect on the soil, and the implications of farming practices on these populations (e.g. tillage, commercial fertilizer, fumigation, cover crops).
- Evaluate organic amendments for nutrient availability and soil organic matter, including and not limited to: yard and leaf waste, municipal compost, biosolids, and anaerobic digestate.

8.3.5 PRODUCT DIVERSIFICATION

Edible Horticulture:

- New variety acquisition, development, best management and commercialization process in tender fruit production.

Ornamental Horticulture:

- Understand market trends, quantify environmental benefits, identify which plants to grow, when to supply them, and how to present and market them.

Field crops:

- Develop new food uses that are connected to existing and emerging market opportunities.

8.3.6 GENETIC TECHNOLOGIES

Edible Horticulture:

- Identify and evaluate new potato lines that can help to provide a 12-month supply of high-quality potatoes to the Ontario fresh and chip processing industries through value-added traits such as early maturity, long term storability and nutritional potential, any of which would serve to enhance the competitiveness and profitability of the Ontario potato industry.
- Genetic improvement and evaluation of hazelnut cultivars, focusing on quality parameters, winter hardiness and pest tolerance.

Field crops:

- Develop high-yielding, high-quality barley, corn, oat, soybean, and winter and spring wheat varieties adapted to Ontario, with genetic resistance to important pathogens including *Fusarium* in wheat, barley, and corn, foliar pathogens, soybean cyst nematode (SCN), soybean sudden death syndrome (SDS), Phytophthora, root rot complexes, seedling diseases, and oat crown rust.
- Forage varietal effects on management factors, such as Neutral Detergent Fiber (NDF) and fiber digestibility (milk/beef/acre), Roundup Ready alfalfa, manure tolerance and yield response, intensive cutting schedules, and other parameters.
- High-yielding edible bean varieties and varieties with resistance to the most important diseases; improved quality traits (seed size, seed coat integrity, seed coat colour).
- Development of high-yielding spring and winter canola varieties adapted to Ontario conditions expressing resistance/tolerance to insects and diseases, improved stand-ability for direct harvest, low pod shatter, tolerance to frost, and specialty oil profiles.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- The Production Systems '**Product Diversification**' priority has potential linkages to priorities under the **Products and Value Chains** and **Bioeconomy** research themes.
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.

8.4 Animal Production Systems Research Priorities

The research priority areas for the Animal Production Systems Research theme to support the development of innovative products, approaches and best management practices are:

- Animal Welfare
- Animal Health

- Production efficiency
- Product quality improvement
- Environmental Ecosystem Impact

Note to Researchers: Proposals must clearly identify which specific priority is being addressed as well as how the proposed research will address a specific priority. Proposals that do not address the specific priority areas indicated below will not be eligible for Tier I funding and may be better suited for Tier II funding.

Priorities that do not identify a specific sector apply to all livestock species.

All research areas apply to both conventional and organic production systems.

8.4.1. ANIMAL WELFARE

Research is needed to:

- Investigate economically viable housing systems and management practices in poultry, pork, veal and rabbits, which align with market and consumer demands and meet animal health and welfare needs.
- Investigate techniques that alleviate and prevent the stress and pain associated with currently accepted animal management practices or housing systems.
- Reduce stress, pain and injuries during transportation, at livestock markets and at slaughter for veal, beef, goat, sheep and dairy sectors.

8.4.2. ANIMAL HEALTH

Research is needed to:

- Reduce the use of medically important antimicrobials by:
    i. Investigating alternatives to antimicrobial treatments, and/or
    ii. Investigating management programs/tools that reduce the need for antimicrobial treatments.
- Reduce the risk of disease and mortality in Ontario livestock with preference in sheep, goats, veal, poultry, equine, and mink.
- Investigate precision agriculture technologies that support cost-effective production.

8.4.3. PRODUCTION EFFICIENCY

Research is needed to:

- Identify factors impacting feed utilization, including nutritional programs with by-products, alternative feeds, or non-human-consumable feed ingredients, and the use of new technologies or treatments.

- Investigate genetic and/or reproductive management methods to optimize production efficiency.
- Investigate management strategies to improve overall health and productivity of young animals.
- Investigate and develop production management practices suitable for animal agriculture in northern Ontario.

8.4.4. ONTARIO PRODUCT QUALITY IMPROVEMENT

Research is needed to:

- Investigate means to produce cost-effective, high-quality products that meet consumer demands.

8.4.5. ENVIRONMENTAL/ECOSYSTEM IMPACT

Research is needed to:

- Reduce the environmental impacts of livestock sectors with preference in beef, dairy, and pork production, while maintaining productivity.
- Measure the potential impact of changes in the climate on animal production systems in Ontario, and develop methods to mitigate expected effects of climate change on animal welfare, health and productivity.

Note to Researchers: Please note the following linkages to priorities described in other themes to identify potential synergies and opportunities:

- Please refer to the **Emergency Management** theme when dealing with new or emerging diseases.
- Please refer to the **Agri-Food and Rural Policy** and the **Emergency Management** themes for other priorities relating to **antimicrobial/drug and pesticide resistance**.
- **Products and Value Chains** priorities (e.g. Identify new technologies to enable production efficiencies in the poultry and beef sectors).
- Researchers seeking help in identifying potential priorities and collaborators may contact UofG's Research Program Director or OMAFRA Theme Research Analyst.