Feeding the Future with Canadian Technology

— SEPTEMBER 2024

ARRELL FOOD INSTITUTE
AT THE UNIVERSITY of GUELPH

UNIVERSITY OF THE FRASER VALLEY
FOOD AND AGRICULTURE INSTITUTE

FOREWORD

Throughout our history Canada has been an agricultural superpower.

This is our moment to double down on this rich tradition and become the world's premier supplier of the best, healthiest, safest, and most sustainable food on the planet. To do this, we must also aspire to be at the centre of the global innovation hubs that create the technologies needed to produce this food.

Ten years ago, I had the privilege of chairing an Advisory Council for Economic Growth on behalf of then finance minister, the Honorable Bill Morneau. We consulted with experts across Canada and around the world, and proposed concrete policy actions to help create the conditions for strong and sustained long-term economic growth and to support Canada's middle class. Our recommendations included bolstering our infrastructure, strategies to attract foreign investment, ideas on how to train the next generation, and ways to build Canada into more of a global trading hub.

We also recommended that it should be possible to unleash the potential of key sectors of the economy, including agriculture, to help drive widespread economic prosperity. The potential of the agricultural sector stood out – illustrating both our country's extraordinary potential to be a global leader as well as demonstrating some of our challenges. We are playing a strong hand; we boast world-leading natural resources such as water and arable land. We are well positioned to take advantage of expanding Asian markets thus creating an opportunity for exporters. Our regulatory environment is amongst the best in the world, and we have a robust infrastructure. We enjoy a sophisticated community of producers and food processors and a have an enviable network of post-secondary training facilities, and world class R&D in our universities.

Yet, our country significantly lags countries such as the Netherlands in terms of the total value of our agricultural exports. The sector is held back by chronic labour shortages and investment is slow to move into the space. As a result, the Advisory Council recommended we set a bold vision, that Canada strives to become the world's trusted supplier of safe and sustainable food for the 21st century.

Since we tabled our report in 2017 a lot has been accomplished. The global innovation supercluster, Protein Industries Canada, has catalyzed hundreds of millions of dollars of innovation. Our colleges and universities continue to produce a world class stream of highly qualified young people. Our exports have grown and broadened to more countries, and we continue to enjoy the reputation as one of the safest food systems on the planet. But still, a huge amount of work remains to be done. As noted in the series of recent reports by the Royal Bank of Canada, Boston Consulting Group, and the Arrell Food Institute at the University of Guelph, there is a massive labour shortage that throttles the system and investment capital is still moving too slowly to really supercharge innovation in the sector.

The world has also moved from crisis to crisis since I chaired the Advisory Council. The Pandemic, ensuing supply chain disruptions, war in Ukraine, and punishing inflation have hurt producers and consumers alike. Now more than ever before is the moment for Canada to step up and take a front row position to be the world's leading supplier of safe and sustainable food.

The accompanying report picks up on some of the challenges laid out by the Advisory Council in 2017. By taking stock of where we've come as a country and engaging in an 18 month dialogue with experts from industry, the investment community, government, and the academy, the Arrell Food Institute at the University of Guelph and the Food and Agricultural Institute at the University of Fraser Valley are giving us a refreshed and updated set of recommendations.

This report also provides a stark reminder of both the opportunity and the urgent need for Canada to realize its potential as an agri-food superpower.

— Dominic Barton

Summer 2024

TABLE OF CONTENTS

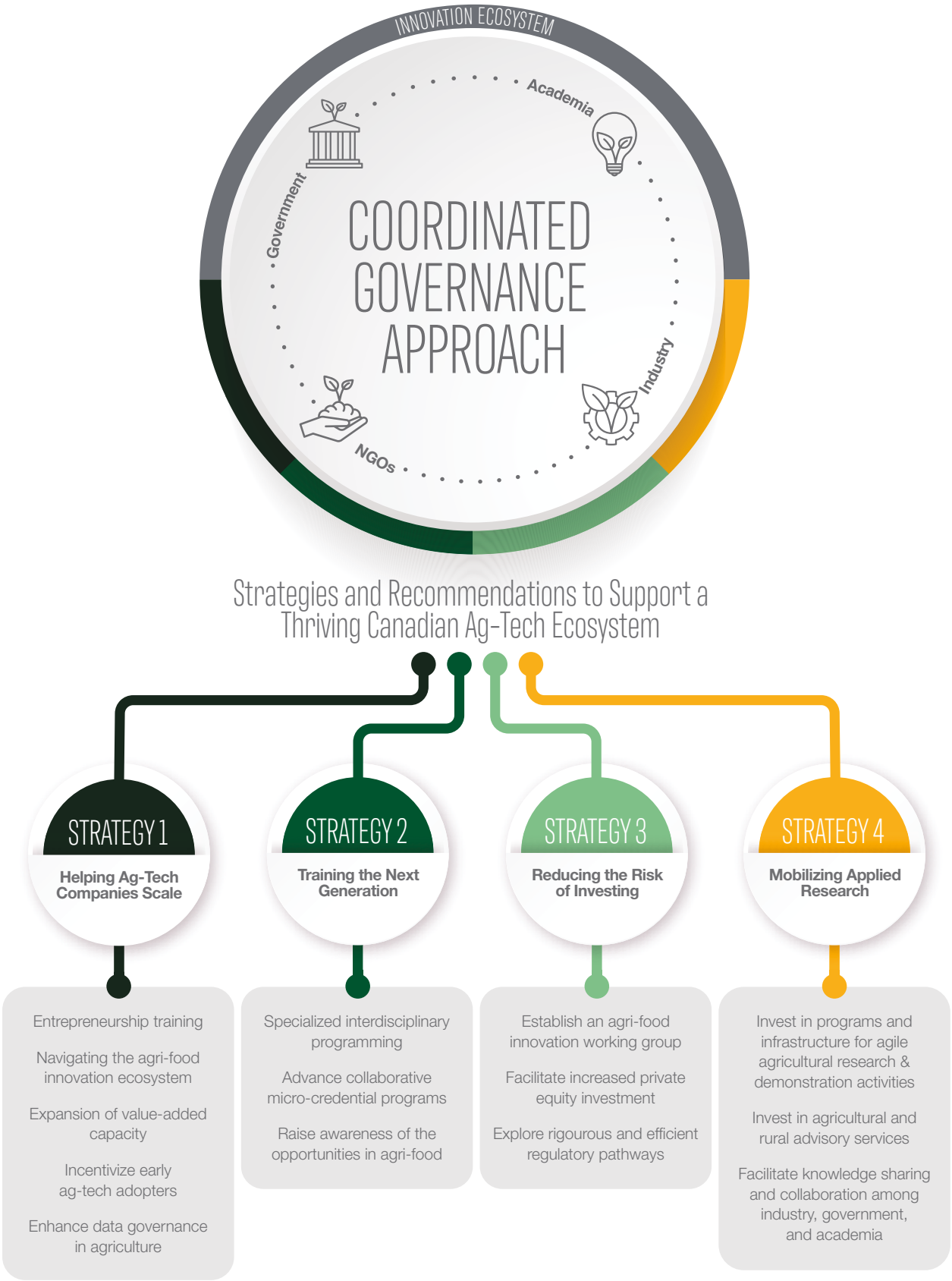


Figure 1. A coordinated governance approach is central to all strategies and recommendations to support a thriving Canadian ag-tech ecosystem.

EXECUTIVE SUMMARY

Agriculture and food technology (ag-tech) is rapidly being deployed across food systems globally.

Ag-tech has many potential benefits – it can reduce greenhouse gas emissions, support business owners facing labour shortages, and contribute to global crop yields and food security goals. Canada can become a global leader in developing and mobilizing ag-tech innovations that improve sustainability and productivity – drawing on key assets including a strong community of innovative farmers, abundant land and water resources, our strength in research and development in agriculture and food, and a highly qualified workforce supported through Canada's agriculture-focused post-secondary institutions. With this foundation, Canada is well positioned to become the key global leader in sustainable ag-tech – an opportunity that can drive economic growth, environmental sustainability, and innovation across the country.

To fully realize this potential, we must address barriers that impact how companies develop, scale, adopt, train, and recruit for ag-tech.

In late 2023 and early 2024, the Arrell Food Institute at the University of Guelph and the Food and Agriculture Institute at the University of the Fraser Valley consulted with over 100 industry, academic, government, and community experts across the country to understand the major opportunities for ag-tech investment, research and development, commercialization, and adoption. Those conversations inform this report, which also reviews Canada's ag-tech landscape, examines how Canada compares to other countries in support for ag-tech, and highlights four strategies that will support the development of innovations for a globally competitive, sustainable agri-food system. Canada will require a coordinated approach from government, industry, academia, and NGOs to reach this lofty goal of leading the world in the development of ag-tech innovations (Figure 1).

Strategy 1: Helping Ag-Tech Companies Scale

For ag-tech to contribute meaningfully to sustainable agriculture, good ideas and technologies must commercialize and scale. Canada has a robust network of incubators/accelerators and funding to support companies as they move from pilot through to commercialization. The country is highly ranked (15th) on the Global Innovation Index[1]—a measure of capacity and success in innovation, and spending on research and development in higher education is relatively high among OECD countries.[2] However, many companies struggle to cross the threshold from start-up to commercial viability.

To help ag-tech companies scale, we suggest:

1. Academic institutions should partner with governments and entrepreneurship support programs to develop entrepreneurial training that integrates technical skills with strategic thinking on commercialization and intellectual property.
2. Government should fund the development of a service-oriented organization that works with industry associations to connect ag-tech small and medium enterprises (SMEs) with investors, programs and funding streams, agricultural specialists, and markets. This would let ag-tech firms better navigate the agri-food business environment, access existing supports and markets, and connect to industry expertise and key players.
3. All levels of government should facilitate access to infrastructure and supports for value-added production, processing, and manufacturing. Policies and incentive programs that increase access to capital and remove regulatory burdens will drive private investment in ag-tech that will help to grow value-added opportunities.
4. Government and industry associations should develop programs to incentivize early ag-tech adopters willing to test new technologies emerging from academia and industry, and involve them early in the development process. Governments can also strengthen the supports and programs that mitigate the risk of adoption for these producers and businesses, as early adopters play a strong role in facilitating technology adoption, extension, and proving or disproving return-on-investment.
5. Government should support, incentivize, and action FAIR principles (findable, accessible, interoperable and reusable for both people and machines)[3] for agricultural data, software, and hardware. National prioritization of FAIR principles will reduce risks for producers experimenting with new technologies and support ethical data governance.

1 WIPO. (2023). Global Innovation Index 2023. https://www.wipo.int/global_innovation_index/en/2023/

2 OECD. (2023). Education at a Glance 2023: Country Note Canada. https://gpseducation.oecd.org/Content/EAGCountryNotes/EAG2023_CN_CAN_pdf.pdf

3 Agri-Food Data Canada. (2024). FAIR Data. https://agrifooddatacanada.ca/fair-data/

Strategy 2: Training the Next Generation

As agriculture changes and novel technologies develop, so too must training. Canadian post-secondary institutions already host world-class agricultural science and ag-tech research. Enrollments in agricultural programs are increasing – yet Canada still struggles to meet agricultural labour needs and skills gaps. Given the changing technological landscape of farming, we need to expand agricultural training to include new technologies, as well as recruit more young people (including more new Canadians) into the sector.

To train the next generation in agri-food, we suggest:

1. Academic institutions should develop specialized interdisciplinary programming that brings teams together across STEM, agricultural science, and business disciplines, with input and funding provided by government and industry.
2. Academic institutions should advance micro-credential programs, developed and delivered through collaborations between agriculture, engineering, computer science, and business schools. These micro-credentials will allow for flexible reskilling and highly specific training as an avenue to address skills gaps in the short- and medium-term.
3. Education and recruitment programs are needed to raise awareness about the fulfilling and rewarding business, research, and career opportunities in Canada's agriculture and food system. Initiatives targeted at youth (K to 12) and at underrepresented groups are especially needed for the sector to avoid missing out on the diverse talent, experience, and ideas that will drive innovation. Highlighting the opportunities offered within the agri-food system to work on sustainability and social justice should be a focus.

Strategy 3: Reducing the Risk of Investing

Investing in ag-tech can be seen as risky for both investors and adopters. Canada is highly ranked in private investment in the ag-tech space globally, with a trusted investment ecosystem and good risk management programs. Ag-tech adoption among farmers is also high. However, specific challenges in agri-food can make investment riskier: the dependence of technology testing and validation on annual growing cycles can lead to longer exits, and heavy regulatory processes for food, pharmaceutical, and nutraceutical applications take time. For producers, investment in ag-tech is risky without a demonstrated return on investment and/or risk mitigation for newer technologies.

To reduce the risk of investing, we suggest:

1. Government should establish an agri-innovation working group, similar to the Netherland's 'Top Team' approach. This working group should be composed of government, academic, industry, and community representatives to shape and steer agri-innovation priorities and strategies for the sector.
2. Venture capital (VC) investment in ag-tech in Canada is lagging, and all innovation ecosystem partners have a role to play in increasing investment levels. Producer organizations, extension personnel and specialized incubators/accelerators can communicate sector-specific challenges to investors and industry to support investment in early-stage companies that struggle with high capital expenditures. Governments should explore instruments that drive patient capital and public-private partnerships to support later-stage companies to scale.
3. Explore regulatory pathways that uphold the safety of our rigorous regulatory system but support a quicker path to market for new innovations.

Strategy 4: Mobilizing Applied Research

Canadian agricultural research is world renowned; our research institutions attract some of the top academic talent in the world; investment in R&D by higher education institutions is high compared with other countries; research papers are among the top cited, globally. Programs such as Mitacs[4] provide the opportunity for early-career researchers and students to advance industry-academia collaboration and develop workforce integration networks. However, the innovation happening in labs and trials does not always lead to commercial scalability and viability at the rates achieved in leading comparator countries. Canada produces papers, but not productivity. At the same time, Canadian business investment in R&D is relatively low as compared to other countries. Validation and product development is largely completed during early research stages, rather than later-stage business operations; funding is needed to support research in later stages of commercialization.

To mobilize applied research, we suggest:

1. Government should create innovative applied research incentives through assessment of research impact, challenge-based prizes and demonstration projects.
2. Canada should invest in agricultural and rural advisory services.
3. Industry and academia need more knowledge sharing and collaboration to develop applied solutions that meet industry and producer needs and increase business funding into R&D activities.

4 Mitacs is a non-profit organization working with "academia, government, and the public and private sectors, to help solve organizational challenges and expand Canada's innovation capacity". (https://www.mitacs.ca/)

INTRODUCTION

Canada's agriculture and food sector is at a crossroads.

As our country and the world face a series of challenges – climate change, significant economic pressures, and a shifting labour force – agri-food offers solutions. The next decade will hold unprecedented opportunities for Canada's agri-food sector to grow the economy while reducing emissions, sequestering carbon, and enhancing food security, productivity and innovation. Emerging agriculture technology (ag-tech) can drive these solutions – but to fully realize this potential, we need to act now to boost our innovation ecosystem.

The time is now to convene and set an agenda for ag-tech innovation that will position Canada as a global leader in sustainable agriculture, ag-tech development, and in driving food security at home and abroad. Government, the agricultural industry, investors, academia and non-governmental organizations have an opportunity to come together to create the blueprint that will contribute to these goals.

Defining Ag-Tech

We define **agriculture and food technologies, or 'ag-tech',** as technology and innovations that promote efficiency, productivity and sustainability across the entire agri-food value chain. The number of possible technologies is vast, so in this report we concentrate on "near-ready and future technologies that could accelerate progress towards achieving food system sustainability,"[5] and especially those currently receiving substantial interest from producers, operators, and investors.[6] We highlight the following five categories as fields ripe with near-ready and future technologies: digital agriculture, precision agriculture, automation, biotechnology, and artificial intelligence.

1. **Digital agriculture** is the use of digital devices to gather, process, and analyze data about specific objects or time to promote efficiency, productivity and sustainability in agricultural operations.[7] This empowers producers and agri-businesses to make enhanced decisions justified by data.

> *The technology solutions of Canadian start-up Semios gather, process, and analyze large amounts of data – empowering producers to strategically manage their farms and make decisions based on real-time data. To date, Semios has raised nearly a quarter of a billion dollars (CAD).[8]*

2. **Precision agriculture** builds on digital data and includes technologies that optimize production to accommodate for variability and uncertainty, such as sensors, enhanced machinery and information management systems.[9]

> *To accommodate for variability and uncertainty in the agri-food sector, Precision.ai has developed AI-powered tools to promote efficiency on-site. Benefits include increased crop yields and a reduction in chemical use. The firm completed a CAD 20 million seed round in 2021.[10]*

5 Herrero, M., et al. (2020) 'Innovation can accelerate the transition towards a sustainable food system', Nature Food, 1(5), pp. 266–272.

6 AGFunder. (2023). 10 Years in Agtech and FoodTech. https://afcms-dev1-research.s3.amazonaws.com/research_reports/AGF_10yr_Zine_F.pdf

7 Purdue University. (n.d.). Digital Agriculture. College of Agriculture. https://ag.purdue.edu/digitalag/

8 Semios. (2021, September 29). Semios raises $100 million in capital to expand agtech platform globally. Semios Blog. https://blog.semios.com/semios-raises-100-million-in-capital

9 Gebbers, R., & Adamchuk, V. I. (2010). Precision agriculture and food security. Science, 327(5967), 828-831.

10 PR Newswire. (2021, May 18). Precision AI raises $20 million to reduce the chemical footprint of agriculture. PR Newswire. https://www.prnewswire.com/news-releases/precision-ai-raises-20-million-to-reduce-the-chemical-footprint-of-agriculture-301282892.html

3. **Automation technologies** include tools that automate the crop and livestock production cycle, such as drones, automated farm and fisheries equipment, and robotics.[11]

> *Leveraging automation to scale farming is a complex task. Elevate Farms continues to innovate in this space, operating large-scale vertical farms and using robotic automation to foster efficiency in the production process. They have raised more than $36 million over a series of funding rounds (as of July 2024).[12]*

4. **Biotechnology** – a revolutionary development in ag-tech – leverages the applied use of living organisms to produce new products, such as cellular agriculture and precision fermentation.[13]

> *Optimizing the applied use of living organisms, AgGene enhances protein content in plant tissues. The start-up collaborates with other agricultural companies to help foster plants' resiliency to climate change and enhance crop production and as of August 2024, have raised over $800,000 since their inception in 2020.[14]*

5. **Artificial Intelligence (AI)'s** data analysis and automation capabilities can be used across the value chain in diverse applications such as making agronomic decisions, reducing loss/waste, addressing labour shortages, modelling potential new management practices or technologies, and improving plant and livestock breeding.

> *Nova Scotia-based startup ReelData AI provides artificial intelligence solutions for the aquaculture industry. The company received USD 8 million in Series A funding in 2023.[15]*
>
> *With AI technology evolving quickly, the range of potential uses in food production, processing and distribution are still being realized. McKinsey & Company estimates that globally, AI could create USD 100 billion in economic value on-farm and USD 150 billion across the agri-food value chain.[16]*

11 Plug and Play Tech Center. (n.d.). The impact of automated farming on the agriculture industry. https://www.plugandplaytechcenter.com/resources/how-automation-transforming-farming-industry/

12 PitchBook. (2024). Elevate Vertical Farms: Company profile. Pitchbook. https://pitchbook.com/profiles/company/431671-51

13 Dakers, S. (1996). Agricultural biotechnology - Opportunities and challenges (BP-393E). Library of Parliament, Science and Technology Division. https://publications.gc.ca/Pilot/LoPBdP/BP/bp393-e.htm

14 PitchBook. (2024). AgGene Inc.: Company profile. PitchBook. https://pitchbook.com/profiles/company/522626-86

15 ReelData AI. (2023) ReelData AI announces $8M USD Series A round. https://www.reeldata.ai/news/reeldata-ai-announces-8m-usd-series-a-round

16 McKinsey & Company. (2024, June 10). From bytes to bushels: How gen AI can shape the future of agriculture. https://www.mckinsey.com/industries/agriculture/our-insights/from-bytes-to-bushels-how-gen-ai-can-shape-the-future-of-agriculture#/

Canada is an agricultural powerhouse.

The agri-food sector provides 1 in 9 jobs and contributes approximately 7% to Canada's GDP.[17] Canada is the fifth largest exporter of agricultural products in the world – dominated by oilseeds, cereals and red meat.[18] However, Canada can improve its efficiency in sustainably producing raw commodities and add capacity to process and manufacture agri-food products domestically.[19] Emerging innovations in ag-tech will play an important part in achieving gains in efficiency and productivity.

> Farm Credit Canada estimates that improvements in our year-over-year total factor productivity – that is, how efficient we are at delivering agricultural value – **will unlock $30 billion in economic opportunity.[20]**

As our climate changes, Canada is projected to experience a longer growing season for many crops, but will also face higher temperatures, increased wildfires, drier summers, wetter winters and springs, and more extreme rainfall events.[21] These impacts will be experienced differently across the country[22] and Canada will likely experience net losses in productivity due to climate change – climatically similar countries like Germany have predicted the loss of 30% of potential yield gains.[23] As our agri-food sector grapples with these climate-related challenges, we must also move in lockstep with other industries to reduce greenhouse gas emissions from the agri-food sector, which are estimated at approximately 8.1% of the country's total emissions.[24] Investment in ag-tech solutions will help us to mitigate and reduce these climate impacts and meet our global commitments to address climate change.

17 Agriculture and Agri-Food Canada. (2023). Overview of Canada's Agriculture and Agri-Food Sector. https://agriculture.canada.ca/en/sector/overview

18 Agriculture and Agri-Food Canada. (2024a). Overview of Canada's Agriculture and Agri-Food Sector. https://agriculture.canada.ca/en/sector/overview

19 Farm Credit Canada. (2023). Canadian agriculture's $30 billion opportunity. https://www.fcc-fac.ca/en/about-fcc/media-centre/news-releases/2023/canadian-agriculture-opportunity#:~:text=Total%20factor%20productivity%20measures%20the,assessing%20trends%20in%20agricultural%20productivity.

20 Farm Credit Canada. (2023). Canadian agriculture's $30 billion opportunity. https://www.fcc-fac.ca/en/about-fcc/media-centre/news-releases/2023/canadian-agriculture-opportunity#:~:text=Total%20factor%20productivity%20measures%20the,assessing%20trends%20in%20agricultural%20productivity.

21 Climate Atlas of Canada. (2024). Agriculture and Climate Change. https://climateatlas.ca/agriculture-and-climate-change

22 Agriculture and Agri-Food Canada. (2020). Climate change impacts on agriculture. https://agriculture.canada.ca/en/environment/climate-change/climate-change-impacts-agriculture

23 Agnolucci, P., De Lipsis, V. (2019) Long-run trend in agricultural yield and climatic factors in Europe. Climatic Change 159, 385–405. https://doi.org/10.1007/s10584-019-02622-3

24 Environment and Climate Change Canada. (2024). 2030 ERP: Agriculture. https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/erp/factsheet-07-agriculture.pdf

From Research to Practice

Measurement, monitoring, reporting, and verification (MMRV) technologies will help farmers to track how much carbon is being sequestered on their farms – helping Canada meet its sustainability goals while ensuring farmers are compensated for these outcomes. Advanced imagery and analysis for soil carbon, interoperable agricultural data sharing systems, and verified digital record keeping will ensure that producers' emissions reduction achievements are efficiently and accurately translated to compensation.

Ag-tech also offers solutions for Canada's changing agri-food workforce. The number of farms across Canada is decreasing – seven small farms each day vanished over the past two decades[25] – while the remaining farms grow in size, making it challenging for new entrants to establish competitive operations. Canadian fishing operations face similar challenges related to equipment and quota access, while regulations and limitations in the aquaculture industry present challenges and disincentives for those wishing to invest in or enter the business.[26] Additionally, fisheries are in decline, in many cases in need of urgent restorative action.[27]

At the same time, labour availability for agriculture and agri-food manufacturing is decreasing. Over half (56%) of agricultural support service employers experienced a labour shortage in 2022.[28] In a survey of aquaculture operators, 63% reported difficulty in filling jobs, compared to 47% in the agriculture industry as a whole[29]. According to Food Processing Skills Canada,[30] 44,000 new jobs will need to be filled by 2025 in food manufacturing. New technologies could help the sector to sustainably manage larger acreages and address labour shortages[31] – but adoption of these technologies will require agricultural producers, innovators, entrepreneurs, and the agri-food workforce to have expertise in diverse areas such as agricultural science, engineering, biochemistry, and digital technology. Canada must be proactive in training new and incumbent generations in the range of skills and expertise needed for the farms of the future.

25 Bockman, C. (2023). What's happening to Canada's farmland. https://www.cbc.ca/news/canada/canada-prime-farmland-1.6877661

26 Canadian Accelerator and Incubator Network. (n.d.). CAIN – Our Members. https://cainetwork.ca/cain-members/

27 Schijns, R., & Rangeley, R. (2023). Oceana Canada Fishery Audit 2023. Oceana Canada. https://doi.org/10.5281/zenodo.10139205

28 CAHRC. (2023). Sowing Seeds of Change – Agriculture Labour Market Forecast 2023-2030. https://cahrc-ccrha.ca/sites/default/files/2024-02/CAHRC_LMI-Report_FEB_2024_EN%20%281%29.pdf

29 CAHRC. (2019). How Labour Challenges Will Shape the Future of the 'Aquaculture' Industry: Agriculture Forecast to 2029. https://cahrc-ccrha.ca/sites/default/files/2021-11/AQU_F2_Reduced%20size.pdf

30 Food Processing Skills Canada. (2024). Recruitment and Retention. https://fpsc-ctac.com/recruitment-retention/

31 RBC Thought Leadership. (2019). Farmer 4.0: How the coming skills revolution can transform agriculture. https://thoughtleadership.rbc.com/wp-content/uploads/Farmer4_aug2019.pdf

Canada has invested billions of dollars to encourage sustainable and efficient production through initiatives such as the Sustainable Canadian Agriculture Partnership (SCAP)[32] and the Agriculture Clean Technology Program (ACTP),[33] among others.[34] Innovative agricultural producers and agri-businesses are leading the way towards a sustainable and productive food system. The private sector is mobilized, with groups such as the Canadian Alliance for Net-Zero Agri-food (CANZA), composed of some of the country's largest agri-food companies, foundations, and think tanks, driving action toward a net-zero sector.[35] Academia and NGOs are engaged, with millions of dollars invested in sustainable agriculture research.[36]

The combination of political will, industry engagement and public concern make this a once-in-a-lifetime opportunity for Canada to capitalize on these investments and realize agriculture's potential to provide solutions to many of our most pressing issues (Figure 2).

However, we need additional building blocks to strengthen our ag-tech innovation ecosystem. Specifically, we need more support to bring innovations to market in a way that sustainably and fairly strengthens enterprises across the supply chain, and we need to highlight agri-food and ag-tech as a viable career pathway for highly qualified personnel (HQP).

To understand how we can best provide these supports and drive ag-tech innovation in Canada, the Arrell Food Institute at the University of Guelph and the Food and Agriculture Institute at the University of the Fraser Valley, under the direction of an expert advisory committee, spoke to stakeholders across the ag-tech innovation ecosystem in Canada. We conducted over 100 one-on-one interviews and gathered larger groups for roundtable discussions. We examined how Canada compares to other countries with strong agricultural innovation systems and combed through hundreds of reports and articles. From this foundation we have developed four strategies that, we believe, will support the Canadian ag-tech innovation ecosystem to drive progress, boost the economy, enhance innovation, and help us to be a world leader in ag-tech development.

32 SCAP. (2024). Sustainable Canadian Agricultural Partnership. https://agriculture.canada.ca/en/department/initiatives/sustainable-canadian-agricultural-partnership

33 Government of Canada. (2024). Agriculture Clean Technology Program. https://agriculture.canada.ca/en/programs/agricultural-clean-technology-adoption-stream

34 Environment and Climate Change Canada. (2024). 2030 ERP: Agriculture. https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/erp/factsheet-07-agriculture.pdf

35 CANZA. (2024). Driving towards a net-zero agri-food system in Canada. https://canza.ca/

36 Natural Sciences and Engineering Research Council of Canada. (2023). NSERC-SSHRC Sustainable agriculture research initiative. https://www.nserc-crsng.gc.ca/Innovate-Innover/SARI-ISRAD/Funding-Financement_eng.asp#:~:text=You%20can%20request%20%24500%2C000%20to,support%20secret%20or%20contract%20research.

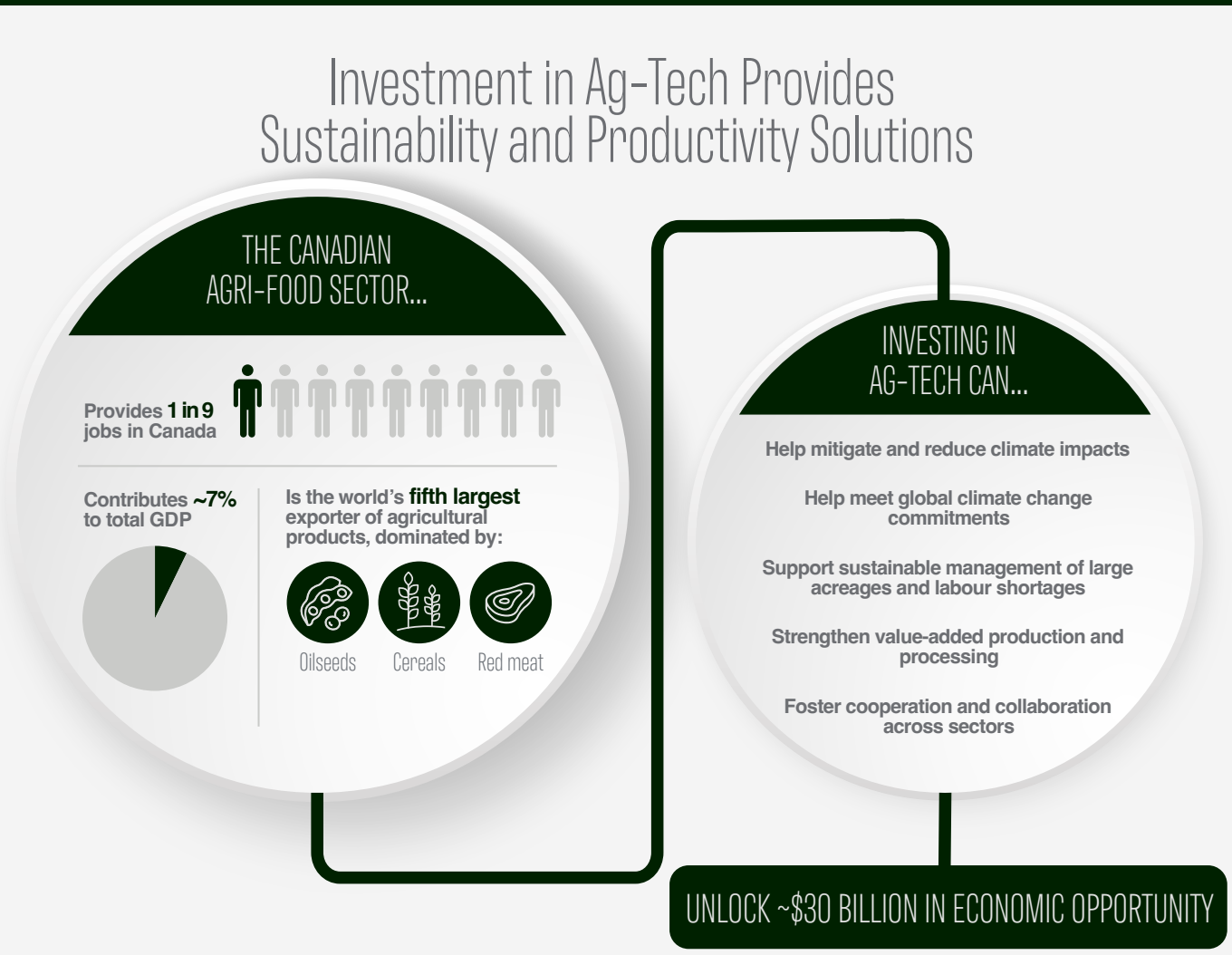


Figure 2. Investment in ag-tech provides sustainability and productivity solutions for Canada, ultimately unlocking ~$30 billion in economic opportunity.

STRATEGY 1: HELPING AG-TECH COMPANIES SCALE

STRATEGY 1

Helping Ag-Tech Companies Scale

- Entrepreneurship training
- Navigating the agri-food innovation ecosystem
- Expansion of value-added capacity
- Incentivize early ag-tech adopters
- Enhance data governance in agriculture

STRATEGY 2

Training the Next Generation

- Specialized interdisciplinary programming
- Advance collaborative micro-credential programs
- Raise awareness of the opportunities in agri-food

STRATEGY 3

Reducing the Risk of Investing

- Establish an agri-food innovation working group
- Facilitate increased private equity investment
- Explore rigourous and efficient regulatory pathways

STRATEGY 4

Mobilizing Applied Research

- Invest in programs and infrastructure for agile agricultural research & demonstration activities
- Invest in agricultural and rural advisory services
- Facilitate knowledge sharing and collaboration among industry, government, and academia

Where We Excel

Canada has an extraordinary entrepreneurial development ecosystem of over 160 incubators and accelerators from coast to coast to coast.[37]

This landscape has a well-established track record of success - increasing the survival rate of businesses, supporting growth, and scaling through increased employment and revenues. Incubator and accelerator programs are often regionally focused and sector-specific, allowing them to provide deep networks of expertise and funding for entrepreneurs. There are a few examples of strong agriculture and technology-focused programs in Canada such as Bioenterprise Canada and Creative Destruction Labs - Rockies that provide mentorship, training, and financial support to aspiring entrepreneurs.

In addition, early-stage innovations are supported by post-secondary institutions. Higher education institutions in Canada shoulder a significant portion of R&D investment, at well over double the OECD average of higher education expenditure as a percentage of gross domestic expenditure on R&D.[38] Federal tri-agency funding streams[39] support a wide array of high-quality research programs across the country. Despite all of this research investment, Canada still underperforms comparator countries in driving products to market. Canada is a leader when it comes to producing high-quality research, but it struggles to translate these findings into applicable solutions for the market – ranking below China and the USA on a per-capita basis for commercializing patents.[40] To accelerate ag-tech innovations, we need to speed up the start-up cycle, protect intellectual property, and address obstacles to business survival and growth.

When it comes to adoption of new technologies, Canada's agricultural risk management programs reduce risks associated with agricultural production and make it easier for producers to invest in new technologies. We also benefit from one of the most trusted and stable regulatory environments on the planet. These well-established assets help enhance stability for farmers, small and medium enterprises (SMEs), and investors – but we must continue national discussions about using funding structures to mitigate risks of innovation and adoption.

37 Canadian Accelerator and Incubator Network. (n.d.). CAIN – Our Members. https://cainetwork.ca/cain-members/

38 OECD. (2024). Main Science and Technology Indicators. https://stats.oecd.org/viewhtml.aspx?datasetcode=MSTI_PUB&lang=en#

39 Social Sciences and Humanities Research Council. (2024). Tri-agency funding programs. https://www.sshrc-crsh.gc.ca/about-au_sujet/collaboration/tri-agency_funding_programs-programmes_financement_trois_organismes-eng.aspx

40 Duruflé, G., & Carbonneau, L. (2016). Forging a Cleaner and More Innovative Economy in Canada: The Challenges of the Financing Chain to Foster Innovation and Growth in the Clean Tech Sector.

Opportunities for Growth

Recommendation 1: Entrepreneurship Education in Agri-Food

Academic institutions should partner with governments and entrepreneurship support programs to develop entrepreneurial training that integrates technical skills with strategic thinking on commercialization and intellectual property.

For founders to succeed, they must have competencies in four areas: entrepreneurship, business and management skills, human resources, and conceptual and relationship skills.[41] Training on entrepreneurship fundamentals has been proven to be foundational to success in commercialization. Entrepreneurship training must also foster skills such as resiliency and design thinking.

In addition, businesses that manage their intellectual property (IP) are more likely to export, grow and seek financing than those that do not.[42,43] Canada is relatively strong, globally, in ag-tech patenting, although this is boosted by large, international precision agriculture companies such as John Deere, CNH Industrial, and Bayer having substantial filings in the country.[44]

When looking at patent activity by Canadian investors as compared to select other countries (USA, Singapore, Netherlands and Ireland), Canada ranked 3rd of 5 countries – just below the Netherlands. However, in ag-tech specifically, Canada fell to 4th when adjusted for population across five broad categories of agricultural technologies – suggesting there is significant room for improvement (see Appendix 1 for more information).

To support stronger intellectual property protection norms and reach early-stage researchers and innovators, academic institutions must work alongside government and industry to protect IP and educate innovators.[45]

41 Mitchelmore, S., & Rowley, J. (2010). Entrepreneurial competencies: a literature review and development agenda. International journal of entrepreneurial Behavior & Research, 16(2), 92-111.

42 IPON. (n.d.). Intellectual Property Ontario. https://www.ip-ontario.ca/

43 IPON. (2020). Report: Intellectual Property in Ontario's Innovation Ecosystem Expert Panel on Intellectual Property. https://files.ontario.ca/books/expert-panel-report-intellectual-property-2020-02-20_0.pdf

44 Intellectual Property Collective of Canada. (n.d.). Precision agriculture: Summary landscape report. https://www.ipcollective.ca/precision-agriculture-summary-landscape-report/#taxonomy

45 Lackéus, M. (2015). Entrepreneurship in education: What, why, when, how. Background paper.

IP strategy must also extend beyond the filing phase – education for companies must also encompass ideation, product development, IP protection and IP commercialization to build a successful IP strategy.[46] This is especially true for small businesses and research projects, where limited capital may mean that projects with potential commercial value do not survive the long process of developing IP. Opportunities should be pursued to streamline requirements and shorten the runway to commercialization and profitability, particularly where agricultural growing seasons are required for validation. Investment needs to account for the length of IP development when determining exits and equity strategies.

Governments must also play a role in ensuring that their IP and patenting policies increase patenting activity and keep innovations (and innovators) in Canada. The Standing Senate Committee on Banking, Commerce and the Economy report in June 2023 said that Canada needs to accelerate "the implementation of a globally competitive intellectual property (IP) regime,"[47] and are considering tax incentives for companies. Canada's Department of Finance was seeking public input earlier this year on a proposed "patent box" regime to offer tax breaks for companies to develop and keep IP in Canada.[48] A February 2024 survey conducted by KPMG showed that 81% of business leaders are in favour of a lower corporate tax rate on revenues derived from Canadian IP.[49]

It is also important to recognize that not all applied research projects will be commercially viable or lead to immediate commercialization, nor should they. Some projects may serve as a stepping-stone towards incremental innovation while others could be commercially viable if their creators understood how to apply them in an agricultural context. While intellectual property protection is an important measure of entrepreneurial activity, it is important that innovation systems remain 'open' to ensure that good ideas are scaled out and not siloed; open-source technologies can be a tool for advancing sustainable ag-tech more broadly and efficiently.[50]

46 World Intellectual Property Organization. (n.d.). Checklist. https://www.wipo.int/sme/en/checklist.html

47 Senate Canada. (2023). Needed: An innovation strategy for the data-driven economy. Report of the Standing Senate Committee on Banking, Commerce and the Economy. https://sencanada.ca/en/committees/BANC/Report/117953/44-1.

48 Scott, J. (2024, January 31). Government of Canada finally launches consultations on SR&ED modernization. BetaKit. https://betakit.com/government-of-canada-finally-launches-consultations-on-sred-modernization/

49 KPMG (2024). Canadian business leaders want better R&D support to strengthen innovation. https://kpmg.com/ca/en/home/media/press-releases/2024/04/canadian-business-leaders-want-better-rd-support-to-strengthen-innovation.html

50 Conti, A., et al. (2023). Incentivizing Innovation in Open Source: Evidence from the GitHub Sponsors Program. https://www.hbs.edu/ris/Publication%20Files/24-014_435c983a-8377-4d49-8b31-1bd5018664bb.pdf

Recommendation 2: Ag-Tech Business Development Organization

Government should fund the development of a service-oriented organization that works with industry associations to connect ag-tech SMEs with investors, programs and funding streams, agricultural specialists and markets. This would let ag-tech firms better navigate the agri-food business environment, access existing supports and markets, and connect to industry expertise and key players.

Key obstacles to the growth of small and medium enterprises (SMEs) include difficulties responding to changing consumer demand, managing rising input costs and labour issues, and navigating programs and funding streams (Figure 3). Canadian companies are also struggling with emerging concerns related to cybersecurity, disruptive technology, and changing environmental and business conditions.[51] Start-ups and established businesses would benefit from increased access to existing supports – from programs and funding to producer organizations and extension specialists – and from connections with investors to help them adapt and grow. Finding the right programs and managing the application process is time-consuming and potentially confusing, while connecting with like-minded investors is another resource-intensive challenge. A service-oriented organization that performs a variety of enabling functions, such as connecting entrepreneurs and SMEs with programs and funding streams, would streamline access and create efficiencies for the applicants and the program staff. Such an organization could also provide a pre-screening service in conjunction with incubators/accelerators and government program staff.

51 Scott, J. (2024, January 31). Government of Canada finally launches consultations on SR&ED modernization. BetaKit. https://betakit.com/government-of-canada-finally-launches-consultations-on-sred-modernization/

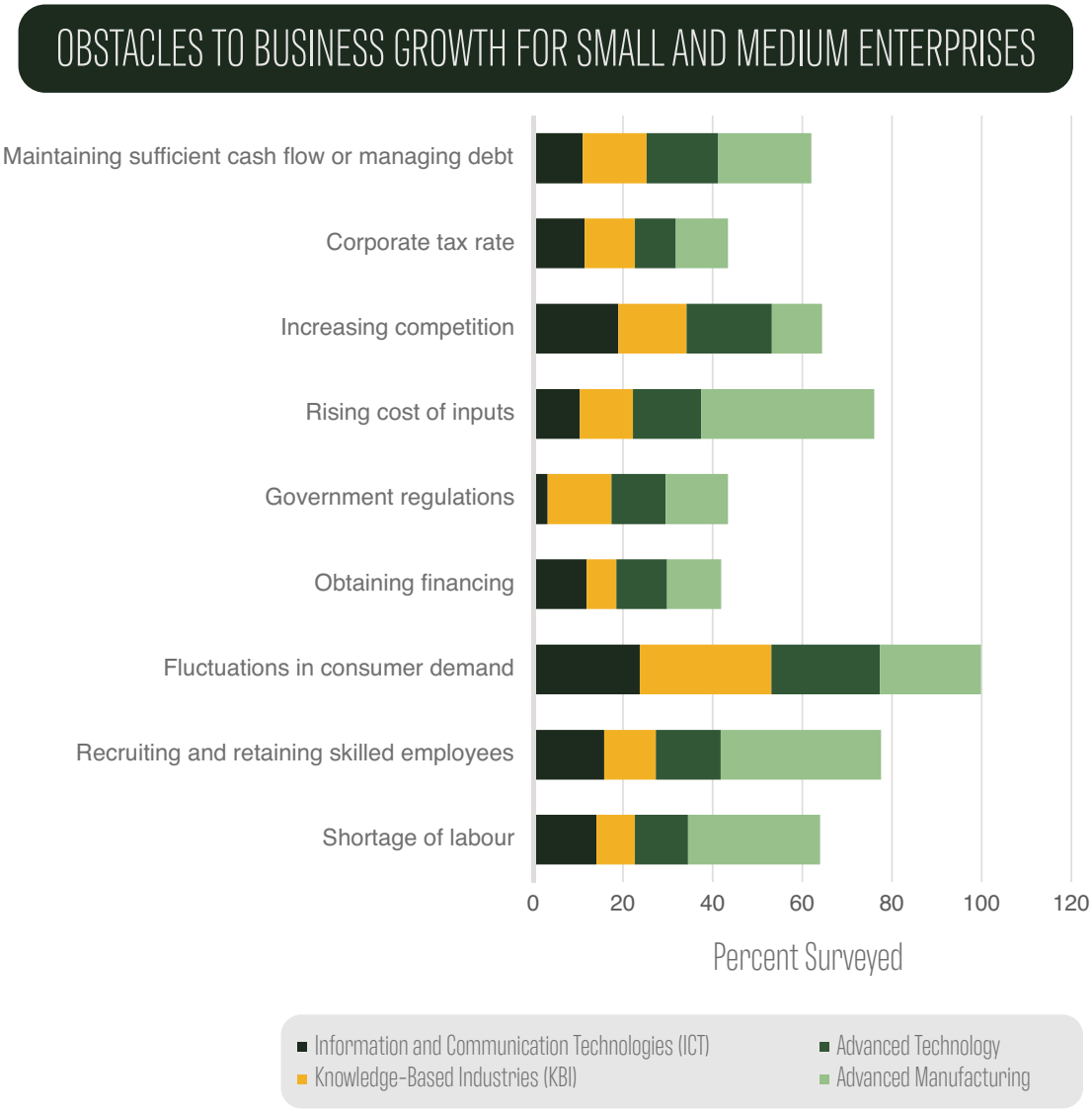


Figure 3. Challenges facing small and medium scale businesses.[52]

In agriculture, startups often have a considerably longer timeline to reach a secure income stream compared to other sectors. A service-oriented organization should also connect Canadian ag-tech entrepreneurs with policies and programs to help bring products to market faster so companies can attract investors, survive, and scale.

This new organization must create entrepreneurial development programs and supports that target the unique characteristics of agricultural innovations and businesses. It will need to attract the interest of entrepreneurs and investors without a background in the sector to the exciting opportunities in ag-tech and draw talent and investment from abroad.

52 Statistics Canada. (2022). Labour force characteristics by industry, annual (x 1,000). https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3310044701

Recommendation 3: Support Expansion of Value-Added Capacity

All levels of government should facilitate access to infrastructure and supports for value-added production, processing, and manufacturing. Policies and incentive programs that increase access to capital and remove regulatory burdens will drive private investment in ag-tech that will help to grow value-added opportunities.

Canada is currently the fifth largest exporter of agri-food and seafood in the world.[53] However, estimates suggest that Canada's total factor productivity – that is, how good we are at turning inputs (e.g., feed, capital, land, fertilizer) into outputs – will decrease through 2030.[54] If we can spur Canadian innovation to increase efficiency and create more value-added products to increase our agricultural productivity to levels observed in the 1990s and early 2000s, Farm Credit Canada estimates we could unlock up to $30 billion of economic opportunity.

Many raw Canadian commodities are sold abroad, only to be processed and then sold back to Canadian markets, representing lost domestic economic opportunities and business efficiencies.[55] Canada excels in raw commodity production for export over food and beverage processing for export (Figure 4), but has an opportunity to scale innovative, sustainable, value-added, export-oriented food, beverage, and ingredient businesses. The development and adoption of Canadian-made technologies could support value-added production.[56]

Supporting business development for "the missing middle" in agri-food systems – mid-stream processors, distributors, and value-added businesses – will make our food systems more internationally competitive and domestically secure. Additionally, it will spur Canadian innovation and develop more environmentally transparent agri-food systems that use ag-tech for carbon measurement and accounting with well-defined and transparent standards.[57]

53 Agriculture and Agri-Food Canada. (2024, June 18). Parliamentary Secretary Drouin announces new funding to help promote Canadian agri-food products around the world. Government of Canada. https://www.canada.ca/en/agriculture-agri-food/news/2024/06/parliamentary-secretary-drouin-announces-new-funding-to-help-promote-canadian-agri-food-products-around-the-world.html

54 FCC. (2023). Canadian agriculture's $30 billion opportunity. https://www.fcc-fac.ca/en/about-fcc/media-centre/news-releases/2023/canadian-agriculture-opportunity#:~:text=Total%20factor%20productivity%20measures%20the,assessing%20trends%20in%20agricultural%20productivity

55 Canadian Chamber of Commerce. (n.d.). Policy matters: Advancing Canada's agriculture and agri-food sector. https://chamber.ca/policy-matters-advancing-canadas-agriculture-and-agri-food-sector/

56 Standing Senate Committee on Agriculture and Forestry. (2018). A growing concern: How to keep farmland in the hands of Canadian farmers. Senate of Canada. https://sencanada.ca/content/sen/committee/421/AGFO/Reports/AGFO_SS-5_Report_Final_e.pdf

57 World Business Council for Sustainable Development. (2023). Achieving a just transition in the energy system. https://www.wbcsd.org/wp-content/uploads/2023/09/Achieving-a-just-transition-in-the-energy-system.pdf

> *"Canada cannot rely on foreign innovations and needs domestic ones so that producers and processors have access to new technologies as early as possible. That way, they can build or retain their competitive advantage."*
>
> *D. Prouse, CropLife Canada*[58]

Increased adoption can be accomplished through targeted government funding, tax incentives, as well as more flexible zoning policies in some jurisdictions. Increased government funding and/or incentives for business investment in sustainable ag-tech infrastructure and value-added business opportunities will be important for establishing a business case for new adoption and increasing the range of businesses willing to pursue these opportunities. Provincial governments in Canada have explored and are exploring grants,[59] tax rebate programs,[60] as well as working with municipalities to support zoning policies[61] that will allow value-added businesses to thrive in Canada.

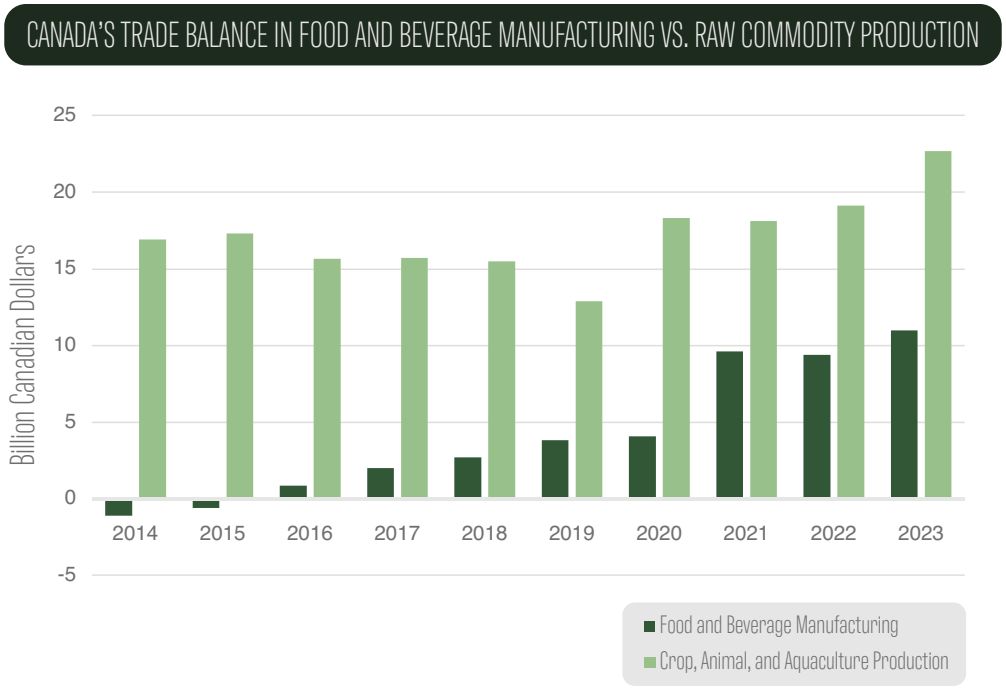


Figure 4. Comparison of raw commodity to food and beverage manufacturing trade balance.[62]

58 Senate of Canada. (2019). Made in Canada: Growing Canada's Value-Added Food Sector. Report of The Standing Senate Committee on Agriculture and Forestry. https://sencanada.ca/en/info-page/parl-42-1/agfo-made-in-canada/

59 Government of Alberta. (2024). Value-Added Program. https://www.alberta.ca/value-added-program#jumplinks-3

60 Government of Saskatchewan. (n.d.). Saskatchewan value-added agriculture incentive. https://www.saskatchewan.ca/business/investment-and-economic-development/business-incentives-and-tax-credits/saskatchewan-value-added-agriculture-incentive

61 Ontario Federation of Agriculture. (2024). Value-Added Agriculture. https://ofa.on.ca/issues/value-added-agriculture/

62 Trade Data Online. (2024). Generate Reports by Product or Industry. https://ised-isde.canada.ca/site/trade-data-online/en

Recommendation 4: Support Early Adopters

Government and industry associations should develop programs to incentivize early ag-tech adopters willing to test new technologies emerging from academia and industry, and involve them early in the development process. Governments can also strengthen the supports and programs that mitigate the risk of adoption for these producers and businesses, as early adopters play a strong role in facilitating technology adoption, extension, and proving or disproving return-on-investment.

For Canadian companies to grow, they need producers and agri-businesses to purchase their products and services. But adopting new technologies and management practices comes with risk. Will the technology perform as promised? Will the technology and training provide an adequate return on investment? Will it integrate well into existing production systems and be interoperable with other technologies being used? Emerging risks also include the data-driven and digital nature of ag-tech, which can leave farming open to malicious cyber security attacks. While sustainability is a key driver of innovation and adoption of ag-tech, these tools require some form of de-risking and a clear return-on-investment (in time savings/convenience or in dollars) for higher rates of adoption.

Neither producers nor early-stage entrepreneurs alone can be expected to bear the risks of innovation. These groups have the least capacity to experiment with risky ventures. But in this moment of great environmental and geopolitical turbulence, and with emerging technologies rapidly coming onto the market, Canada needs our producers and entrepreneurs to be able to experiment, figure out what works, and discard non-viable solutions (i.e. fail quickly).

Government can develop supports and programs to incentivize early adopters in agriculture and food. These programs should capitalize on the valuable knowledge and networks within existing agricultural advisory services and industry associations and connect innovators with early ag-tech adopters to help startups reach a viable product and sustainable revenue more quickly. Government also needs to ensure that publicly-funded agricultural and rural advisory services have the expertise and resources to be effective.

We recommend that programs should follow these principles to help mitigate risks:

a. *Involve adopters early in product development*
b. *Recognize barriers to adoption and adoption trends across the sector*
c. *Help innovators work with early adopters from diverse operations*
d. *Involve early adopters in supporting widespread adoption*

a. Involve adopters early in product development

For ag-tech adopters, many technologies require significant up-front investment and training – and may not yet have a proven return on investment. Involving early adopters earlier in development and testing would ensure there is more "in field" experience built into product development and launch, helping to decrease risks for adopters. Strong agricultural extension networks and academic institutions equipped to trial new tools and methods must be supported for more effective collaboration with the agricultural industry, a better understanding of on-farm application, and accelerated product adoption. [64]

b. Recognize barriers to adoption and adoption trends across the sector

A barrier to ag-tech adoption is that the economic returns needed to justify investments in new technology are much more likely to come from increases in productivity than from sustainability improvements. Supports and incentives will be needed to spur adoption of sustainable technologies where the ROI is uncertain or unattainable. In the words of one technology developer:

> *"We have to take more of the risk off the farmers who are trying new things, especially if it has to do with sustainability and reducing their carbon impact."*
>
> *(Interview Subject, Technology Company)*

Lessons in Failure

The practice of R&D produces far more failures than successes. What can hold innovation back is a fear of failure. Failure can be considered an essential component of experimentation and a key stepping stone to radical innovation. The sooner you fail, the sooner you can evaluate what went wrong and how to adjust. In the process of failure, learning occurs, and new ideas or new uses for the original idea may result. In a rapidly changing tech landscape, rather than waiting for what looks like the perfect solution to put into development, a series of fast failures and iterations can result in an outcome much better suited to the current market.[63]

The term 'fail quickly' does not mean to give up. It means to celebrate that failure is a part of the journey to achieving success. With each reiteration, there is a new opportunity for a breakthrough, and the only guaranteed 'failure' may be giving up entirely.

63 Giles, S. (2018, April 30). How to fail faster (and why you should). Forbes. https://www.forbes.com/sites/sunniegiles/2018/04/30/how-to-fail-faster-and-why-you-should/

64 Agmatix. (n.d.). Innovating in agriculture: Harnessing data-driven strategies for field trials. Agmatix. https://www.agmatix.com/

The Impact of Technology on Farm Efficiency and Sustainability

There is increasing evidence regarding return-on-investment for precision agriculture technologies. Research has found demonstrated benefits in reduced costs/higher yields, as well as time and labour savings via adoption of precision agriculture technologies such as auto-steer, yield monitoring, and variable rate application.[65] This research suggests that some technologies save time while others save money, and seldomly do they do both.

In a recent systematic literature review,[66] researchers synthesized data from over 130 peer-reviewed papers from the EU, finding the following economic benefits of digital technology adoption:

- *Almost 60% in fertilizer savings, and 8-80% savings in pesticides, through use of variable rate technology.*
- *Up to 97% in time savings for certain tasks and 22-49% reductions in fuel use through use of automated vehicles.*
- *Yield improvements of 10-15% through use of farm management information systems.*

65 Thompson, N. M., Bir, C., Widmar, D. A., & Mintert, J. R. (2019). Farmer Perceptions of Precision Agriculture Technology Benefits. Journal of Agricultural and Applied Economics, 51(1), 142–163. https://doi.org/10.1017/aae.2018.27

66 Papadopoulos, G., Arduini, S., Uyar, H., Psiroukis, V., Kasimati, A., & Fountas, S. (2024). Economic and environmental benefits of digital agricultural technologies in crop production: A review. Smart Agricultural Technology, 8, 100441. https://doi.org/10.1016/j.atech.2024.100441

The most recent Canadian census of agriculture found that just over half of farmers report using at least one type of the following technologies: soil sampling, auto-steer, slow-release fertilizer, variable rate tech, GIS mapping, drones, robotic milkers, or robotic greenhouse equipment technology.[67] Of the technologies surveyed, soil sample tests and auto-steer were the most common, especially compared with robotic greenhouse equipment, robotic milkers, or drones (Table 1).

Challenges and barriers to adoption of technologies are experienced upstream in the agri-food sector as well. Off-farm technologies can increase supply chain transparency, reduce waste, and support consumer dietary change.[68] However, lack of expertise, risk-averse culture, and other organizational barriers, along with high costs are barriers for agri-food companies to adopt supply chain technologies.[69]

67 Easher, T.H., et al. (2024). Canadian agriculture technology adoption. Discov Data 2, 1. https://doi.org/10.1007/s44248-024-00008-0

68 WEF. (2022). How digital technology can accelerate food sustainability. https://www.weforum.org/agenda/2022/09/how-digital-technology-can-accelerate-food-sustainability/

69 Sharma, M., Joshi, S., & Govindan, K. (2023). Overcoming barriers to implement digital technologies to achieve sustainable production and consumption in the food sector: A circular economy perspective. Sustainable Production and Consumption, 39, 203–215. https://doi.org/10.1016/j.spc.2023.04.002

Table 1. 2021 Canadian census of agriculture tech adoption rates (percentage of total farms by sector).[70] Dark grey cells indicate adoption rates greater than 40%, light grey cells indicate adoption rates between 20-39%, and white cells indicate adoption rates of 19% or less.

	Auto-Steer	GIS Mapping	Variable Rate	Drones	Soil Test	Slow-Release Fertilizer	Robotic Milking	Robotic Greenhouse Equipment
Oilseed and grain farming	57%	27%	29%	6%	49%	36%	0%	0%
Vegetable and melon farming	21%	13%	20%	4%	44%	30%	0%	1%
Fruit and tree nut farming	7%	5%	20%	3%	35%	30%	0%	0%
Greenhouse, nursery, and floriculture production	4%	3%	10%	2%	23%	29%	0%	5%
Other crop farming	8%	4%	6%	2%	15%	11%	0%	5%
Beef cattle ranching and farming	11%	5%	8%	2%	16%	14%	0%	0%
Dairy cattle and milk production	26%	16%	17%	3%	74%	39%	20%	0%
Hog and pig farming	27%	18%	17%	3%	48%	22%	0%	0%
Poultry and egg production	16%	10%	9%	2%	22%	14%	0%	0%
Sheep and goat farming	4%	3%	4%	1%	16%	10%	0%	0%
Other animal production	5%	3%	5%	2%	11%	10%	0%	0%

c. Help innovators work with early adopters from diverse operations

Adoption trends may stem from differences in producers' risk perception or the perceived benefit of the technology. More high revenue farms have used at least one technology compared to low revenue farms (86.9% compared to 20.6% of farms, respectively).[71] That may be because farms with higher revenues have higher risk tolerance to experiment with novel technologies[72] or are more likely to have the economies of scale and the capital to make the purchase viable. Additionally, technologies that have been around longer (soil testing, auto-steer) are the most widely adopted, possibly because there is a proven return on investment, a clear benefit, and less risk.

70 Easher, T. H., Enstroem, R., Griffin, T., & Nilsson, T. (2024). Canadian agriculture technology adoption. Discover Data, 2(1), 1. https://doi.org/10.1007/s44248-024-00008-0

71 Chen, Z. J. and Jewitt, A. (2023). Canada's farms integrate renewable energy production and technologies toward a future of sustainable and efficient agriculture. Statistics Canada. https://www150.statcan.gc.ca/n1/en/pub/96-325-x/2021001/article/00016-eng.pdf

72 Eastwood, C.R. and Renwick, A. (2020) 'Innovation Uncertainty Impacts the Adoption of Smarter Farming Approaches', Frontiers in Sustainable Food Systems, 4. https://www.frontiersin.org/article/10.3389/fsufs.2020.00024.

When de-risking producer investment in sustainable ag-tech, care must be taken that operational size (and related access to capital and resources) does not dictate access to technology:

> *"I think ag-tech is huge piece of the puzzle for getting us to be more sustainable, economically and environmentally. But we need to make sure it's at the right scale. We can't continue on this path of producing technologies that are unaffordable for our average size farm."*
>
> *(Interview Subject, Academic Leadership)*

Incentives for early adopters should prioritize diverse farm and operation sizes, commodity types, and business models to better pursue an even playing field.

d. Involve early adopters in supporting widespread adoption

Early adopters – those individuals who are keen to invest in novel technologies on their operations – play a key role in wider adoption trends. To encourage wider technology trials and adoption, it may be beneficial to target these individuals with programs that support both the adoption and the implementation of new technologies.

> *"A recommendation I have is to figure out ways to communicate with more progressive farmers ahead of time, to flag different innovations down the pipeline.."*
>
> *(Interview Subject, Investor)*

> *"So we have to find that balance where we can reward early adopters who are taking more of the risk, as opposed to the later adopters who are essentially buying proven technology."*
>
> *(Interview Subject, Government)*

In Canada, the Canadian Agri-Food Automation and Intelligence Network operates a Smart Farm Network covering several farming regions of Canada, to demonstrate on-farm ag-tech and advance ag-tech adoption. Similar strategies are employed across comparator countries. The Netherlands 'Farm of the Future' initiative, as well as Japan's Smart Agriculture Demonstration projects work with farmers to adopt, trial, and transparently communicate research.

Recommendation 5: Enhance Data Governance in Agriculture

Government should support, incentivize, and action FAIR principles (findable, accessible, interoperable and reusable for both people and machines)[73] for agricultural data, software, and hardware. National prioritization of FAIR principles will reduce risks for producers experimenting with new technologies, and support more ethical data governance practices.

Data governance is a challenge in ag-tech, as adopters must have the multi-disciplinary expertise to integrate new technologies and systems in an area where national standards and tools are not yet clearly defined. SMEs and producers often decide whether to adopt new technologies based, in part, on their integration with and within their existing technology ecosystem. Interoperability – the ability for hardware and software to communicate, regardless of by whom or how they were developed – is incredibly important for ag-tech adoption and development. To overcome these problems, we should support FAIR principles for data management, which state that digital research outputs, including data sets, should be findable, accessible, interoperable and reusable for both people and machines.[74] This will help to address operator concerns about how their data is used, who has access to it, and if they will be compensated for its use.

> *"Our fear is that there's going to be a proliferation of a number of different groups looking to collect sustainability data. And then those tools not being able to interact or talk to each other, and without assurance to the farmer that their data is being aggregated and their privacy is maintained.."*
>
> *(Interview Subject, Non-Governmental Organization)*

More efficient use of data can be achieved by addressing lack of interoperability between technologies. Currently, there is an abundance of data in the agricultural sector – much of which is not being used.

> *"I think that's probably everyone's challenge right now is determining how to take advantage of all this knowledge and all this data that's coming out. And because there's so much of it and not all of it is useful, how do you make sense of what's most useful?"*
>
> *(Interview Subject, Academic Leadership)*

73 Agri-Food Data Canada. (2024). FAIR Data. https://agrifooddatacanada.ca/fair-data/

74 Agri-Food Data Canada. (2024). FAIR Data. https://agrifooddatacanada.ca/fair-data/

With stronger communication between tools and technologies, data may be more seamlessly collected as well as aggregated, analyzed, and developed into stronger analytical products. The Japanese government has responded to this challenge with the development of their Agricultural Data Collaboration Platform (WAGRI), which allows for data, collected across an array of systems and by various public and private users, to be stored and shared across diverse tools for more useful products. At a smaller scale, Wageningen University similarly allows for research institutes to connect to data sharing infrastructure through its Wageningen Common Data Solutions' (WCDS) programme. In Canada, Agri-Food Data Canada is supporting the agri-food research data ecosystem through training, connections, and investments in technology, infrastructure and culture.

Fair, equitable, and inclusive data governance policies are central to any interoperable system. All users and data providers must agree to fair usage, storage, management, and compensation systems. Agriculture and Agri-Food Canada's Open Science Action Plan 2021-2022 to 2025-2026 calls for "Phased-in implementation of findable, accessible, interoperable and reusable (FAIR) data principles" within the department.[75] To date, however, Canada has not developed overarching FAIR data governance policies outside of national agencies or departments, but such work is ongoing elsewhere, such as the European Union's FAIR data governance policy.[76]

> *"How does one pull information together and make it valuable to the data contributors? That's going to be interesting to watch and observe. There are little shoots of that here and there in some other jurisdictions – in the US or Europe and so on."*
>
> *(Interview Subject, Government)*

By building on existing initiatives and modeling successful work globally, the Canadian Government can support, incentivize, and action FAIR principles for agricultural data, software, and hardware.

75 Agriculture and Agri-Food Canada. (2021). Agriculture and Agri-Food Canada's Open Science Action Plan 2021-2022 to 2025-2026 – Enable and Equip. https://agriculture.canada.ca/en/department/agriculture-and-agri-food-canadas-open-science-action-plan-2021-2022-2025-2026-enable-and-equip

76 European Commission. (2024). European Data Governance Act. https://digital-strategy.ec.europa.eu/en/policies/data-governance-act

STRATEGY 2: TRAINING THE NEXT GENERATION

STRATEGY 1

Helping Ag-Tech Companies Scale

- Entrepreneurship training
- Navigating the agri-food innovation ecosystem
- Expansion of value-added capacity
- Incentivize early ag-tech adopters
- Enhance data governance in agriculture

STRATEGY 2

Training the Next Generation

- Specialized interdisciplinary programming
- Advance collaborative micro-credential programs
- Raise awareness of the opportunities in agri-food

STRATEGY 3

Reducing the Risk of Investing

- Establish an agri-food innovation working group
- Facilitate increased private equity investment
- Explore rigourous and efficient regulatory pathways

STRATEGY 4

Mobilizing Applied Research

- Invest in programs and infrastructure for agile agricultural research & demonstration activities
- Invest in agricultural and rural advisory services
- Facilitate knowledge sharing and collaboration among industry, government, and academia

Where We Excel

Canada enjoys a world class network of colleges and universities that boast expertise in agri-food.

Our post-secondary agricultural and food institutions offer a wide range of degree and certificate programs across all levels and host many globally leading research facilities including fisheries, aquaculture, and marine science, genomics, and soil, crop, and animal science. The Deans Council – Agriculture, Food and Veterinary Medicine is a national organization connecting our five veterinary medicine and eight agriculture and food faculties. This foundation gives us a world class base on which to grow our aspirations to be one of the world's undisputed top countries for agri-food technology development. Universities, vocational schools and applied educational institutions play important roles in translating new technologies to on-farm trials and demonstrations, then in supporting training and adoption of emerging technologies. Agriculture, fisheries, and veterinary institutions, in particular, have a long history of providing support services and advancing applied research. These resources are spread across Canada; however, they are not evenly distributed, tending to concentrate in key regions such as Southern Ontario, Quebec, Alberta, and Saskatchewan. In the ag-tech sector, specifically, resources are often concentrated in a handful of urban centres. Creating flexible, interdisciplinary, and applied training programs that cater to regional agri-food strengths will drive Canada's ag-tech innovation ecosystem forward.

Opportunities for Growth

Recommendation 1: Strengthen Interdisciplinary Educational Programming

Academic institutions should develop specialized interdisciplinary programming that brings teams together across STEM, agricultural science, and business disciplines, with input and funding provided by government and industry.

Canada has seen steady growth in the number of students registering for agri-food programs (see Appendix 2 for more information). International students have led the increase in post-secondary enrolment in general, including in agricultural programs.[77]

77 Statistics Canada. (2023). Table 37-10-0018-01 Gross domestic product, expenditure-based, provincial and territorial, annual (dollars x 1,000,000).

As the agri-food landscape changes, new graduates will need expertise not only in traditional disciplines such as soil, crop, or animal science, but also expertise with sophisticated technologies and "systems thinking" skills such as project management, critical thinking, communications, and conflict resolution. This is because the workplace of the future, whether it is on a farm or somewhere else in the economy, will include small collaborative teams leveraging technology to identify and develop relevant solutions.

Agriculture also has an image problem in attracting program applicants; it is too often associated only with farming, with either small scale operations or traditional commodity production. We need agriculture to be recognized for what it is: one of the most vibrant and exciting sectors of the knowledge economy, and a priority sector for advancing global sustainability and food security. To participate in this knowledge economy, graduates need technical skills beyond (but including) agricultural disciplines, such as data science, entrepreneurship, finance, geographic information systems (GIS) science, and computation.

To create graduates with the necessary skills, we suggest Canada has a key opportunity to build on our robust post-secondary ecosystem, creating programming that brings together interdisciplinary groups. This innovative educational programming should blend executive training-style immersion, case-based learning, problem identification, skills development, and group work, following best practices in applied learning.[78,79]

Such an approach will help to address a key challenge identified during expert interviews – that we need to break down barriers between sectors and promote interdisciplinary collaboration; actions shown to catalyze novel ideas and outputs in tackling complex problems.[80] Drawing on a diverse knowledge base ensures that new technologies are rooted in industry challenges and provides hands-on and cross-sectoral learning opportunities.

> *"You've got all these ag tech companies and people who have never been on a farm, trying to develop and pilot out this tech but they don't yet have a real-world context or those connections and that expertise."*
>
> *(Interview Subject, Academic Leadership)*

78 Harvard Business School. (n.d.). Case study method. https://online.hbs.edu/blog/post/case-study-method

79 Sartania, N., Sneddon, S., Boyle, J. G., McQuarrie, E., & de Koning, H. P. (2022). Increasing collaborative discussion in case-based learning improves student engagement and knowledge acquisition. Medical Science Educator, 32(5), 1055–1064.

80 Higgins, L. E., & Smith, J. M. (2022). Documenting development of interdisciplinary collaboration among researchers by visualizing connections. Research Evaluation, 31(1), 159-172.

Entrepreneurship and business education must be integrated into more agri-food programming to help empower individuals to begin a business and be confident in operating it. Teaching students how to find additional revenue sources and manage, in many cases, multi-million dollar operations should be fundamental to core agri-food curricula, and not just in agri-business specific programs. Graduates with stronger competencies in entrepreneurial mindset, operations, finance and business creation will contribute to economic development, as well as to the success of start-ups and existing agri-food operations.

Conversely, curricula addressing issues and opportunities in agri-food should be included not only in business and entrepreneurship programs, but in a wide range of programs including STEM and social sciences. The agri-food system is fundamental to Canada's social fabric, to environmental sustainability, and to the economy. Wider recognition of the world-changing impact of the agri-food system, and its contribution to social good, will help to attract diverse and talented innovators from outside the industry.

Recommendation 2: Address Evolving Skills Gaps with Responsive Micro-credential Programs

Academic institutions should advance micro-credential programs, developed and delivered through collaborations between agriculture, engineering, computer science, and business schools. These micro-credentials will allow for flexible reskilling and highly specific training as an avenue to address skills gaps in the short- and medium-term.

The agriculture sector is projected to face substantial labour gaps over the coming decades – up to a 15% increase in peak season labour gaps, or approximately 100,000 jobs, by 2030.[81] RBC estimates that targeted immigration policies aimed at attracting 30,000 skilled farmers can address some short-term challenges related to labour shortage and aging farm populations, while the interdisciplinary learning we recommended above will provide solutions in the longer term.[82] However, gaps remain. We are projected to need 49,000 additional ag-tech workers within the next year.[83]

81 Canadian Agriculture Human Resource Council. (2024). LMI Report February 2024. https://cahrc-ccrha.ca/sites/default/files/2024-02/CAHRC_LMI-Report_FEB_2024_EN%20%281%29.pdf

82 RBC. (2023). Farmers Wanted: The labour renewal Canada needs to build the Next Green Revolution. https://thoughtleadership.rbc.com/farmers-wanted-the-labour-renewal-canada-needs-to-build-the-next-green-revolution/

83 Ivus, M., et al. (2022). Overview: Canadian Agri-Food Technology. Information and Communications Technology Council (ICTC). https://ictc-ctic.ca/articles/overview-canadian-agri-food-technology

Automation and technology is a partial solution to the labour shortage, but workers need skills and training to operate these technologies.[84] Nearly two-thirds (65%) of Canadian producers in a recent survey indicated that more training and skills development is required for the agri-food sector[85] – and agriculture is not alone in experiencing skills shortages, with 55% of high-tech entrepreneurs in the IT sector also struggling to recruit skilled workers.[86]

Data suggests Canada faces a skills shortage in food production, but a skills surplus in Science, Technology, Engineering, and Mathematics (STEM) fields (Figure 5); this may be an opportunity to attract students in STEM fields to the agricultural sector.

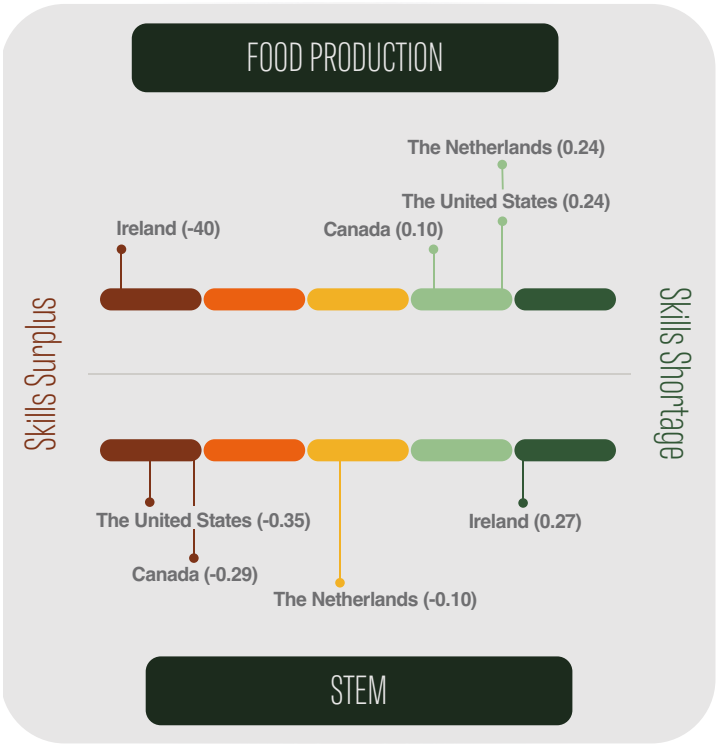


Figure 5. Adapted from RBC[87] and OECD[88] 'Food Production' and 'Engineering, Mechanics, and Technology' skills data.

84 Agriculture and Agri-Food Canada. (2023). What we heard report: Agricultural labour strategy. https://agriculture.canada.ca/en/department/transparency/public-opinion-research-consultations/what-we-heard-report-agricultural-labour-strategy#s8

85 Agriculture and Agri-Food Canada. (2023). What we heard report: Agricultural labour strategy. https://agriculture.canada.ca/en/department/transparency/public-opinion-research-consultations/what-we-heard-report-agricultural-labour-strategy#s8

86 IT World Canada. (n.d.). Thriving amid Canada's tech talent shortage. https://www.itworldcanada.com/sponsored/thriving-amid-canadas-tech-talent-shortage#:~=Skill%20gaps%20affect%20businesses%20of,our%20talent%20pool%20is%20essential

87 RBC. (2023). Farmers Wanted: The labour renewal Canada needs to build the Next Green Revolution. https://thoughtleadership.rbc.com/farmers-wanted-the-labour-renewal-canada-needs-to-build-the-next-green-revolution/

88 OECD. (2024). Skill needs by country. https://data-explorer.oecd.org/vis?tenant=archive&df[ds]=DisseminateArchiveDMZ&df[id]=DF_S4J2022&df[ag]=OECD&dq=NLD%2BIRL%2BCAN.10-3%2B12%2B10-4&to[TIME]=false&vw=tb

Flexible upskilling and retraining programs can support current workers to learn on their own time and such programs can respond, in real-time, to industry needs.[89] The Government of Canada and industry are already investing in these programs. For example, Protein Industries Canada, in partnership with the University of Saskatchewan, has created a short, hybrid training program, Automation & Digital Agriculture Specialist.[90] The program served a majority (~75%) of individuals identified as members of underrepresented groups, with nearly half of participants (44%) identifying as women.

A suite of micro-credentials that provide specialized training in an agricultural context may be a solution, but the learning opportunities need to be accessible and well marketed to both attract new talent and reach existing workers.

Recommendation 3: Raise Awareness of the Opportunities in Agri-Food

Education and recruitment programs are needed to raise awareness about the fulfilling and rewarding business, research, and career opportunities in Canada's agriculture and food system. Initiatives targeted at youth (K to 12) and at underrepresented groups are especially needed for the sector to avoid missing out on the diverse talent, experience, and ideas that will drive innovation. Highlighting the opportunities offered within the agri-food system to work on sustainability and social justice should be a focus.

Agriculture in Canada is not generally seen as a favoured business opportunity or career path. Although enrollment in Canada's post-secondary agriculture programs is strong, it is not clear that we are attracting the top talent to agri-food in the same way as the medicine, digital technologies or aerospace sectors. When we think of the brilliant, passionate people who change the world with their ideas, do they see the potential in agri-food? A general lack of awareness of the opportunities in agriculture not only affects innovation and entrepreneurship potential, but investment in ag-tech as well.

In terms of the workforce, by 2030, there are projected to be over 100,000 vacant jobs in the Canadian agriculture sector.[91] These vacancies are a result of various positions requiring diverse skillsets – the sector requires workers beyond labour focused roles. Canada's Economic Strategy Tables found that top reasons for labour shortages in agri-food included lack of availability of skilled talent in STEM and high-skills occupations, lack of awareness from

89 Innovation, Science and Economic Development Canada. (2023). Upskilling for Industry Initiative. https://ised-isde.canada.ca/site/upskilling-industry-initiative/en

90 Protein Industries Canada. (2022). Increasing skills and talent in Canada's agrifood sector. https://proteinindustriescanada.ca/projects/increasing-skills-and-talent-in-canadas-agrifood-sector

91 CAHRC-CCRHA. (n.d.). Canadian Agricultural Human Resource Council projects job vacancies will surpass 100,000 by 2030 as nearly one-third of agri-workforce retires. https://cahrc-ccrha.ca/cahrc/news-releases/new-report-canadian-agricultural-human-resource-council-projects-job-vacancies

those trained in general occupations (eg. skilled trades) about the opportunities in the agri-food sector, and perceptions about working in the agri-food industry.[92] Similarly, when the Senate of Canada looked at Canada's food processing capacity in 2020-21, they heard that there is a lack of awareness about job opportunities in the sector generally, and that preconceptions about the sector lead to a low level of interest in food processing careers. The Senate of Canada's Standing Committee on Agriculture and Agri-Food[93] heard testimony that guidance counsellors "are not inclined to guide young people into this sector." Other recent reports echo these concerns, including a report on cybersecurity in Canadian agriculture from the Community Safety Knowledge Alliance,[94] which states "awareness and training should also start early for children and youth, who may be interested in pursuing careers in Canada's agri-food sector."

Awakening people to the opportunities to effect change towards environmental sustainability and social justice through the agri-food system is seen as a priority.[95,96,97,98] In a recent CAHRC survey focused on non-traditional job seekers to agriculture, over two thirds of respondents identified helping to solve social and/or environmental challenges as a career goal.[99]

We also need to make agri-food a more attractive option for equity-seeking and Indigenous people who could bring their knowledge and talent to an industry where they are significantly underrepresented. Racialized groups and Indigenous Peoples represent only 5% of Canada's farm operators, despite comprising close to one-third of Canada's total population.[100] However, racialized and immigrant farm operators are more likely to have a post-secondary degree, certificate, or diploma than non-racialized operators[101] – suggesting that greater inclusion of underrepresented groups is an opportunity to bring new knowledge, skills, and talent to this industry. Significantly for ag-tech, these groups are also substantially underrepresented in the digital economy in general.[102]

92 Government of Canada. (2018). The Innovation and Competitiveness Imperative: Seizing Opportunities for Growth, A Report from Canada's Economic Strategy Tables. https://ised-isde.canada.ca/site/economic-strategy-tables/en/report-2018/report-canadas-economic-strategy-tables-agri-food

93 Senate of Canada. (2022). Confronting Urgent Challenges and Building the Resilience of the Canadian Food Supply Chain: Report of the Standing Committee on Agriculture and Agri-Food. https://www.ourcommons.ca/Content/Committee/441/AGRI/Reports/RP11851497/agrirp05/agrirp05-e.pdf

94 Community Safety Knowledge Alliance. (2022). Cyber Barn Raising: A Framework and Recommendations for Strengthening Cyber Resilience in Canadian Agriculture. https://cskacanada.ca/wp-content/uploads/2023/03/CSKA-CyberBarnRaising-FIN-digital.pdf

95 Financial Post. (2023, May 23). Tech, sustainability key to attracting young talent to an evolving agriculture sector. https://financialpost.com/pmn/commodities-business-pmn/agriculture-commodities-business-pmn/tech-sustainability-key-to-attracting-young-talent-to-an-evolving-agriculture-sector-2

96 Conference Board of Canada. (2024). The Next Frontier in Canada's Agri-Food Sector - Technology-Driven Labour and Skills Transitions.

97 Agriculture and Agri-Food Canada. (2023). What we heard report: Agricultural labour strategy. https://agriculture.canada.ca/en/department/transparency/public-opinion-research-consultations/what-we-heard-report-agricultural-labour-strategy

98 Parker, Becky. (2016). Inspiring Gen Z to Consider Careers in Agriculture and Food. Nuffield Canada. https://www.nuffieldscholar.org/reports/ca/2015/inspiring-gen-z-consider-careers-agriculture-and-food

99 CAHRC-CCRHA. (2023). Identifying and Addressing Barriers to Careers In Agriculture. https://cahrc-ccrha.ca/resources/document/identifying-and-addressing-barriers-careers-agriculture

100 Statistics Canada. (2023). A story about the diversity of Canada's farm operators. https://www150.statcan.gc.ca/n1/pub/96-325-x/2021001/article/00017-eng.htm

101 Statistics Canada. (2023). A story about the diversity of Canada's farm operators. https://www150.statcan.gc.ca/n1/pub/96-325-x/2021001/article/00017-eng.htm

102 ISED.(2019). Building a nationof innovators. https://ised-isde.canada.ca/site/innovation-better-canada/en/building-nation-innovators

Perceptions of the agri-food sector as a viable career path vary among equity-seeking communities. Agriculture and Agri-Food Canada, in consultations with stakeholders for a National Agricultural Labour Strategy, heard repeatedly that employees have experienced bias and discrimination when pursuing careers in agriculture, leading them to leave the sector.[103] A recent survey found that women have negative perceptions of potential employment in the agri-food sector, but perceptions among Indigenous Peoples and immigrant populations were more positive than the rest of the total survey population.[104]

The industry will need to take action to address these negative experiences, while recruitment programs will need to counteract unfavourable perceptions of agricultural workplaces. Survey data for both Canada's Indigenous Peoples and for immigrants to the country suggest that it is not a lack of interest or awareness that limits agricultural careers for either group, but rather other issues, such as lack of access to capital and financing for ag-tech, or lack of recognition of foreign credentials or experience by the Canadian government.[105]

Further work, thinking, and funding is required to design and develop programming that addresses these complex considerations, and we encourage the continued development of financing and funding mechanisms that recognize systemic barriers in access to capital among underrepresented groups.

103 Agriculture and Agri-Food Canada. (2023). What We Heard Report—Agricultural Labour Strategy. https://agriculture.canada.ca/en/department/transparency/public-opinion-research-consultations/what-we-heard-report-agricultural-labour-strategy

104 CAHRC. (2023). Identifying and Addressing Barriers to Careers in Agriculture. https://cahrc-ccrha.ca/sites/default/files/2024-02/Identifying%20and%20Addressing%20Barriers%20to%20Careers%20in%20Agriculture%20-%20FINAL.pdf

105 CAHRC. (2023). Identifying and Addressing Barriers to Careers in Agriculture. https://cahrc-ccrha.ca/sites/default/files/2024-02/Identifying%20and%20Addressing%20Barriers%20to%20Careers%20in%20Agriculture%20-%20FINAL.pdf

STRATEGY 3: REDUCING THE RISK OF INVESTING

STRATEGY 1

Helping Ag-Tech Companies Scale

- Entrepreneurship training
- Navigating the agri-food innovation ecosystem
- Expansion of value-added capacity
- Incentivize early ag-tech adopters
- Enhance data governance in agriculture

STRATEGY 2

Training the Next Generation

- Specialized interdisciplinary programming
- Advance collaborative micro-credential programs
- Raise awareness of the opportunities in agri-food

STRATEGY 3

Reducing the Risk of Investing

- Establish an agri-food innovation working group
- Facilitate increased private equity investment
- Explore rigourous and efficient regulatory pathways

STRATEGY 4

Mobilizing Applied Research

- Invest in programs and infrastructure for agile agricultural research & demonstration activities
- Invest in agricultural and rural advisory services
- Facilitate knowledge sharing and collaboration among industry, government, and academia

Where We Excel

Compared with other countries, many aspects of our agri-food infrastructure are world-leading.

We have one of the most trusted and stable regulatory environments on the planet, leading to a well-regarded, high-quality, and safe Canadian agri-food brand globally. While these regulations lead to greater entry requirements and exit times for new and emerging SMEs, they build investor confidence. We also have business risk management programming including crop insurance that helps reduce risks associated with crop failures, advanced research and development in agri-food, and access to markets in Canada and internationally. These strengths, along with new funding to promote Canada's agri-food products globally,[106] make ag-tech an exciting opportunity for investors.

However, specific challenges in agri-food can make investment riskier: the dependence of technology testing and validation on annual growing cycles can lead to longer exits, and heavy regulatory processes for food, pharmaceutical, and nutraceutical applications take time. For producers, investment in ag-tech is risky without a demonstrated return on investment and/or risk mitigation for newer technologies.

Globally, 2022-23 saw a sharp decline in private investment in ag-tech, including in Canada. Private investment in ag-tech in Canada is strong but lags comparator countries. We were 6th in the world for private investment in 2022, with 102 deals totaling USD 1.2 billion,[107] and 9th in the world in 2023, with total deals of USD 416 million.[108]

Despite these challenges, ag-tech in Canada still saw a 16% growth in private equity investment between 2022 and 2023.[109]

106 Agriculture and Agri-Food Canada. (2024, June 18). Parliamentary Secretary Drouin announces new funding to help promote Canadian agri-food products around the world. Government of Canada. https://www.canada.ca/en/agriculture-agri-food/news/2024/06/parliamentary-secretary-drouin-announces-new-funding-to-help-promote-canadian-agri-food-products-around-the-world.html

107 AgFunder. (2023). Global AgriFoodTech Investment Report 2023. https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/?download=true

108 AgFunder, (2024). AgFunder Global AgriFoodTech Investment Report 2024. https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/?download=true

109 CVCA. (2023). Canadian Private Equity Market Overview. https://www.cvca.ca/assets/files/reports/year-end-2023-vc-pe-canadian-market-overview/CVCA_PE_Q4_2023_FINAL-2.pdf

Opportunities for Growth

Recommendation 1: Establish an Agri-Food Innovation Working Group

Government should establish an agri-food innovation working group, similar to the Netherland's 'Top Team' approach. This working group should be composed of government, academic, industry, and community representatives to shape and steer agri-innovation priorities and strategies for the sector.

While private investment in Canadian ag-tech is strong, there remains a need for greater collaboration and coordination among stakeholders to build investment direction and confidence. The Standing Senate Committee on Agriculture and Forestry[110] found lack of cooperation and coordination among government, academic, research institution, and industry stakeholders to be a key barrier in advancing agri-food innovation across the country. Echoing the Netherland's Top Sector Agri-Food approach, a standing team representing academia, industry, and government could shape private and government investment directions that are in line with market trends as well as the public good. Bringing these groups together to shape innovation agendas and set investment priorities is a crucial step to reduce risk for investment in sustainable ag-tech.

According to the Global Entrepreneurship Monitor,[111] Canada's entrepreneurial ecosystem is on par with comparable countries, but has room for improvement (see Appendix 3). Partnerships are needed to reduce risks for investors and entrepreneurs (e.g., offtake agreements),[112] while governments can offset risks through tax incentives for research and development (e.g., SR&ED credits). To flesh out these mechanisms, we urgently need industry, government, and academic stakeholders to come together to identify strategies to reduce risk for investment in the ag-tech space, increasing private investment and accelerating the benefits of ag-tech for Canada.

> *"We need to upgrade infrastructure, cultivate relentless innovation, secure global market access, and forge strong, collaborative networks, all while prioritizing sustainable growth."*
>
> *(Interview Subject, Investor)*

110 Standing Senate Committee on Agriculture and Forestry. (2018). A growing concern: How to keep farmland in the hands of Canadian farmers. Senate of Canada. https://sencanada.ca/content/sen/committee/421/AGFO/Reports/AGFO_SS-5_Report_Final_e.pdf

111 GEM. (2024). GEM 2023/2024 Global Report—25 Years of Progress. Global Entrepreneurship Research Association. https://www.gemconsortium.org/reports/latest-global-report

112 McKinsey & Company. (2024). Seizing opportunities amid the ag-tech capital drought. https://www.mckinsey.com/industries/private-capital/our-insights/seizing-opportunities-amid-the-agtech-capital-drought

Tools for Managing Risk

There are certain resources available to investors and entrepreneurs to reduce risk such as offtake agreements as well as Scientific Research & Experimental Development (SR&ED) Credits.

An offtake agreement is a contractual agreement between a producer and a buyer to purchase a future production.[113] These agreements are valuable for firms preparing to scale as they may have confidence in knowing an agreement is standing as they grow the venture.

Scientific Research & Experimental Development (SR&ED) Credits foster innovation by providing tax credits for expenditures necessary to deliver R&D, such as wages, materials and overhead costs.[114] Such offerings incentivize the development of innovative products, services and knowledge.

113 Senken. (2024, May 24). Offtake agreements. Senken Glossary. https://www.senken.io/glossary/offtake-agreements

114 Government of Canada. (2023). Scientific Research and Experimental Development (SR&ED) tax incentives. https://www.canada.ca/en/revenue-agency/services/scientific-research-experimental-development-tax-incentive-program.html

Recommendation 2: Facilitate Increased Private Equity Investment

Venture capital (VC) investment in ag-tech in Canada is lagging, and all innovation ecosystem partners have a role to play in increasing investment levels. Producer organizations, extension personnel and specialized incubators/accelerators can communicate sector-specific challenges to investors and industry to support investment in early-stage companies that struggle with high capital expenditures. Governments should explore instruments that drive patient capital and public-private partnerships to support later-stage companies to scale.

There is a significant need for an increase not only in the number of investors in the Canadian market for ag-tech but also the amount of capital being invested. Activity surrounding ag-tech investment has recently cooled. The average deal size fell nearly 40% in 2023,[115] while 90% of non-dilutive[116] funding came from SR&ED credits.[117]

Ag-tech offers great promise with the potential to feed the future, mitigate climate change, and realize untapped economic potential. However, capital is necessary to realize this impact, and investors will need patience as returns can be seen gradually over time.

115 Canadian Venture Capital and Private Equity Association (CVCA). (2024). 2023 Canadian Venture Capital Market Overview. https://reports.cvca.ca/books/ugbs/#p=26

116 Non dilutive funding is a term used to describe funding that does not require the recipient to give up equity or ownership in their company (e.g., loans, grants, awards, and tax incentives). https://www.rbcx.com/ideas/startup-insights/funding-101-how-does-a-startup-get-funding/#:~:text=Non%2Ddilutive%20financing%20means%20capital,a%20set%20period%20of%20time.

117 Canadian Venture Capital and Private Equity Association (CVCA). (2024). 2023 Canadian Venture Capital Market Overview. https://reports.cvca.ca/books/ugbs/#p=26

Globally ag-tech is facing a Venture Capital (VC) investment drought.[118] Despite a rise in the total number of agri-food focused venture capital funds over time (Figure 6), the number of funds invested in agri-food startup deals declined globally by 60% between 2022 and 2023.[119] Canada lags the United States in attracting ag-tech investment.[120] High-value Canadian start-ups require 55% more VC funding to achieve the same levels of success as their US counterparts, as companies must internationalize to scale beyond our relatively small domestic market.[121]

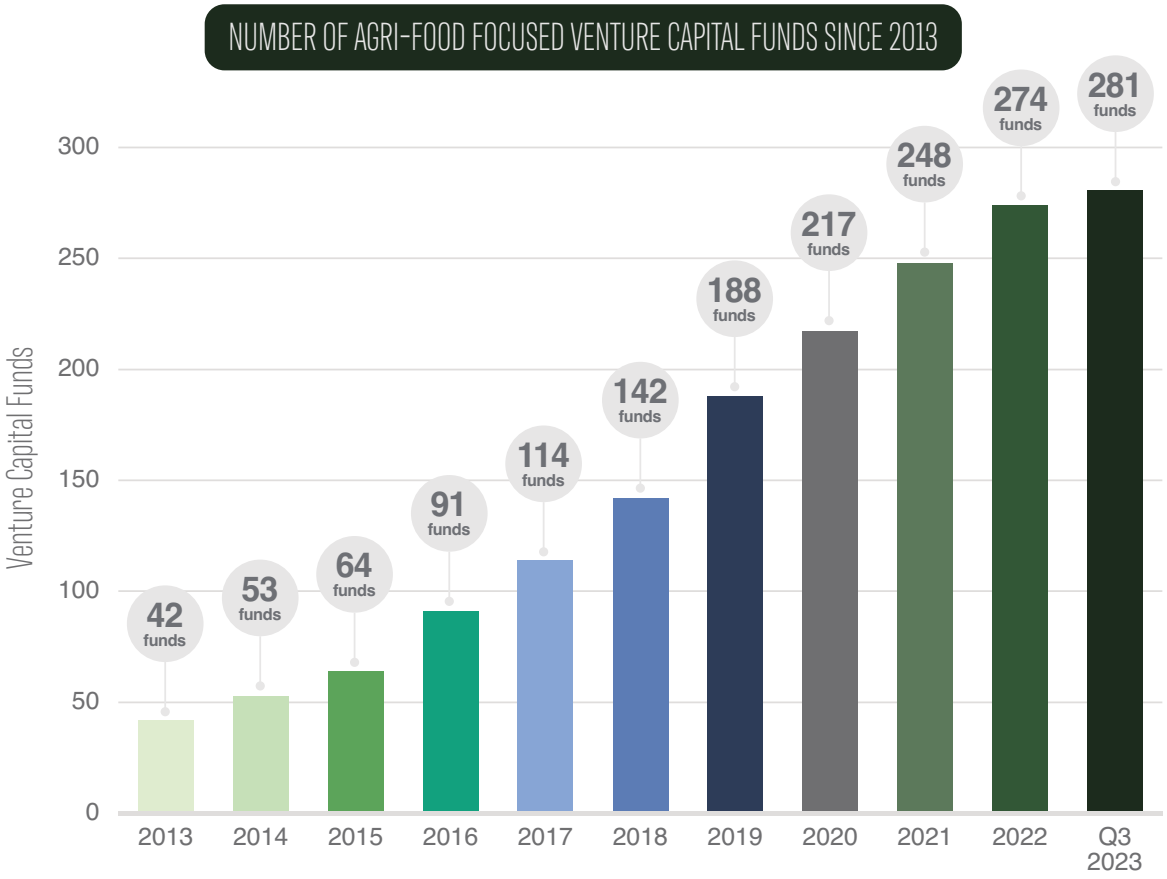


Figure 6. Growth of global agri-food focused VC funds over time. Image adapted from AgFunder.[122]

118 McKinsey & Company. (2024). Seizing opportunities amid the ag-tech capital drought. https://www.mckinsey.com/industries/private-capital/our-insights/seizing-opportunities-amid-the-agtech-capital-drought

119 AgFunder, (2024). AgFunder Global AgriFoodTech Investment Report 2024. https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2024/?download=true

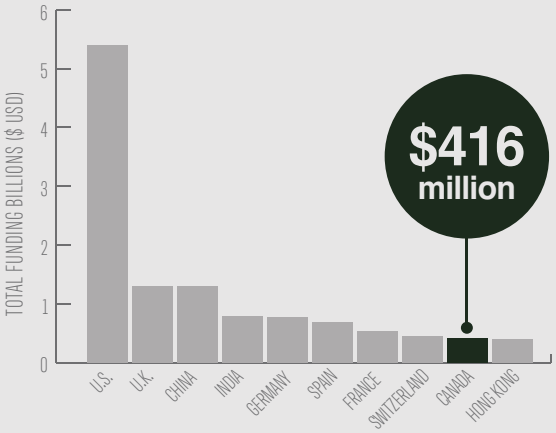
120 AgFunder. (2023). Global AgriFoodTech Investment Report 2023. https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/?download=true

121 Business Development Bank of Canada. (2020a). VC in Canada: How do we stack up against the rest of the world? https://www.bdc.ca/en/articles-tools/blog/vc-canada-how-do-we-stack-up-against-rest-of-world

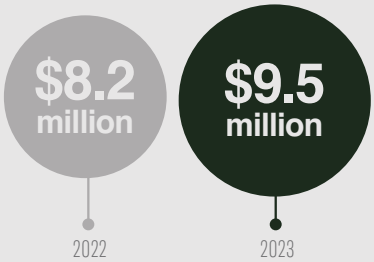
122 AGFunder. (2023). 10 Years in Agtech and FoodTech. https://afcms-dev1-research.s3.amazonaws.com/research_reports/AGF_10yr_Zine_F.pdf

INVESTMENT IN AG-TECH IN CANADA IS STRONG...

Canada ranked ninth in the world for private investment in 2023.



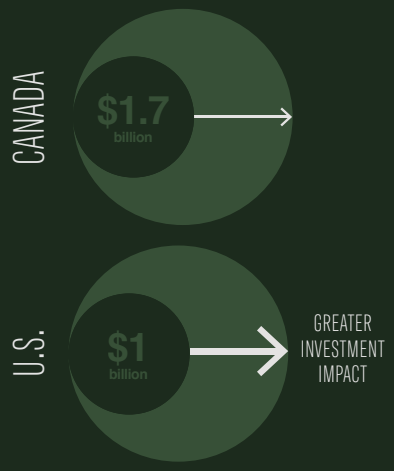
AVERAGE DEAL SIZE



Between 2022 and 2023, Canada saw a 16% growth in private equity investment.

...BUT, CANADA LAGS BEHIND THE U.S. IN ATTRACTING VC INVESTMENT

High-valued Canadian start-ups require 55% more VC funding to achieve the same levels of success as their U.S. counterparts.



More comprehensive support is needed to foster Canada's competitiveness in the global ag-tech landscape.

RESOURCES FOR EXISTING INCUBATORS & ACCELERATORS

SECTOR-FOCUSED PROGRAMS

STRONGER RELATIONSHIPS WITH INDUSTRY

> *"Currently, Canada has few AgTech-specific VCs, and even fewer are Operator VCs—those who bring not just capital, but the critical expertise needed to guide startups to success. These VCs provide strategic direction, industry insights, and operational know-how, leveraging their networks to enhance credibility and attract further investment."*
>
> *(Interview Subject, Investor)*

More resources are required to ensure Canada has a strong network of agri-food focused incubators and accelerators. These incubators and accelerators should foster relationships with experienced partners, including producer organizations and extension specialists, to ensure that start-ups are producing solutions well aligned with domestic end-user needs but designed to be globally scalable. Supporting SMEs to access international markets will foster Canada's competitiveness in the global ag-tech landscape.

In addition to increasing overall funding, we must create more comprehensive support for early-stage companies. Entrepreneurs face substantial hurdles in moving from pilot/demonstration scales to commercial technology adoption and dissemination.[123] A key barrier for early-stage entrepreneurs is difficulty finding funds to cover large capital expenditures and overhead – especially in industries with a high capital expenditures component such as equipment manufacturing, vertical farming, or robotics and automation.

> *"Many funds are smaller in size, which limits their ability to invest in business models that have a high capex [capital expenditures] component."*
>
> *(Interview Subject, Investor)*

This challenge is compounded by complex funding structures that often require matching cash or detailed financial information, which can prohibit entry into the research and development and/or scaling phases of innovation.

Later-stage start-ups, in comparison, often struggle to mature and integrate into the market. Technology Readiness Level (TRL) measures the maturity level of a technology, which ranges from 1 (conceptual) to 9 (fully operational).[124] Research councils provide good support for companies at early stages of readiness, but many companies at the upper levels (4-7) cannot scale through the "Valley of Death," the operational period of a start-up at the beginning of commercialization where little revenue is generated[125] often due to a lack of funding, difficulties in

123 Inventures Canada. (2024). Entrepreneurship: Accelerating scale-up. https://inventurescanada.com/blog/news/entrepreneurship-accelerating-scale-up/

124 NASA. (2023). Technology Readiness Levels. https://www.nasa.gov/directorates/somd/space-communications-navigation-program/technology-readiness-levels

125 Harvard Business Review. (2022). An entrepreneur's guide to surviving the death valley curve. https://hbr.org/2022/04/an-entrepreneurs-guide-to-surviving-the-death-valley-curve

scaling technology, and limited adoption from the marketplace.[126] For agricultural companies, this acute period of development can be particularly difficult to navigate, given the relatively slow nature of research with biological systems and the requirements of Canada's regulatory system.

> *"Moving innovations from a really great idea in a university lab or field trial – getting tech over that hurdle is a challenge. How do they scale it up and make it useful for every farmer? There's a funding gap from idea to innovation to implementation and adoption."*
>
> *(Interview Subject, Non-Governmental Organization)*

There are several possible strategies to incentivize more patient capital – investment that prioritizes a diverse set of outcomes beyond short-term returns. One strategy includes tailoring financial instruments to sustain the progression of start-ups with incremental funding, to support firms as they advance through the "Valley of Death." Layered approaches to patient capital investment, such as public-private partnerships, provide assurance over the longer term and reduce risk to investing. In Canada, future work with the federal and provincial governments and financial institutions will be required to identify key components of a patient capital strategy for the ag-tech sector – we recommend looking to examples such as the United Kingdom, where government developed an instrument to drive investment in high-growth and capital-intensive business and worked with British Business Bank to secure fund assets.[127,128]

Recommendation 3: Ensure Regulations Do Not Disadvantage Canadian Innovators

Explore regulatory pathways that uphold the safety of our rigorous regulatory system but support a quicker path to market for new innovations.

Canada's regulatory system is known globally for its quality and the large scale of export goods that are produced across the country. From a branding perspective this is a great strength, reducing the need to validate claims of health or sustainability benefits beyond the already rigorous regulatory requirements.

126 Gbadegeshin, S. A., Al Natsheh, A., Ghafel, K., Mohammed, O., Koskela, A., Rimpiläinen, A., & Kuoppala, A. (2022). Overcoming the valley of death: a new model for high technology startups. Sustainable Futures, 4, 100077

127 U.K. Government. (n.d.). Patient Capital Review: Industry panel response. https://assets.publishing.service.gov.uk/media/5a82f16b40f0b62305b95264/PCR_Industry_panel_response.pdf

128 Deloitte. (2020). The Future of Growth Capital Report. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/financial-services/deloitte-uk-the-future-of-growth-capital-august-2020.pdf

This is, however, a significant barrier or deterrent for SMEs and early-stage innovators, who may lack the the resources to endure through Canada's rigorous data requirements and approval processes. This stands in contrast to the market-driven system in the USA, with quicker approval processes and access to a much larger market.

The United States Department of Agriculture (USDA) has many systems that prioritize a quick path to market, allowing the commercial environment to determine viability and results. This includes categories for additives such as Generally Regarded as Safe (GRAS). Allowing comparable products to contribute to a new solution's viability drastically reduces the runway to market for new products, and places much of the onus for proving benefit and impact on the industry or business that is selling. In contrast, Canada has significant infrastructure for validation and testing that occurs well before commercialization, but at the pre-market stage, businesses may lack the revenue required to support these activities.

To be clear, Canada should not reduce the quality or rigor of our regulatory system, as the reputation and commitment to global health is fundamental to our national values. This has been clearly stated by the Treasury Board's External Advisory Committee on Regulatory Competitiveness (EACRC), which has been developing recommendations aimed at making Canada's regulatory system more competitive, innovative, and effective. The EACRC has produced insightful recommendations concerning regulatory barriers. AAFC's Sector Engagement Tables provide an agri-food specific advisory role on advancing Canada's growth and competitiveness through five sector tables (Animal Protein, Field Crops, Food Manufacturers, Horticulture, Seafood) and four thematic tables, one specifically on Agile Regulations (as well as Consumer Demand and Market Trends, Skills Development, Sustainability). These collaborative approaches with external stakeholders will position Canada's regulatory system for continual improvement and outcome-driven results. Government, at all levels, needs to build on this work to shorten the path to commercial viability, support new and emerging businesses through the often expensive and technically-dense regulatory process, and increase the rate at which Canadian innovations reach the domestic and export markets. Efforts are also needed across jurisdictions, to reduce interprovincial barriers.

Additionally, industry leaders need to increase their investment in validation level studies to empower new businesses to emerge from the regulatory process with sound operational resources to grow and scale. Part of that process will involve research partnerships with universities where access to their facilities is either subsidized for use by SMEs or developed through industry partnership with clear IP implications for emerging solutions and technologies. This will ultimately require collaboration across sectors on policy, risk and cost mitigation, and infrastructure access.

STRATEGY 4: MOBILIZING APPLIED RESEARCH

STRATEGY 1

Helping Ag-Tech Companies Scale

- Entrepreneurship training
- Navigating the agri-food innovation ecosystem
- Expansion of value-added capacity
- Incentivize early ag-tech adopters
- Enhance data governance in agriculture

STRATEGY 2

Training the Next Generation

- Specialized interdisciplinary programming
- Advance collaborative micro-credential programs
- Raise awareness of the opportunities in agri-food

STRATEGY 3

Reducing the Risk of Investing

- Establish an agri-food innovation working group
- Facilitate increased private equity investment
- Explore rigourous and efficient regulatory pathways

STRATEGY 4

Mobilizing Applied Research

- Invest in programs and infrastructure for agile agricultural research & demonstration activities
- Invest in agricultural and rural advisory services
- Facilitate knowledge sharing and collaboration among industry, government, and academia

Where We Excel

Sustainable food systems are a science, technological and innovation priority for the federal government, but there is no specific program dedicated to agri-food research, and available funding tends to concentrate in provincial agri-food powerhouses such as Ontario, Quebec, Alberta and Saskatchewan.

Canada has an enviable research landscape with existing agricultural research infrastructure across universities, colleges, and federal facilities.

Collaborations such as Agriculture and Agri-Food Canada's "Living Lab" network and the Canadian Agri-Food Automation and Intelligence Network (CAAIN) led Pan-Canadian Smart Farm Network provide opportunities for direct interaction between industry and research. Research councils have directed significant funding towards research on agriculture and food in recent years, including major investments by the Canada First Research Excellence Fund to the universities of Guelph and Saskatchewan. The National Research Council of Canada's 'On The Horizon' report[129] identifies agriculture as a key area for investment to address challenges such as climate change and sustainable resource use, through innovations such as atypical food production technologies. In addition, some jurisdictions of Canada still retain functioning public agricultural advisory services, with deep expertise and wide networks that have proven effective in evaluating and supporting the adoption of new technology in agri-food production and processing. They play a key role in advising on and facilitating stakeholder input into research priorities and R&D activities (public, institutional, private, and within commodity organizations). Canada has the opportunity to use this foundation as a launchpad for strategic investment to enhance our capacity for innovation in agriculture and food.

Opportunities for Growth

Recommendation 1: Invest in Programs and Infrastructure for Agile Agricultural Research & Demonstration Activities

Government should create innovative applied research incentives through assessment of research impact, challenge-based prizes and demonstration projects.

129 National Research Council of Canada. (2022). On the horizon: Several perspectives on Canada's technology future - 2030–35. https://nrc.canada.ca/en/corporate/planning-reporting/horizon-several-perspectives-canadas-technology-future-2030-35

Investments in research often can and should translate into socioeconomic benefits to Canada. When evaluating applied research outputs and outcomes, funders should consider the practical application of findings and alignment with stakeholders' interests, rather than traditional academic metrics of success (i.e. publication outputs).[130] More than half of researchers in a recent survey agree that societal impact should be given more prominence in research evaluations, emphasizing outcomes and public engagement.[131]

Challenge-based learning and prizes are another innovative strategy that, when student-focused, can lead to enhanced learning and training, as well as the development of possible solutions to real-world problems. In these programs, transdisciplinary teams address a socially relevant problem. This approach has led to successful student learning outcomes such as improved problem solving and multidisciplinary teamwork, as well as beneficial industry outcomes including enhanced partnerships and development of commercial products.[132] Beyond academia, other programs, such as the XPRIZE, offer a substantial purse to challenge winners.[133] In these programs, the successful innovation will receive seed project funding. Several Canadian foundations are experimenting with challenge-based prizes to develop potential solutions to complex problems in ag-tech and food security, such as enhancing berry productivity.[134] Challenge-based learning and prizes can possibly remedy some of the challenges with traditional grant funding, where application writing can feel challenging and inefficient.

> *"When we put a funding proposal in front of a consortium that has 20 different funding agencies, or organizations or provincial groups, or commodity groups behind it, and we don't know who we're actually pitching to, it makes it so difficult to write a compelling proposal."*
>
> *(Interview Subject, Non-Governmental Organization)*

130 Hicks, D. (2012). Performance-based university research funding systems. Research policy, 41(2), 251-261

131 Fecher, B., & Hebing, M. (2021). How do researchers approach societal impact?. Plos one, 16(7), e0254006.

132 Gallagher, S. E., & Savage, T. (2023). Challenge-based learning in higher education: an exploratory literature review. Teaching in Higher Education, 28(6), 1135–1157. https://doi.org/10.1080/13562517.2020.1863354

133 XPRIZE. (2024). XPRIZE. https://www.xprize.org/

134 Weston Foundation. (2024). Homegrown Innovation Challenge. https://homegrownchallenge.ca/

Successful research mobilization also stems from agriculture demonstration zones and field trials; both the Netherlands and Japan have very successfully used demonstration farms to trial technologies and communicate with farmers, while Canadian entities such as Olds College offer tools like interactive maps on their Smart Farm, part of a network of Smart Farms led by CAAIN.[135] The University of Guelph has a network of agriculture and aquaculture research stations and facilities operated in partnership with the provincial government, while the Canadian government operates research stations across the country, such as the Central Experimental Farm in Ottawa.[136] However, much of the country's legacy infrastructure is in need of investment and modernization[137] and there is an opportunity to further develop demonstration projects across all of Canada's diverse agricultural contexts to share information amongst researchers, government, industry, and perhaps most importantly the producers who are being asked to adopt emerging tools and technologies. Even after successful demonstration of technologies on farms, however, we still need to ensure we bring innovations from demonstration to widespread adoption:

> *"There's a need for real farms where we can trial some technologies. There's a lot of excitement around that and a lot of it is around showing how this actually works in a region. That's really exciting, but then you still have to figure out how we actually go the last mile."*
>
> *(Interview Subject, Government)*

Recommendation 2: Invest in Agricultural and Rural Advisory Services

Canada should invest in agricultural and rural advisory services.

A strong publicly-funded advisory network provides knowledge and networks to support ag-tech research and development, strengthening connections between researchers, entrepreneurs, and end-users. These specialists have a long history of helping the agri-food industry evaluate and demonstrate new technologies to support and spur adoption of those best suited to regional or sector-specific needs.

135 Olds College. (2024). Olds College Smart Farm. https://oldscollege.maps.arcgis.com/apps/MapTour/index.html?appid=db178e7c19fd433695cfa5008b85ae84

136 Agriculture and Agri-Food Canada. (2024c). About the Central Experimental Farm. https://agriculture.canada.ca/en/contact-agriculture-and-agri-food-canada/central-experimental-farm/about-central-experimental-farm

137 ISED. (2019). Building a nation of innovators. https://ised-isde.canada.ca/site/innovation-better-canada/en/building-nation-innovators

Studies have shown impressive rates of return on investment in agricultural extension.[138] Countries like Ireland have recognized the value of agri-food and rural advisory services, embedding them into their long-term agriculture, fisheries, and rural strategies. Notably, Ireland's strategic plans include a strong focus on ensuring advisors are supported in maintaining cutting-edge expertise, in the face of rapidly changing technology.[139] There is also recognition that agricultural advisory services help the industry to deal with complex and controversial issues affecting the sector and play a role in combatting misinformation that could hold the sector back, both in environmental and economic sustainability.[140]

Agricultural and rural advisory services enhance innovation and economic productivity on a variety of fronts, including strengthening rural enterprises and the rural economy. This can catalyze local research and development, fostering close collaboration between entrepreneurs and end-users throughout development and adoption. Extension services also support the agricultural industry in adapting to the increasing pace of technological change, to structural changes in the agri-food sectors, to climate change, and to practice changes in support of sustainable development goals.[141] Of increasing importance, agri-food system cybersecurity and biosecurity can also be strengthened through well-resourced advisory networks.[142]

Recommendation 3: Facilitate Knowledge Sharing and Collaboration Among Industry, Government, and Academia

Industry, academia, and government need more knowledge sharing and collaboration; this can help to develop applied solutions and increase business funding into R&D activities.

There is a strong correlation between a country's economic development and its collaboration with universities.[143] Canada has robust research and development funding streams through the higher education sector (such as tri-agency funding composed of the Canadian Institutes of Health Research, National Sciences and Engineering Research Council of Canada, and the Social Sciences and Humanities Research Council.[144]

138 North American Agricultural Advisory Network. (2022). Feeding North America Through Agricultural Extension. https://naaan.csusystem.edu/

139 Government of Ireland Department of Agriculture, Food and the Marine. (2021). Food Vision 2030: A World Leader in Sustainable Food Systems. Government of Ireland Department of Agriculture, Food and the Marine. https://www.gov.ie/en/policy/b2a3c-food-vision-2030-a-world-leader-in-sustainable-food-systems/

140 North American Agricultural Advisory Network. (2022). Feeding North America Through Agricultural Extension. https://naaan.csusystem.edu/

141 Blum, M.L., et al. (2020). Agricultural Extension in Transition Worldwide - Policies and Strategies for Reform. Food and Agriculture Organization. Agricultural extension in transition worldwide. Policies and strategies for reform | Knowledge for policy (europa.eu)

142 North American Agricultural Advisory Network. (2022). Feeding North America Through Agricultural Extension. https://naaan.csusystem.edu/

143 Terán-Bustamante, A., et al. (2021). University–industry collaboration: a sustainable technology transfer model. Administrative Sciences, 11(4), 142

144 McGill University. (n.d.). Tri-agency administration guide. McGill University. https://www.mcgill.ca/research/about/ran/tri-agency-administration-guide

There is also investment made by private business. Yet in comparison to other OECD countries, this investment remains relatively low from the business sector, while government investment in R&D in Canada is well below the OECD average (Figure 7).[145]

Agricultural research and development focus on a broad range of goals, including raising yields, reducing input costs, and decreasing climate change emissions.[146] Research suggests that a doubling of agricultural R&D spending in the United States by the year 2050 would provide greater economic gains, generating a substantial return on investment while contributing to the reduction of greenhouse gas emissions;[147] Canada could expect to see similar benefits.

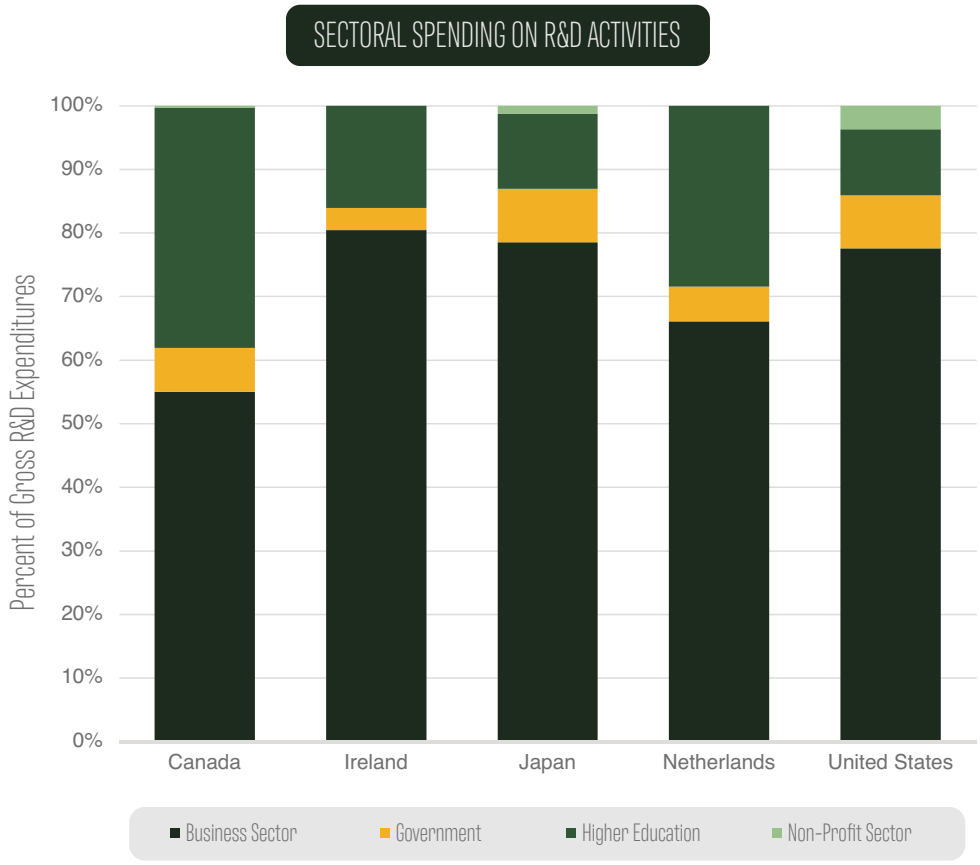


Figure 7. Gross expenditure on R&D (GERD), breakdown by sector for 2021, the most recent year with available data. Data are from OECD.[148]

145 OECD. (2024). Main Science and Technology Indicators. https://stats.oecd.org/viewhtml.aspx?datasetcode=MSTI_PUB&lang=en#

146 Blaustein-Rejito, et al. (2022). Assessing Federal R&D Funding for Agricultural Climate Mitigation. https://thebreakthrough.org/issues/food-agriculture-environment/from-lab-to-farm

147 Baldos, U. L. C. (2023). Impacts of US Public R&D Investments on Agricultural Productivity and GHG Emissions. Journal of Agricultural and Applied Economics, 55(3), 536–550. https://www.cambridge.org/core/journals/journal-of-agricultural-and-applied-economics/article/impacts-of-us-public-rd-investments-on-agricultural-productivity-and-ghg-emissions/E25A5C3188345C9AE380702A38C5A0D3

148 OECD. (2024). Main Science and Technology Indicators. https://stats.oecd.org/viewhtml.aspx?datasetcode=MSTI_PUB&lang=en#

There is a gap that needs to be addressed between applied research results and industry impact, with one report suggesting that only 40% of projects actually impacted the efficiency and competitiveness of partner organizations.[149] To bridge this gap, collaboration between academia, government and industry can ensure projects have real-world impact, develop practical results, and support technology transfer.[150] Appendix 4 provides more information on best practices in developing strong partnerships.

Industry-academic partnerships and a strong agricultural extension system will be particularly important to mobilize and drive applied research. While some businesses have both the freedom and ready access to capital to drive R&D activities, they may lack networks or supports to diffuse innovation and access new knowledge or technologies.

> *"My observation and experience is that often industry may not know or may not have access to the network. Universities have so many faculty members and so many researchers who are doing different types of research. And small companies in particular don't have the resources to really learn about all that."*
>
> *(Interview Subject, Academic Leadership)*

Additionally, industry-academic partnerships can and should address the current lack of proximity between technology developers and farmers.

> *"Our ag-tech tends to be concentrated where the broader tech sector is. That means that we have some ag-tech companies closer to farms, but there's still a huge glut of them that are located where the tech sector is biggest."*
>
> *(Interview Subject, Consultant)*

Overall, our innovation ecosystem needs to mobilize applied research through improved industry-academic collaboration and support stronger ties between academia, industry and government.

149 Pertuze, J. A., et al. (2010). Best practices for industry university collaboration. MIT Sloan Management Review.

150 García-Cañada Candela, M. (2024, April 30). Bridging the gap: Technology transfer from academic research to market realities. Plug and Play Tech Center. https://www.plugandplaytechcenter.com/resources/bridging-the-gap-technology-transfer-from-academic-research-to-market-realities/

CONCLUSION

Ag-tech is advancing rapidly and being implemented globally, offering significant benefits to our food system, such as addressing labor shortages, enhancing agri-food productivity, and promoting sustainability.

A stronger ag-tech ecosystem in Canada would contribute to the country's prosperity, through economic opportunities, GDP growth, the attraction of global talent and investment, and improved environmental sustainability. Canada has an abundance of knowledge, infrastructure, and human capital that can achieve meaningful outcomes through thoughtful research and development of agricultural technologies.

We are poised to be a global leader in agriculture and food innovation, but we need to act now to realize this potential.

The four strategies presented in this report can lead Canada to a more effective, productive ag-tech innovation ecosystem, responding to key needs identified through our research and discussions: helping ag-tech companies scale, training the next generation, reducing the risk of investing, and mobilizing applied research. Specific recommendations are tailored to government, the agri-food industry, investors, organizations supporting entrepreneurs, and academia – but what we need most is a collaborative approach with all players working together to set goals, targets, and develop programs and policy, and take bold action to accelerate Canada's agri-food innovation ecosystem.

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Interview subjects

APPENDIX 1: PATENT ACTIVITY IN CANADA

In Canada, it is estimated that roughly one-third of Canadian resident business patents fall in a 'high-tech' category, but that overall year-by-year high-tech patent application numbers have not risen since the early 2000s.[151]

There are a variety of indicators that capture patent activity. For example, some studies consider jurisdiction (i.e. where patents are filed) as a measure of national innovation activity, finding that China is a global leader in issuing patents.[152] Other studies examine patent inventor countries of origin (i.e. where the inventor is a resident) to better capture trends related to national talent, skills, and entrepreneurship development, finding the United States to lead in this metric.[153] We consider the latter indicator in this section to understand where Canadian inventors rank among comparator countries. In terms of overall patent activity, Canada ranks in the middle, slightly behind the Netherlands, for 2020 patents filed under the Patent Cooperation Treaty (PCT) – an international treaty administered by the World Intellectual Property Organization (Figure 8).

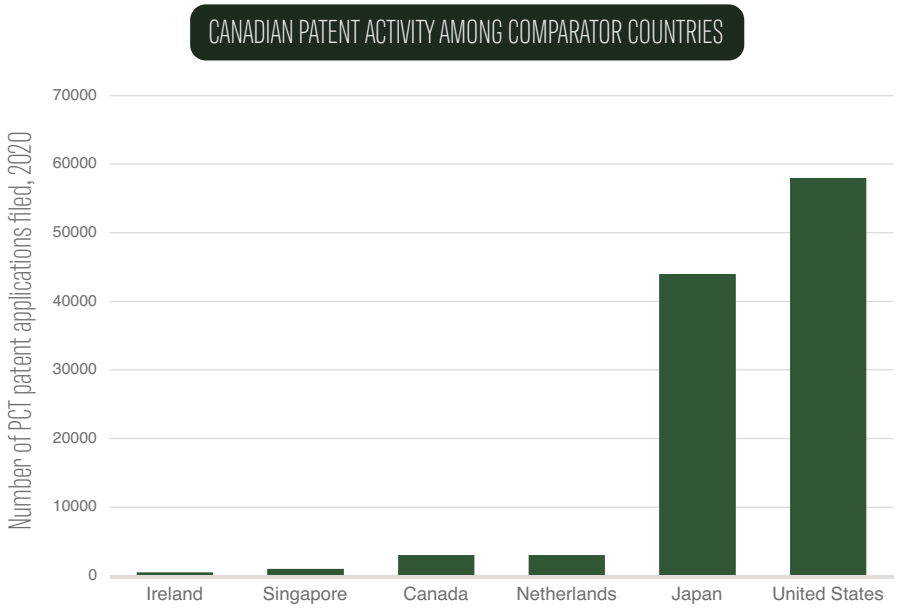

Figure 8. Number of patent applications filed through the World Intellectual Property Organization; data from OECD.[154]

151 Gagnon, D. (2024). Innovation in focus: Exploring trends in the development of advanced technology through patent applications. https://www150.statcan.gc.ca/n1/en/catalogue/222000012024002

152 McKinsey & Company. (2020). Needle in a haystack: Patents that inspire agricultural innovation. https://www.mckinsey.com/industries/agriculture/our-insights/needle-in-a-haystack-patents-that-inspire-agricultural-innovation

153 Liu, W., et al. (2022). Capturing information on global knowledge flows from patent transfers: An empirical study using USPTO patents. Research Policy, 51(5), 104509. https://doi.org/10.1016/j.respol.2022.104509

154 OECD. Data Explorer. Patents by Technology. https://data-explorer.oecd.org/

Trends are similar for ag-tech patent data. Through a targeted search of agriculture-related patents in WIPO's PatentScope database[155] – a global, searchable database drawing from PCT applications as well as national/regional patent databases – we found Canada's number of patents and citations in the field of agriculture technology. We searched five broad categories of agriculture technologies (biotechnology, biologicals, software, robotics, and cultivated meat) by inventor nationality from January 1 2021 to December 31 2023, documenting total number of patents (filed or accepted) (Figure 9). We took an average of this number of patents across the three years and determined the number of patents per million people for each country, using national population data from the year 2022. From our findings, Singapore, the United States, and the Netherlands currently outrank Canada in number of ag-tech patents per million inhabitants across the agricultural technology categories we searched.

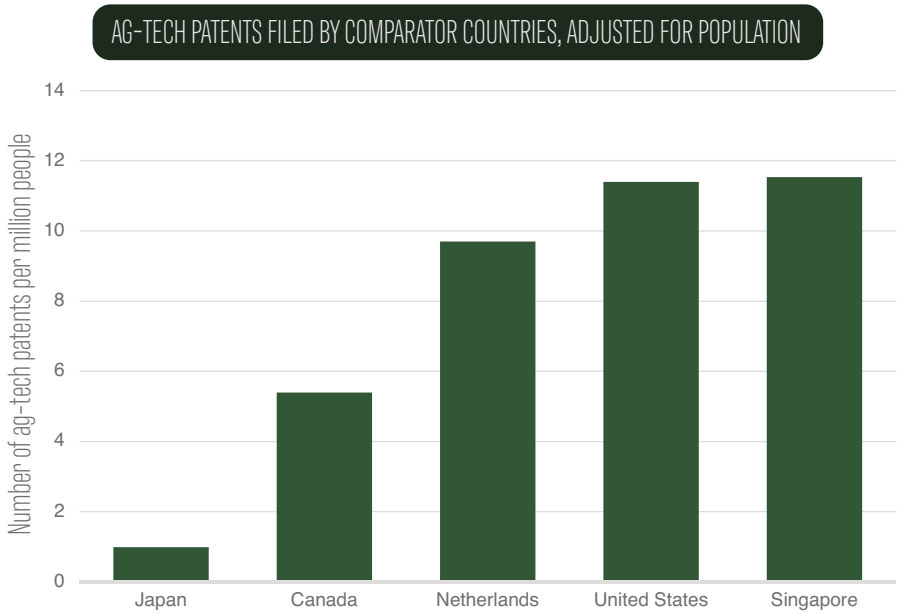

Figure 9. Number of ag-tech patents filed per year by inventor nationality, per million people, across five comparator countries; data adjusted per million population (2022) from PatentScope.[156]

155 WIPO PatentScope. https://www.wipo.int/patentscope/en/

156 WIPO PatentScope. https://www.wipo.int/patentscope/en/

APPENDIX 2: CANADIAN INVESTMENT IN EDUCATION

In Canada, just over 50% of spending on post-secondary education was from public sources, as of 2020, when Canada sat at 28th out of the 34 OECD countries with data available (Figure 10).[157] Federal government cash transfers to post-secondary education have fallen from 0.5% of GDP in 1983-84 to 0.19% in 2021-22, during a period of significant growth in enrollment. The past 15 years have seen provincial operating expenditures on post-secondary education go down in 9 out of 10 provinces. The average has fallen from 4.4% of total government spending in 2010-11 to 3.9% in 2019-20 for the nine provinces (Newfoundland and Labrador is the exception). Shortfalls are increasingly made up by international student tuition.[158]

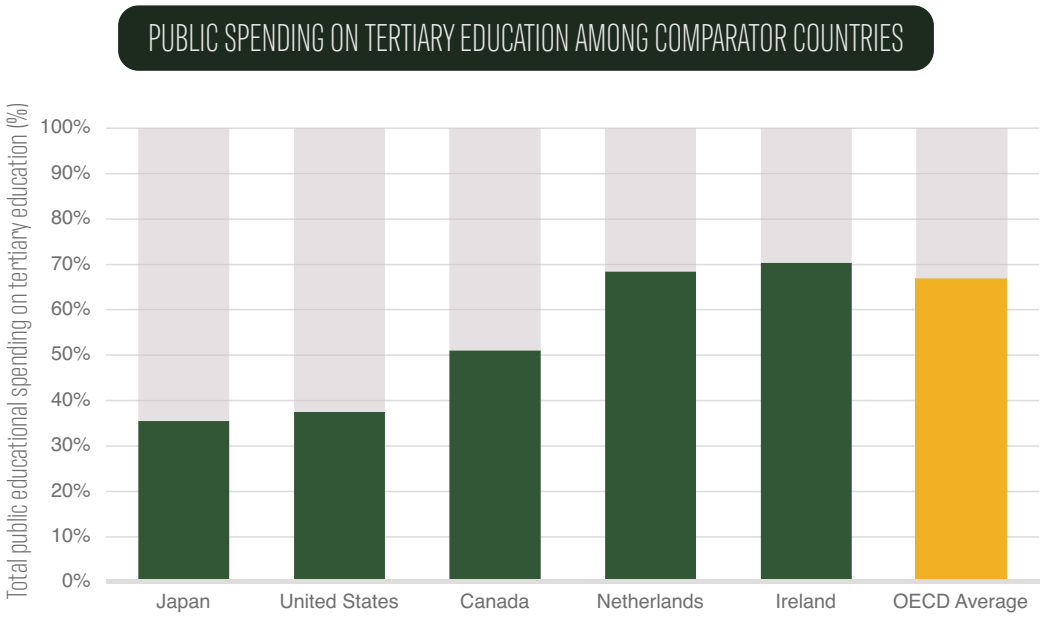

Figure 10. Spending on tertiary (post-secondary) education as percent of total education spending among comparator countries.[159,160]

157 Spending on Tertiary Education, 2020. (2020). https://data.oecd.org/eduresource/spending-on-tertiary-education.htm#indicator-chart

158 CAUT. (2020). Canada and the Provinces. https://www.caut.ca/resources/almanac/2-canada-provinces

159 Spending on tertiary education is defined by the OECD as the total expenditure on the highest level of education, covering private expenditure on schools, universities, and other private institutions delivering or supporting educational services. https://www.oecd.org/en/data/indicators/spending-on-tertiary-education.html#indicator-chart

160 Spending on Tertiary Education, 2020. (2020). https://data.oecd.org/eduresource/spending-on-tertiary-education.htm#indicator-chart

Looking at agricultural education, in particular, it is difficult to compare support for agricultural education and agricultural extension across countries. For example, the OECD data for agricultural education for Canada includes "Both federal and provincial level expenditures for Agricultural College/University and Agricultural Specific Education,"[161] while the data for the US includes only the National Institute for Food and Agriculture education programs, the Agricultural Resource Conservation and Demonstration Program, the Meat and Poultry Processing Capacity Technical Assistance Program, and the Meat and Poultry Processing Agricultural Workforce Training Program.[162]

For agricultural extension services in Canada, the OECD data includes "Both federal and provincial level expenditures for Business Development Initiatives, Business Management Initiatives, Departmental Advisory Services, Leadership Initiatives and other External Advisory Services and Other Knowledge Transfer, and Veterinary College … in addition to the federal level expenditure for Agricultural Policy Research Network Contribution, Agricultural Greenhouse Gases Program, Agri-Food Innovation Program and Canadian Agri-Science Clusters."[163] In the US, however, the OECD data currently includes only the USDA budget expenditure for extension services.[164] However, comparing OECD data to US Congressional Research Services data shows a wide discrepancy in the values, while such a comparison is not possible for Canada due to a lack of available data.

Table 2. US Government Expenditure on Agricultural Extension: Comparison of Data Sources (2019-2022)

	USD, Millions			
Data Source	2019	2020	2021	2022
OECD Data – US expenditures on agricultural extension services[165]	121.00	126.00	129.00	144.98
US Congressional Research Service Data –Federal appropriations for extension activities[166]	505.60	526.60	538.50	550.70

161 OECD. (2023). Canada: Estimates of Support to Agriculture. https://www.oecd.org/content/dam/oecd/en/topics/policy-issues/agricultural-policy-monitoring/psecse-mon2023-cookbooks/cookbook-can-2023.pdf

162 OECD. (2023). US: Estimates of Support to Agriculture. https://www.oecd.org/content/dam/oecd/en/topics/policy-issues/agricultural-policy-monitoring/psecse-mon2023-cookbooks/cookbook-usa-2023.pdf

163 OECD. (2023). Canada: Estimates of Support to Agriculture. https://www.oecd.org/content/dam/oecd/en/topics/policy-issues/agricultural-policy-monitoring/psecse-mon2023-cookbooks/cookbook-can-2023.pdf

164 OECD. (2023). US: Estimates of Support to Agriculture. https://www.oecd.org/content/dam/oecd/en/topics/policy-issues/agricultural-policy-monitoring/psecse-mon2023-cookbooks/cookbook-usa-2023.pdf

165 OECD. (2024). Agricultural Policy Monitoring and Evaluation. https://data-viewer.oecd.org/?chartId=4dd220f5-8b1d-4ddb-b2fe-e20e58570dc2

166 US Congressional Research Service. (2024). The Agricultural Cooperative Extension System: An Overview. https://sgp.fas.org/crs/misc/R48071.pdf

In Canada, it has been well documented that public support for agricultural extension has been decreasing in recent decades.[167] Significantly, the use of extension services in Canada is much higher by large farms (over $1 million in sales) than by farms with less than $100,000 in sales. In turn, these large farms are much more likely to be early adopters, with over one third reporting that they would be among the first to try a new agricultural innovation, compared to only 11% of small farm operations.[168]

There has been a consistent increase in Canada over the past two decades in the total number of students enrolled in post-secondary programs related to agriculture (Figure 11). These enrollments have occurred unevenly across the country.[169] Most total student enrollment increases have occurred in Ontario as well as British Columbia (difference of 3,879 and 1,656 students enrolled between 2000 and 2021, respectively). The highest percent increases occurred in Prince Edward Island and the Territories; while overall enrollments in agriculture, natural resource, and conservation programs are relatively low (under 100 students per year), enrollments increased by over 500 and 200 percent in each respective region since the year 2000. Enrollment in French speaking provinces of Québec and New Brunswick have stayed the same or decreased since 2000.

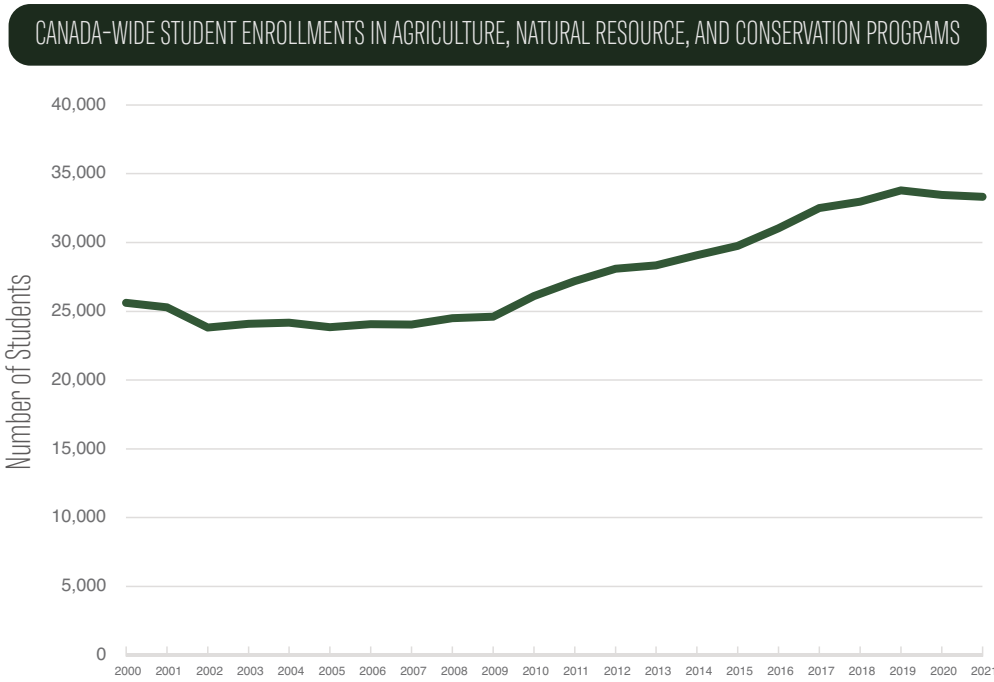

Figure 11. Canadian student enrollment in agriculture, natural resource, and conservation programs over time. Source: StatsCan.[170]

167 North American Agricultural Advisory Network. (2022). Feeding North America Through Agricultural Extension. https://naaan.csusystem.edu/

168 AAFC. (2016). An Overview of the Canadian Agriculture and Agri-Food System 2016. https://ideas.repec.org/p/ags/aaacem/235204.html

169 Statistics Canada. (2023). Canadian postsecondary enrolments and graduates, 2021/2022. https://www150.statcan.gc.ca/n1/daily-quotidien/221122/dq221122b-eng.htm

170 Statistics Canada. (2023). Postsecondary enrolments, by field of study, registration status, program type, credential type and gender. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3710001101

APPENDIX 3: AG-TECH INVESTMENT IN CANADA

The Global Entrepreneurship Monitor[171] suggests that overall declining VC funding across the Canadian economy indicates a risk-averse market. This echoes recent data that have shown a substantial decline in VC ag-tech funding globally, estimated at 30% between 2022 and 2023.[172] While risk is inherent to any investment, it is particularly relevant in the case of ag-tech. Agriculture is a challenging sector in which to invest, due to the time it takes for proof-of-concept and return-on-investment to be established. This was described by one ag-tech investor as follows:

> *"And so if you've got a fund, a company is in year four, and an entrepreneur comes in saying look, invest in my biologicals, I'm going to do A, B, C, and D, you're going to say look I can't invest in this. By the time it's ready and at [a high] TRL,[173] I'm in year eight of my fund. And there's no way in these last two years that [the company] going to be able to commercialize it and create value."*
>
> *(Interview Subject, Investor)*

171 GEM. (2022). Global Entrepreneurship Monitor 2021/2022 Global Report - Opportunity Amid Disruption. https://www.gemconsortium.org/file/open?fileId=50900

172 McKinsey & Company. (2024). Seizing opportunities amid the ag-tech capital drought. https://www.mckinsey.com/industries/private-capital/our-insights/seizing-opportunities-amid-the-agtech-capital-drought

173 TRL: Technology Readiness Level

A robust entrepreneurial culture relies on perceptions of low risk, high financial support, and low government interference, among other considerations. The Global Entrepreneurship Monitor[174] undertook a survey of national experts to rank a variety of considerations related to their perceptions of the health of national entrepreneurial ecosystems. Perceptions of financing and government taxes/ bureaucracy in Canada are on par with all comparator countries (notwithstanding the Netherlands), yet still have substantial room to improve on this 9-point scale (Figure 12).

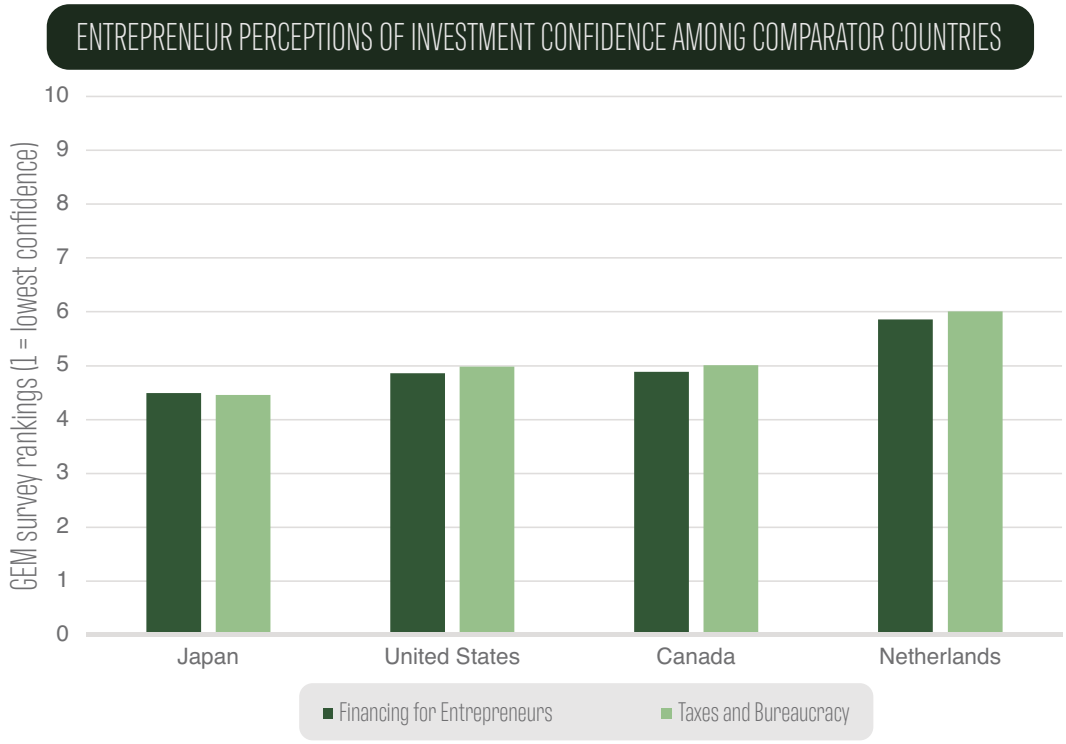

Figure 12. 2023 GEM survey ranking results of investment confidence (scale from 1 to 9), in terms of financing available for entrepreneurs and taxes and bureaucracy.[175]

174 GEM 2023/2024 Global Report—25 Years of Progress. (2024). Global Entrepreneurship Research Association. https://www.gemconsortium.org/reports/latest-global-report

175 GEM. (2023). Entrepreneurial Framework Conditions. https://www.gemconsortium.org/data/key-nes

APPENDIX 4: BUILDING STRONG ACADEMIC-INDUSTRY PARTNERSHIPS

Innovation is a social process – it depends on knowledge sharing and relationships.[176] A successful partnership must include a shared research agenda, shared understanding of the long-term potential of partnership, and shared all-embracing communication.[177] Researchers need to build networks with key collaborators from government and industry. These collaborations can build on the STEPS framework (Sharing, Transparency, Engagement, Partnership, Strong relationships) to build a partnership with mutual benefit.[178]

Programs such as Mitacs[179] are an important step toward bridging academia and industry. Yet, careful development of these partnerships is required. A proper evaluation approach must be developed to effectively measure the impact of research that is underway, allowing for review and adjustment to best align with challenges faced in society.[180] This would require the establishment of liaison roles within the research partnership. A team of researchers has developed a collaborative framework integrating various best practices for fostering University-Industry Collaboration (UIC) with an emphasis on creating an ecosystem that nurtures collaboration between universities and industry.[181]

176 Terán-Bustamante, A., et al. (2021). University–industry collaboration: a sustainable technology transfer model. Administrative Sciences, 11(4), 142

177 Elsevier. (2021, January 27). University-industry collaboration: A closer look for research leaders.

178 Lecouturier, J., et al. (2024). The critical factors in producing high quality and policy-relevant research: insights from international behavioural science units. Evidence & Policy, 20(2), 141-162.

179 Mitacs is a non-profit organization working with “academia, government, and the public and private sectors, to help solve organizational challenges and expand Canada’s innovation capacity”. (https://www.mitacs.ca/)

180 Coombs, S. K., & Meijer, I. (2021). Towards evaluating the research impact made by universities of applied sciences. Science and public policy, 48(2), 226-234.

181 Awasthy, R., et al. (2020). A framework to improve university–industry collaboration. Journal of Industry-University Collaboration, 2(1), 49-62.

The framework highlights the following strategies.

1. *Understand the Variety of Interactions*
2. *Identify Stakeholders*
3. *Understand the "Why"– Identify the Motivation*
4. *Identify and Appoint Suitable People and Involve Leadership*
5. *Ensure Basic Partnership Characteristics*
6. *Establish Efficient Communication*
7. *Strengthen the Dissemination Strategy*
8. *Address IP Concerns*
9. *Adopt Policies to Encourage/Facilitate Collaboration*
10. *Adopt Strategy to Encourage Collaboration*
11. *Focus on Social Capital Resources*
12. *Setup Rewards and Incentives*
13. *Management of the Collaboration*
14. *Alumni Association*

When promoting applied research, the FAIR principles (Findable, Accessible, Interoperable, Reusable) for agricultural data, software, and hardware provide insights for stakeholders to leverage in solution development and offer knowledge for policy development.[182] Ensuring that engagement is being managed throughout the research program allows for cooperation while promoting the application of knowledge creation.

182 European Commission. (2024). European Data Governance Act. https://digital-strategy.ec.europa.eu/en/policies/data-governance-act