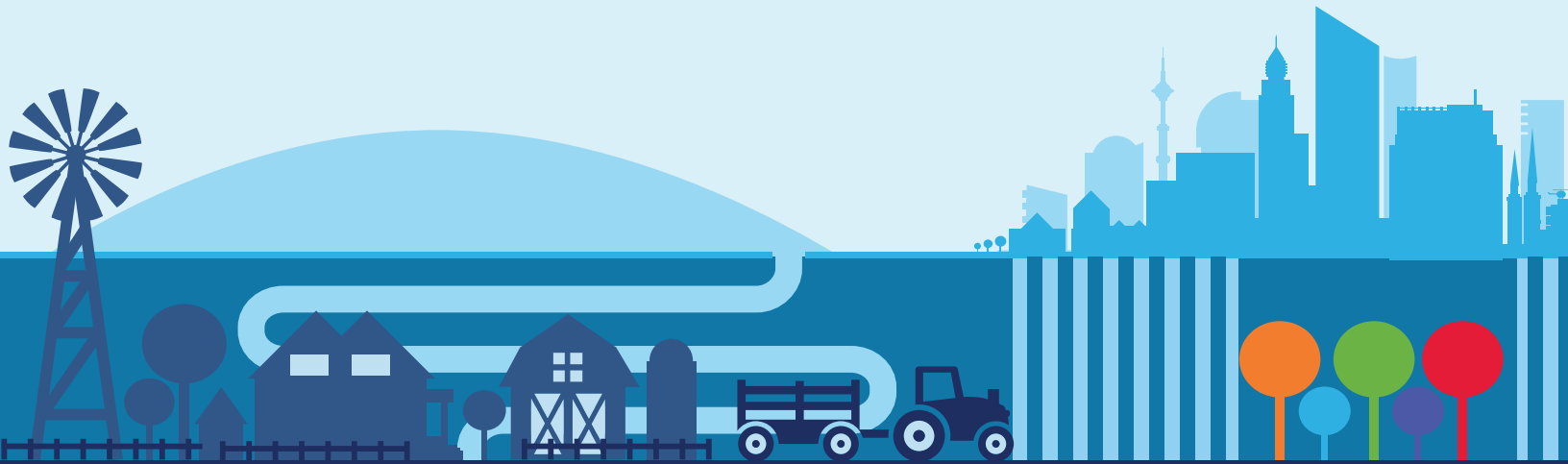


PATHWAYS TO IMPACT: AGRICULTURAL RESEARCH



THE CANADIAN AGRICULTURE SECTOR LEADS INTERNATIONALLY WITH AN IMPRESSIVE RECORD OF RESEARCH AND TECHNOLOGY DEVELOPMENT WHICH CONTRIBUTES DIRECTLY TO THE NATIONAL ECONOMY

Agriculture in Canada is an industry that spans a number of sub-sectors, from primary producers and agri-food processors to food manufacturers. This integrated system reveals a competitive value chain that generates significant economic benefits to the Canadian economy.

The agriculture industry supports a total labour force of more than 2 million and produces \$55 billion in domestic agri-food exports. From research to commercialization, strong connections between academia, farms, industry and all levels of government accelerate innovation to ensure national and international food security while taking steps to mitigate the impact on our climate. Canada is home to less than 0.5 percent of the world's population, yet Canadian researchers published 4.7 percent — more than 90,000 — of the world's scientific papers in agriculture and related areas between 1997 and 2014.

Given the importance of the sector to Canada, governments and academic institutions have made agricultural

research a priority. Agricultural research depends on state-of-the-art infrastructure, funding for research grants and research talent. The Canada Foundation for Innovation (CFI) provides funding for research infrastructure to academic institutions on behalf of the federal government. This helps institutions recruit leading researchers and enables them to compete for research funding.

The CFI, working in collaboration with its partners, has gathered evidence to identify benefits to Canadians stemming from five areas of agricultural research, and uncover common pathways from research to impact. The Agricultural Institute of Canada, a national organization that advocates for agricultural research and innovation, compiled an overview of the Canadian landscape as context for this study.

Understanding the pathways to impact from academic research through to innovation and ultimately practice and process improvements will help to ensure that Canada continues to be a world leader.

KEY MESSAGES

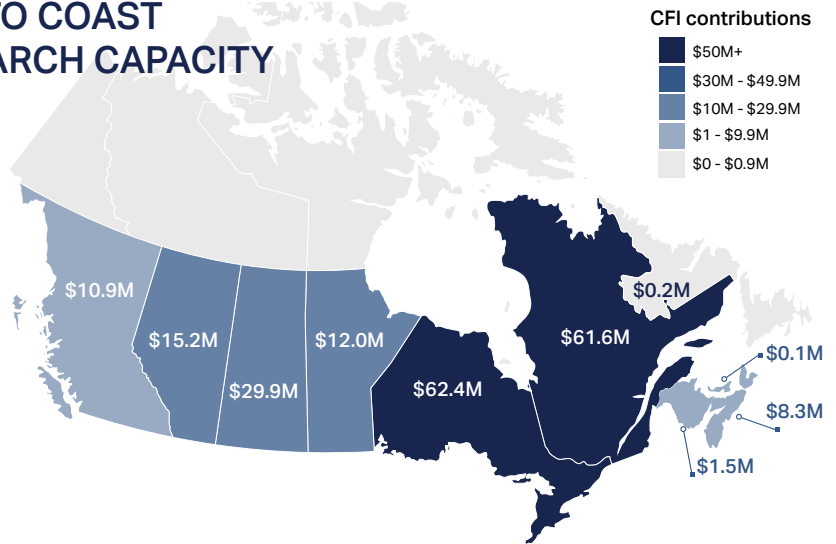
It is through strong collaboration linkages that new ideas become innovations and yield benefits to Canadians.

Trainees are central to creating and strengthening linkages across and within sectors.

Engagement between researchers and farmers accelerates the uptake of new technologies.

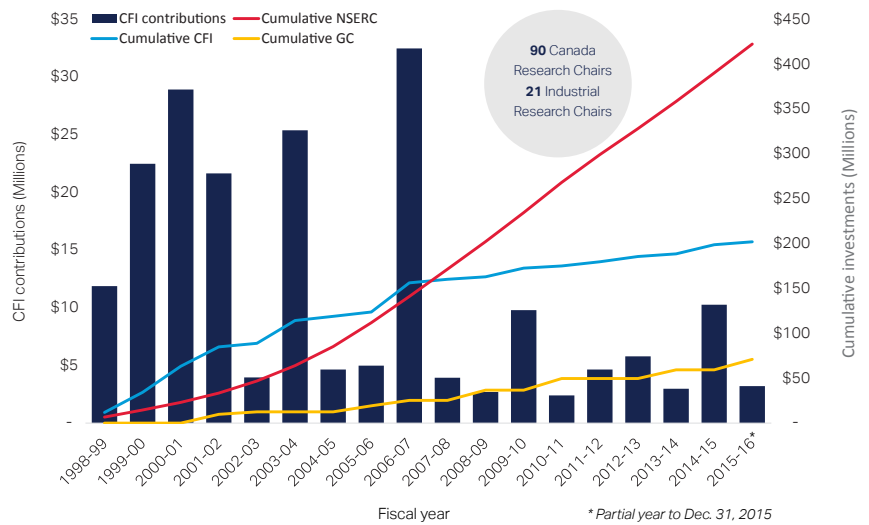
INFRASTRUCTURE FROM COAST TO COAST ENHANCES AGRICULTURAL RESEARCH CAPACITY

The CFI has committed over **\$200 million** toward **510 research infrastructure projects** at 61 institutions in the area of agriculture and food science between 1998 and 2016. This represents about 4 percent of total CFI investments made in research infrastructure during the same period. The CFI funds up to 40 percent of a project's research infrastructure costs. Partner funding represents more than **\$550 million** invested across Canada, for a total investment of more than **\$750 million** in infrastructure to advance agricultural research.

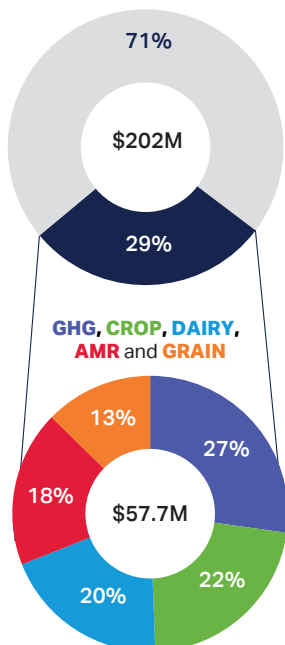


RESEARCH AND RESEARCH INFRASTRUCTURE FUNDING

Leaders of CFI-funded research projects in agriculture have successfully obtained research funding from the Natural Sciences and Engineering Research Council (NSERC) of Canada and Genome Canada (GC), and in smaller amounts from the Social Sciences and Humanities Research Council (\$14 million since 2008) and the Canadian Institutes of Health Research (\$32 million since 2008). Many of them also hold Canada Research Chairs or Industrial Research Chairs.



TOTAL AGRICULTURE vs. AREAS OF STUDY



INVESTMENTS IN AREAS OF STUDY

Five specific areas of agricultural research were selected for this study in consultation with an advisory group composed of representatives from 20 organizations including universities, federal and provincial government departments and agricultural associations.

- **Greenhouse gases (GHG)** – research on evaluating agricultural policies, techniques and tools to help mitigate Canada's impact on the environment
- **Resilient crops** – research on seed and plant genetics to make them more valuable, less vulnerable and increase yield
- **Dairy farming** – research on all facets of the industry including dairy cattle welfare, milk production, dairy by-product processes, and genetic evaluation
- **Antimicrobial resistance (AMR)** – research on mitigating the growing risks of antimicrobial resistance through novel prevention and therapeutic approaches in animal agriculture
- **Grain storage** – research on methods, technologies and structures used to house or prepare grain for storage

HOW CANADA BENEFITS

Greenhouse gases: 29 projects, \$15.7M

Canadian agriculture contributes on average 59 megatonnes of CO₂-equivalent gases to the atmosphere every year, which is approximately eight percent of the country's emissions. The University of Guelph's Claudia Wagner-Riddle studies nitrous oxide, methane and carbon dioxide cycles. Through her research enabled by CFI-funded infrastructure, she created guidelines to help farmers implement greenhouse gas mitigating technologies. Her team helped Clovermead Farms in Alma, Ontario, implement the guidelines by installing an anaerobic digester that produces biogas from organic waste. The biogas is used to generate enough electricity to heat the barn and house and also sell energy back to the grid. Overall, the greenhouse gases emitted from the farm are reduced, creating a beneficial **environmental impact** that can be scaled to the national level with uptake of the guidelines. The Ontario government is monitoring this research to inform policies.

Resilient crops: 31 projects, \$12.8M

Nearly 36 million hectares of land in Canada are used uniquely for crop production. CFI has supported the development and production of new varieties of staple foods and the creation of new technologies to increase plant adaptations to changing climatic and pathogenic conditions. Peter Pauls at the University of Guelph studies the genomes of beans, corn and soybeans and identifies markers for bacterial and fungal resistance as well as yield and quality traits of the crops. He has produced transgenic corn with improved resistance to diseases, like Fusarium, which is a prevalent fungal disease in Canada's grain crops. The identification of genes for disease resistance in plants produces better quality crops that require fewer agrochemical inputs and increases yield, key factors to the **economic and environmental sustainability** of the industry.

Dairy farming: 18 projects, \$11.3M

Dairy products total nearly \$17 billion of Canadian manufactured shipments annually. CFI supported Canada's first genomic laboratory dedicated to dairy yeasts at Université Laval. Steve Labrie studies the impact of milk composition on the properties of specialty and artisan cheeses. His group demonstrated the importance of the whole-cheese fungal microflora ecosystem during cheese making and ripening processes. As a result, new genomic-based tools are having a positive **economic impact** for industrial partners, such as Agropur Coopérative, to better control production, limit losses and create high-quality cheeses with a longer shelf life.

Antimicrobial resistance: 5 projects, \$10.6M

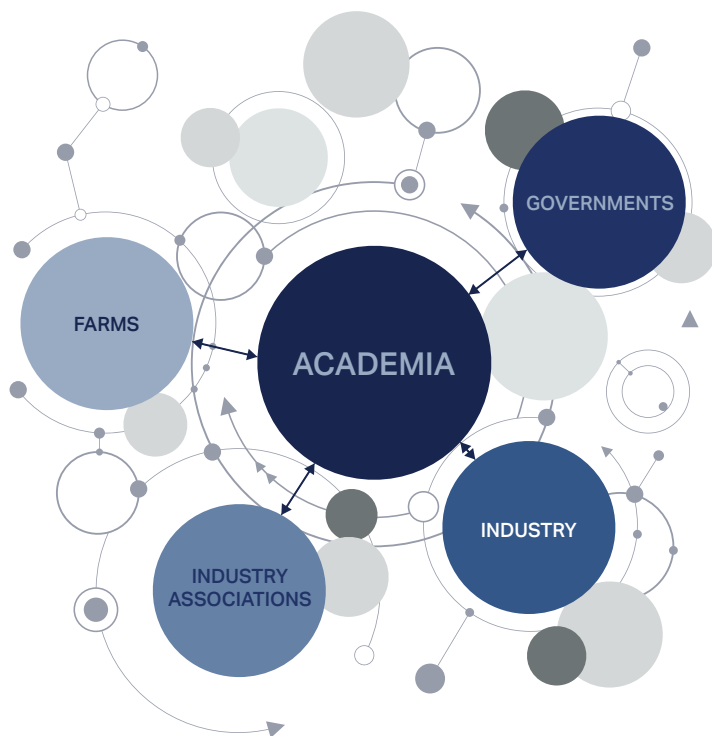
Agriculture accounts for an estimated 50 percent of all antibiotic use. The emergence of drug-resistant, disease-causing bacteria from the overuse and misuse of antibiotics is a growing public health concern worldwide. CFI-funded infrastructure is playing a key role in the development of vaccine and therapeutic approaches aimed at reducing the use of antibiotics in agricultural settings. Sylvain Quessy, at the Université de Montréal, is investigating the use of viruses to make antibiotic-free chicken. This approach targets bacteria with more precision, so unlike with broad spectrum antibiotics, beneficial bacteria stay intact. This technique can reduce the amount of antibiotics needed for therapeutic agriculture use, and may have future use in disease prevention. Decreasing the use of antibiotics has positive **health benefits** for both animals and people.

Grain storage: 4 projects, \$7.3M

Canada is among the top grain exporters in the world, producing nearly 70 million tonnes of grain each year. CFI-funded infrastructure supported the development of grain processing with infrared technology. Jitendra Paliwal at the University of Manitoba and Tom Scott at the University of Saskatchewan worked collaboratively with companies Cargill and BoMill to develop technology to detect grain infected with the Fusarium fungus. This technology can sort 3,000 kernels of wheat per second. The technology was tested on five tonnes of wheat from a Saskatchewan farmer. Seven percent of the kernels in the sample provided were infected with the fungus, much more than allowable levels of two to three percent. After sorting, just one percent were infected, thus saving the crop. This is an example of an **economic impact on a local level**; broader uptake would have even greater impact on the amount of grain available to market and **overall food security**.

HOW DOES AGRICULTURAL RESEARCH LEAD TO IMPACT?

Innovation in agriculture stems from a desire to improve efficiency and productivity, decrease environmental impact and strive towards a more socially responsible agricultural system. Through this study, we observed strong collaborations between and within academia, governments, industry and industry associations. It is through these strong linkages that ideas become new innovations and yield benefits to Canadians.



"Our research capabilities have been strengthened through the infrastructure combined with our established links with the agriculture industry and rural communities. This has put Canada in a strategic position to be recognized as a world leader for agricultural and rural water quality research."

Robert Gordon, formerly at the Nova Scotia Agricultural College

PATHWAYS TO IMPACT

Linkages through resource sharing

Shared access to leading-edge infrastructure and field sites promotes active collaboration between researchers and end-user communities.

"If you want to do medical research, you need a hospital. If you want to do agricultural research, you need a real farm and agricultural infrastructure in the field to do it."

Peter Pauls, University of Guelph

"About half of my research has been conducted on farms. Just because we have some infrastructure on campus doesn't mean all the research is done here."

Derek Lynch, Dalhousie University

Linkages through trainees

Trainees create and strengthen ties within and between all sectors in agricultural research.

"The CFI-funded infrastructure acts as a magnet to draw candidates from Canada and abroad. When they finish their studies, they are snapped up by consulting companies, government agencies, and universities, thanks to the exceptional technical expertise acquired while working with the infrastructure."

Chandra Madramootoo, McGill University

"Students are at the forefront of new approaches. They are the main vector of technology transfer and socioeconomic impacts. Our research and training drives all technology development in the dairy sector."

Marc-André Sirard, Université Laval

Linkages through research evidence

Research evidence is the driver for innovation in all areas of agriculture. It allows industry to scale-up, helps establish policies and guidelines to help ensure that Canadian standards remain high, and provides farmers with new and improved ways to maximize their productivity while controlling costs.

"The on-farm dairy cattle lameness benchmarking system developed, in part, using the CFI-funded infrastructure has been adopted by the Dairy Farmers of Canada and an international company. The use of our work developed using the CFI-funded infrastructure by private and government agencies has also resulted in the employment of our graduates based on their expertise in the implementation and management of our benchmarking system."

Marina von Keyserlingk, The University of British Columbia