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Canadian Agriculture and Food Research Effectiveness and Competitiveness

A time-series analysis of public & private funding envelopes

By Sabrina Gulab and Guillaume Lhermie

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EXECUTIVE SUMMARY

The agri-food sector plays vital role in country's economy as well as a major contributor towards global food production. In 2023, the sector contributed 7% to Canada's gross domestic product (GDP). It provides national food security and has steadily increased its efforts to reduce its environmental footprint over the last decades. The agri-food sector is one of the most progressing sectors with regards to innovation adoption, but it can lag behind other economic sectors (Alston et al., 2023). Research and innovation are key to accelerate productivity, while mitigating impacts on planetary health.

Assessing the landscape of agri-food research is crucial from a policy perspective, as it provides a comprehensive understanding of the current state, strengths, gaps, and opportunities within a country's research and innovation framework. This assessment is vital for shaping targeted and effective policies that can drive sustainable development, economic growth, and societal well-being. Such an analysis allows for the strategic allocation of resources to maximize impact, foster innovation, and enhance the competitiveness of the agri-food sector.

This report evaluates the trends in public and private sector investments in agri-food research from 2013 to 2023, with a focus on identifying funding priorities across key research areas. Additionally, the report examines the alignment of research funding with agriculture programs and frameworks defined by the Canadian government. Specifically, it compares the funding priorities during the Growing Forward 2 (GF2) and Canadian Agriculture Partnership (CAP) periods. These two regimes exhibited distinct research funding trends, and this report evaluates the alignment of these funding trends with the programs and strategies outlined under each regime. The report also provides a jurisdictional scan of Research and Development (R&D) policies and programs in selective OECD countries, as well as trends in expenditure in these countries.

Using aggregated data funded by both public and private institutions, the analysis provides insights into the total investments made over a 10-year period, emphasizing key research areas such as productivity and growth, protection and risk resilience, and environmental stewardship. The findings reveal that over the past decade, the public sector has invested approximately CAD 2.4 billion, while the private sector contributed around CAD 837 million. Of these investments, research in production and growth dominated funding, with a combined investment of CAD 1.4 billion, underscoring its critical role in advancing agricultural innovation. Research in protection and risk resilience and environmental stewardship received approximately CAD 1.1 billion and CAD 770 million, respectively, highlighting the growing attention to climate adaptation and sustainability within the sector.

Between the GF2 (2013–2018) and CAP (2018–2022) periods, significant shifts in public and private sector funding priorities were observed. During the GF2 period, funding from both sectors for protection and risk resilience increased, with substantial investments in areas such as animal health, plant protection, and food safety, achieving an average annual growth rate of 31.2%. This was followed by funding growth in protection and risk resilience with average annual growth rate of 10.18% and environmental stewardship, which experienced the highest growth at 56.63% annually. Similarly, during the CAP period, both sectors prioritized environmental stewardship, with an average annual growth rate of 25.94%. However, funding for production and growth and protection and risk resilience declined, with annual growth rates of -1.06% and -0.73%, respectively.

These trends reflect a growing emphasis on sustainability and long-term risk management in Canada's agri-food research landscape, with both public and private sectors working towards improving agricultural productivity, fostering innovation, and enhancing competitiveness. The alignment of research funding with policy frameworks, as well as the increased focus on climate adaptation and sustainability, signals Canada's commitment to developing a resilient, innovative, and globally competitive agri-food sector.

The Jurisdictional scan of global spending on agricultural R&D has significant growth in R&D spending, rising from $31 billion in 2000 to $47 billion in 2016, with an annual growth rate of 2.5% during the 2010–2016 period. However, this growth decelerated compared to the 2000–2010 period, primarily due to reduced investments in middle-income countries like Brazil and China, and negative growth in high-income countries such as the United States.

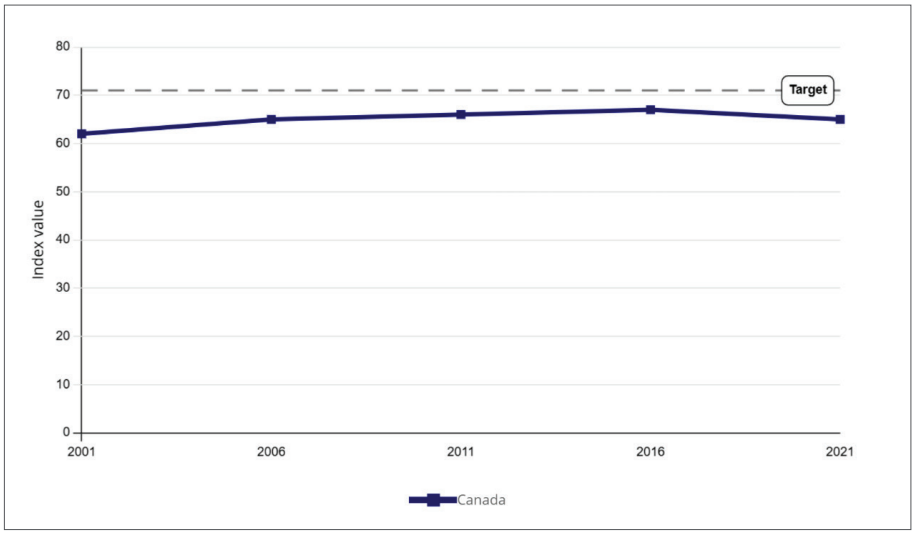
In 2018, five countries—China, the United States, India, Brazil, and Japan—dominated agricultural R&D spending, collectively accounting for nearly two-thirds of the global total. While Canada's spending declined from $0.86 billion in 2013 to $0.68 billion in 2022, placing it as the lowest among the top seven OECD countries. The research intensity ratio, which measures R&D spending as a proportion of agricultural gross domestic product (AgGDP), offers a comparative perspective. Over a decade, Australia led with an average ratio of 1.68%, followed by Canada (1.33%) and Brazil (1.32%). In contrast, high-spending nations like China and Europe reported lower ratios of 0.64% and 1.2%, respectively, with India recording the lowest at 0.29%.

PART 1: INTRODUCTION

The Canadian agriculture and food sector is a diverse and integrated system, encompassing a wide range of activities from crop production, livestock farming food processing, distribution and retail, Agriculture technology and Innovation, and trade and export. The sector plays vital role in country's economy as well as a major contributor towards global food production. In 2023, the sector contributed 7% to Canada's gross domestic product (GDP) with annual revenue of $150.0 billion and employs over 2.3 million people across country (AAFC, 2023).

However, the sector faces two apparently contradictory injunctions: produce more, to ensure its competitiveness on global markets and reinforce domestic food sovereignty and global food security; reduce drastically the pressures it poses to the environment at large (carbon emissions, water footprint, impacts on soils and biodiversity) and increase animal health and welfare. To address environmental challenges, government of Canada focuses on promoting environmentally friendly farming practices, enhancing food security, and ensuring the long term viability of its agriculture sector (AAFC, 2023). Yet, the Agri-Environmental Sustainability Indicator shows that Canada is not performing well and remains far from the target (see Figure 1).

Figure 1: Agri-Environmental Sustainability Performance Indices



Source: AAFC

The strategy aligns with Canada's commitment to reducing its carbon emission by 30% by 2030 (AAFC, 2023). Moreover, it aims to create a more resilient production system by integrating environmental, social, and economic consideration into agricultural practices. Additionally, the government targets to achieve these goals through the collaboration between producers, industry stakeholders, and research institutions.

The complex agricultural production system in Canada has evolved over time through scientific advancements and various innovations. Its dynamic nature enables agriculture to tackle the competing challenges of ensuring food and nutrition security, enhancing livelihoods, combating climate change, and managing natural resources sustainably. Research and Development (R&D) investment is key to the advancement of the agriculture sector and delivery of new technology and knowledge.

Agricultural R&D consistently delivers strong returns. For instance, research by CGIAR shows a $10 return for every dollar invested over the last 50 years, driven by advancements in crop varieties, pest management, and sustainable practices. Similarly, investments in climate-smart agriculture and regenerative practices are particularly impactful for long-term sustainability and resilience to climate change, although they require upfront capital and patient investment approaches. Meta-analyses show that agricultural R&D investments yield a median ROI of about 10:1 globally, up to 20:1 in the United States. These returns come from increased crop yields, reduced input costs, and improved resilience to climate change (Lloyd, 2021; OECD, 2012).

Yet, ROI for agriculture tends to manifest over decades, requiring sustained investment. Despite its high payoff, agricultural R&D remains underfunded compared to other sectors, especially in high-income countries like those in the G7. R&D is fundamental to ensure productivity growth, competitiveness and sustainability of the Canadian agriculture sector. While private sector investment in agriculture, particularly in biotechnology, has grown significantly, public funding is crucial for addressing systemic issues, as well as for supporting discovery research.

Knowledge generated through R&D spills over into broader industries, requiring a workforce capable of adapting and applying new technologies, thereby increasing the demand for advanced education and specialized training. This is evident in regions with high R&D spending, which tend to form knowledge clusters and attract skilled talent.

Furthermore, R&D-driven industries, such as biotechnology and renewable energy, create high-skill, high-wage jobs that incentivize education and continuous professional growth (Shah et al.,2024; Statistics Canada 2024). These industries also encourage universities and research institutions to align curricula with evolving industry needs, fostering a virtuous cycle of learning and innovation. Programs like the EU's Horizon initiative and Canada's Innovation Superclusters integrate workforce development with R&D funding, emphasizing lifelong learning and upskilling.

Finally, R&D investments correlate with higher workforce productivity and economic mobility. For example, the OECD report (OECD, 2012) and World Bank report that countries with robust R&D ecosystems, such as Germany and South Korea, exhibit higher tertiary education enrolment and stronger economic outcomes. Overall, R&D serves as a cornerstone for sustainable human capital development by bridging innovation with education and economic opportunity.

However, despite the detailed program review reports published by Agriculture and Agri Food Canada (AAFC), and Statistics Canada, we do not have robust source of information on research funding and research activities. A complete coherent system that provides evidence on the funding sources, and spending is missing, which makes it difficult to identify key players and gaps in the agri-food research ecosystem. Additionally, over the past ten years the Canadian agri-food system has transformed with complexities, which requires investment in more advanced technologies and sustainable practices, in bother private and public sectors. Undoubtedly, significant expenditures were made on agri-food research, yet it is hard to determine whether research priorities of both the public and private sector align.

This report aims to fill the gap by providing a 10-year retrospective analysis on the spending of both public and private sectors. We identify key research priorities and build comprehensive database of agri-food research across Canada through collecting data starting in 2013 from funding and academic institution. We provide an international comparison of R&D spending in the agri-food sector between Canada and other countries with shared features. We finally propose recommendations for decisions makers in public and private sectors.

The intricate Canadian agri-food research system is comprised of a complex network that includes various entities such as funders, intermediaries, and performers who each play a crucial role in the overall framework. Funders, defined as the institutions that allocate financial resources for research and development endeavors, include a diverse range of organizations such as Canadian public institutions at both the federal and provincial levels, private institutions that encompass agribusinesses and Agri-entrepreneurs, as well as industry groups, which consist of specific commodity-focused groups and industry associations that advocate on behalf of farmers, ranchers, and producers in the agricultural sector. These funders are instrumental in providing vital financial support for research initiatives that are specifically related to particular commodities, including but not limited to beef, grains, and poultry, thereby facilitating advancements in these areas.

Noteworthy, industry groups often take on the role of intermediaries, actively engaging in the support of research activities and extending their influence through various extension programs that aim to disseminate knowledge and practices to those within the agricultural community. In addition to funding, they also play a crucial role in fostering collaboration between researchers and practitioners, ensuring that the findings are not only innovative but also practical and applicable in real-world scenarios.

Academic institutions and research centers operate as dynamic entities that utilize various sources of funding to engage in the creation and dissemination of innovative and groundbreaking research that pushes the boundaries of knowledge and technology. The specific categories and types of research that these esteemed institutions are involved in producing can be described as follows:

Basic (or Discovery or Fundamental) Research concentrates on the comprehensive understanding of biological, chemical, and physical phenomena pertinent to flora, fauna, soil, and ecosystems. Illustrative examples include the examination of plant and animal genetics, soil microbiology, or the physiological processes of both plants and animals.

Applied Research encompasses investigations that address tangible issues within the agricultural sector and seeks to resolve them. This type of research emphasizes the creation of innovative technologies, practices, and methodologies that confer direct advantages to the agricultural industry. Illustrative examples comprise precision agriculture technologies and pest management strategies.

In-field application Research pertains to investigations conducted within a farm or field environment, where the practical implementation of agricultural, environmental, or technological advancements can be assessed and appraised. This form of research is essential for comprehending the efficacy of novel technologies, practices, or interventions in real-world scenarios, as opposed to controlled laboratory or experimental contexts. Such research frequently entails collaboration with farmers and agricultural experts to ensure that findings are relevant and can be effectively implemented in real-world scenarios.

1.2 OVERVIEW OF CANADIAN POLICIES AND PROGRAMS FOR AGRICULTURE SECTOR SINCE 2013

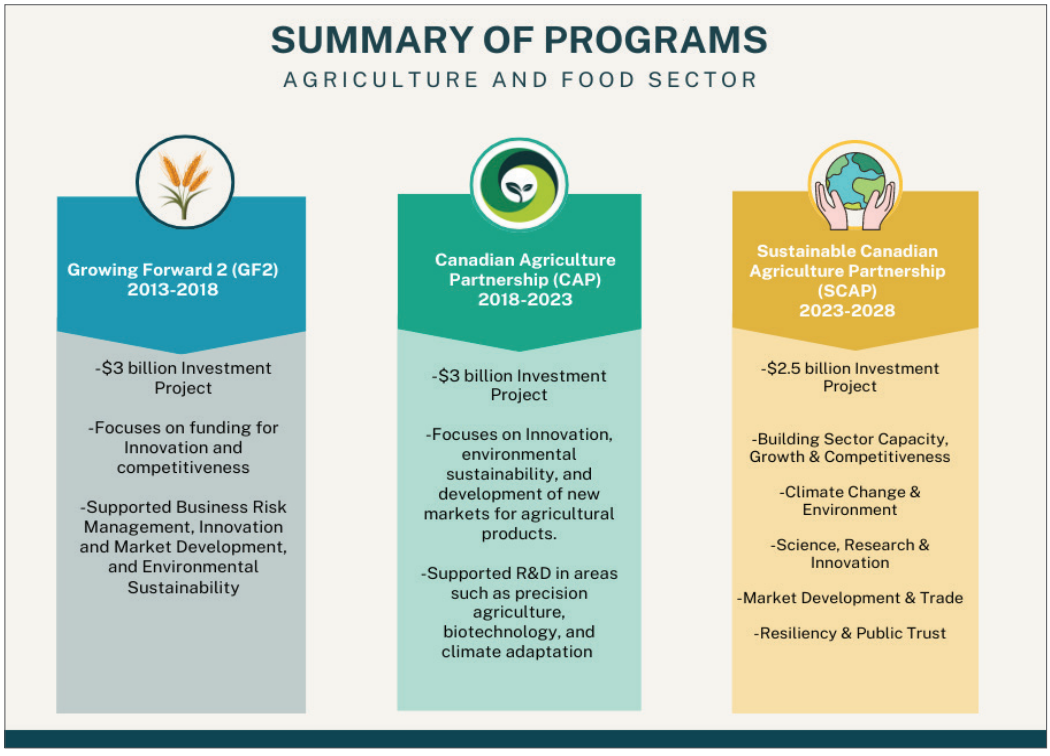
Since 2013, Canada's agricultural policy of R&D has evolved through various initiatives to enhance innovation, sustainability, and global competitiveness in the agri-food sector. In 2013 Growing Forward 2 (GF2) program was launched by Federal, Provincial and Territorial (FPT) governments with a budget of $3 billion, this program promoted Competitiveness and Market development (CMD), Innovation, Adaptability and Industry Capacity (AIC, 2017) (AAFC, 2017). The program included research and innovation as a main element in agriculture and food sector to receive funds to improve environmental and productivity sustainability by focusing on activities that enhance innovation, from the stage of discovery to commercialization and adoption.

In 2018, five-year Canadian Agricultural Partnership (CAP) framework agreement was introduced that replaced previous GF2 Program. The $3 billion CAP investment focuses on innovation, environmental sustainability, and the development of new markets for agriculture products. Moreover, CAP supports R&D in areas such as precision agriculture, biotechnology, and climate adaptation to help farmers and agribusinesses remain competitive. Under CAP, a specific program for research was initiated called as AgriScience program, that funds both basic and applied research with a focus on improving crop yield, pest management, and food safety. It includes streams for industry-led government funded research projects, fostering collaboration between researchers and agriculture industry

Similarly, in 2021 Agriculture Clean Technology (ACT) program was launched that provided funds for R&D and the adoption of clean technologies in the agriculture sector, such as precision agriculture, and waste reduction technologies to reduce greenhouse gas emissions and improve environmental outcomes. It further encourages innovation in sustainable farming techniques through applied research in energy efficiency, sustainable crop production, and greenhouse gas mitigation (OECD, 2021).

The sustainable Canadian Agriculture Partnership 2023-2028 replaced CAP and came into effect. This new policy framework included an additional CAD 500 million funds with a strong focus on climate change and the environment, including strong commitment towards reducing greenhouse-gas emissions in the agriculture sector by 3 to 5 $MtCO_2eq$ (OECD 2023). Additionally, the government of Canada Launched 2030 Emission Reduction Plan (ERO) in March 2022, announcing CAD 1 billion funds for over six years to support sustainable agriculture and encourage significant reduction in GHG emissions. The plan included a strategy of spending 30% of funds on the development and adoption of clean technologies, precision agriculture, and the bioeconomy (see Figure 2).

Figure 2: Summary of Agriculture Programs

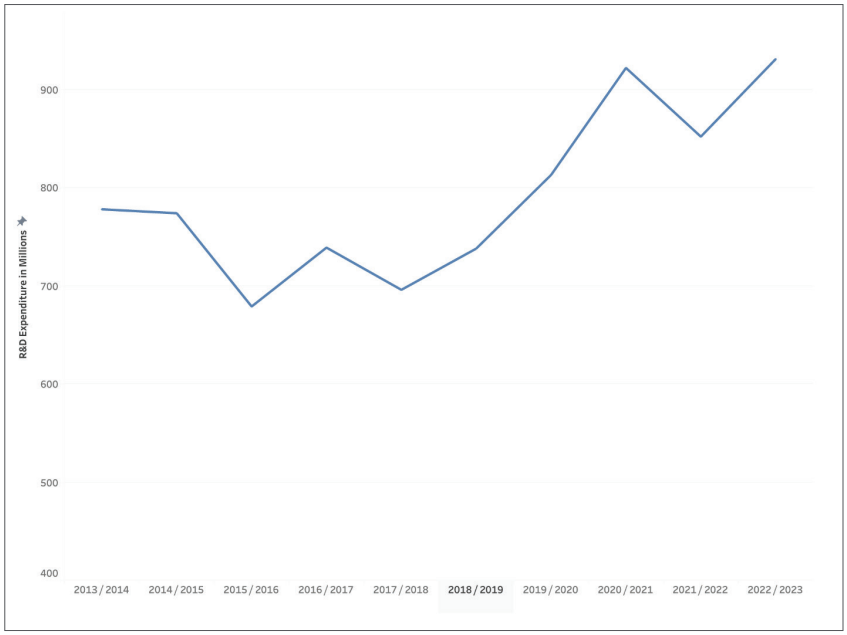


1.3 MACRO TRENDS IN CANADA'S PUBLIC AND PRIVATE SECTOR EXPENDITURES FOR AGRI-FOOD RESEARCH (STATISTICS CANADA)

Over the past ten years Canada has invested significantly in R&D in its agriculture sector to foster innovation, support sustainability, and ensure competitiveness and effectiveness in the sector. Recent R&D initiatives have focused on reducing the environmental impact of agriculture. This includes researching methods to reduce greenhouse gas emissions, improve water use efficiency, and enhance soil health through conservations techniques.

In Canada, support for R&D comes under the cost-shared strategic initiatives between federal and provincial/territorial governments. The federal government contributes 60%, and the provincial governments 40%. Figure 3 shows that federal government Support for agriculture R&D under GF2 period (2013-2018) was lower than SCAP period. During early phase of SCAP, the expenditure for R&D significantly increased until 2020. Under CAP program and during fiscal year 2021-2022, the government of Canada provided CAD 98.4 million for over ten years to launch new Natural Climate Solutions for Agriculture Fund (OECD, 2021). This new initiative significantly contributed toward rise in the R&D expenditure in 2021.

Figure 3: Agriculture R&D Total Federal Expenditure

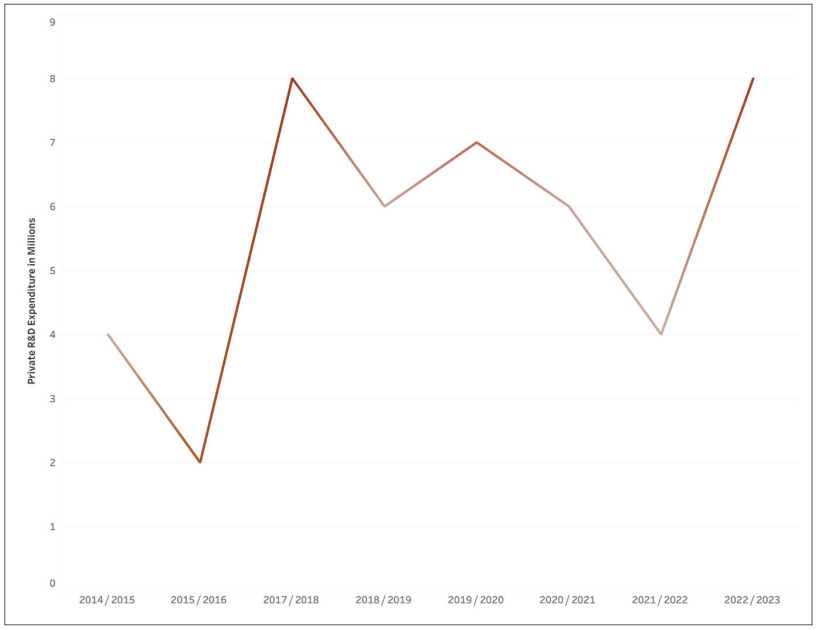


Source: Statistics Canada, 2024

Private sector investment in Canada plays a substantial role in advancing innovation, improving productivity and ensuring sustainability and competitiveness in the sector. With growing demand for technology and sustainable practices, private institutions like industry/commodity specific groups are increasingly investing in R&D to create new technologies, such as precision agriculture, digital tools, and biotechnology. Besides investing in productivity and growth in the sector, the private sector has shown considerable support towards protecting plant and animal health by investing in research. These innovations help optimize animal and crop productivity, reduce environmental impact, and address challenges posed by climate change. Additionally, the private sector is also engaged in commercialization of innovative technologies often facilitated by

partnership between private sector and research institutions and government. Recent data from Statistics Canada, 2024 shows highest private sector expenditure of around CAD 8 million in 2017 and 2022 (see Figure 4).

Figure 4: Private Sector R&D Expenditure on Primary Agriculture



Source: Statistics Canada, 2024

PART 2. ANALYSIS OF ORIGINAL DATA FROM PUBLIC AND PRIVATE SECTOR FUNDING FOR AGRI-FOOD RESEARCH FROM 2013 TO 2023

Both public and private sector funding data were collected, and curated to determine the total funding for various agri-food research areas. Our database currently includes information on 20,650 agri-food research projects supported by 1,150 public and private funding sources. Projects are organized into 3 tier-1 category: Productivity and growth, Protection and risk resilience, environmental stewardship; and 11 tier-2 categories (see Figure 5). The funding amount is displayed in real 2022-2023 dollars.

Figure 5: Agri-food Research Priorities and Sub-categories

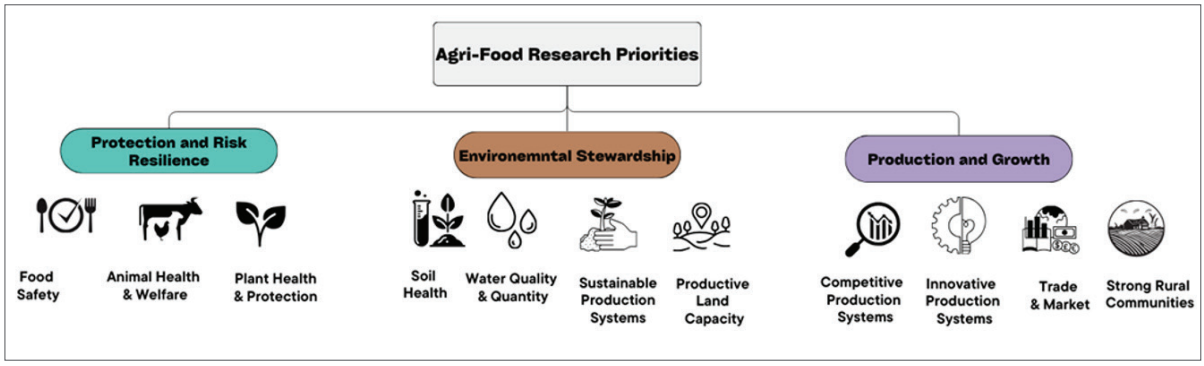


Table 1 presents summary statistics of our database. Our results show that on average, CAD 164,000 was spent per project, with a median investment of CAD 46,000. Over the 10-year period, the average investment for research in productivity and growth, protection and risk resilience, and environmental stewardship was approximately CAD 165,000, CAD 162,000, and CAD 163,000, respectively. This data underscores the varying levels of investment across different research areas, reflecting priorities in the agri-food sector. Table 2 presents a summary of the total investments made by both sectors across each category and research focus. Our findings indicate that research in production and growth received the highest total investment, amounting to CAD 1.4 billion from both the public and private sectors. In contrast, research projects centered on protection and risk resilience, as well as environmental sustainability, saw total investments of CAD 1.1 billion and CAD 750 million, respectively. Figure 6 presents the funding distribution of funds for year 2013,2018, and 2023 in real 2022-2023 terms.

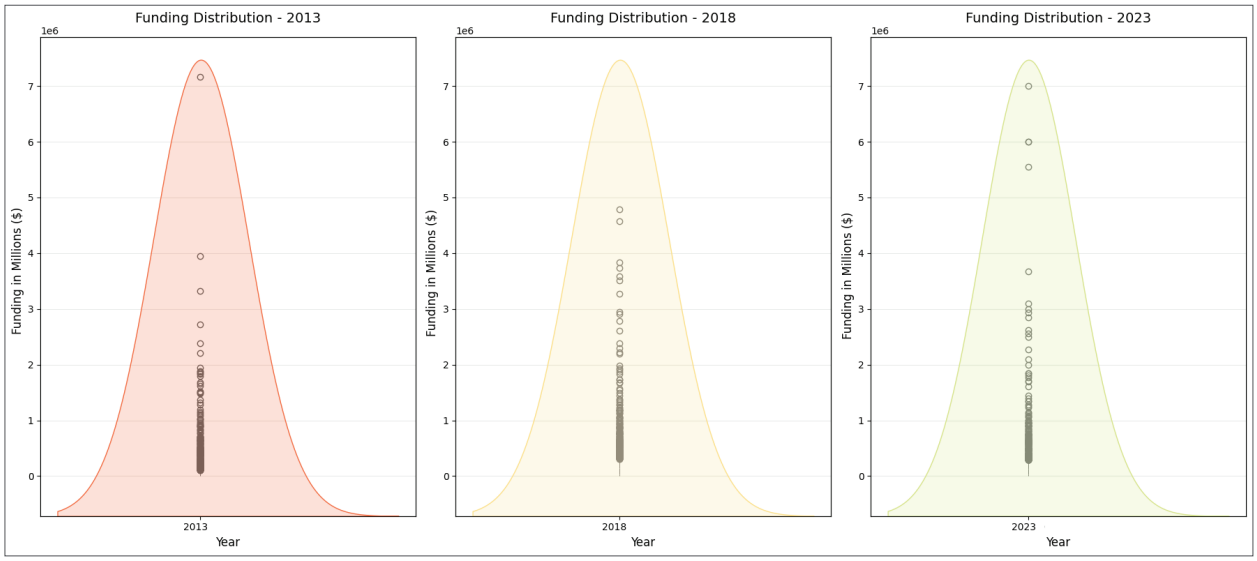
Table 1: Summary Statistics

	Total Number of Projects	Average Spending	Median
Productivity and growth	8,587	$165,000	$47,000
Protection and risk resilience	7,392	$162,000	$46,000
Environmental stewardship	4,671	$163,000	$43,000
Total	**20,650**	**$164,000**	**$46,000**

Table 2: Summary of Total Investments by Public and Private Sector in Different Research Areas

Research Areas	Environmental Stewardship	Productivity and Growth	Protection and Risk Resilience	Grand Total
Animal health and welfare			$569 million	$569 million
Competitive production systems		$853 million		$853 million
Food safety			$159 million	$159 million
Innovative products and product improvement		$497 million		$497 million
Plant health and protection			$440 million	$440 million
Productive land capacity	$27 million			$27 million
Soil health	$150 million			$150 million
Strong rural communities		$15 million		$15 million
Sustainable production systems	$426 million			$426 million
Trade, market and target sector growth opportunities		$17 million		$17 million
Water quality and quantity	$145 million			$145 million
Grand Total	**$750 million**	**$1.4 billion**	**$1.1 billion**	**$3.3 billion**

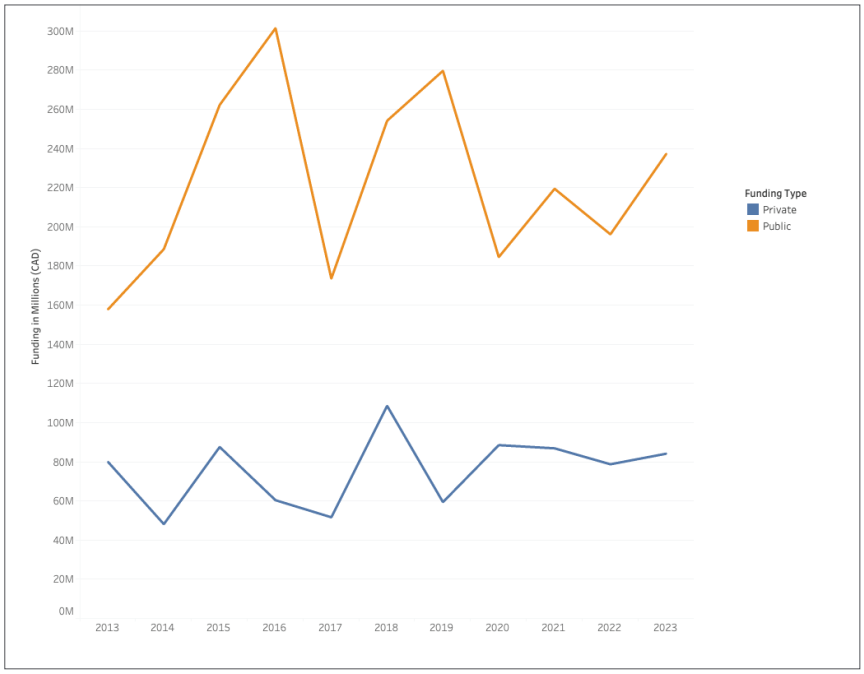
Figure 6: Funding Distribution for Agri-Food Research Projects in 2013, 2018, and 2023 (Real 2022-2023 terms)



2.1 PUBLIC AND PRIVATE SECTOR INVESTMENT FOR AGRI-FOOD RESEARCH

Over the past decade the agri-food research funding in Canada, in real 2022-2023 dollar, has exhibited notable fluctuations (see Figure 7), with average annual growth rates of 8.3% in the public sector and 10.6% in the private sector. Public sector invested around CAD 2.4 billion in 10 years, while private sector contributed around CAD 837 million.

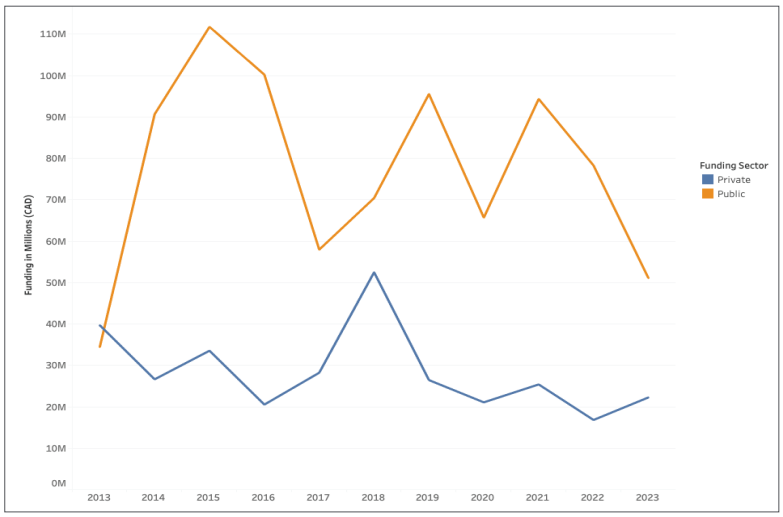
Figure 7: Public and Private Investment for Agri-Food Research, 2013-2014 to 2022-2023 (Real 2022-2023 terms)



The following sections analyze shifts in funding trends within each sector and research category, providing insights into how these investments align with the government-defined agricultural programs and strategies. This evaluation aims to identify whether research priorities, such as productivity, resilience, and sustainability are being effectively addressed through these funding allocations.

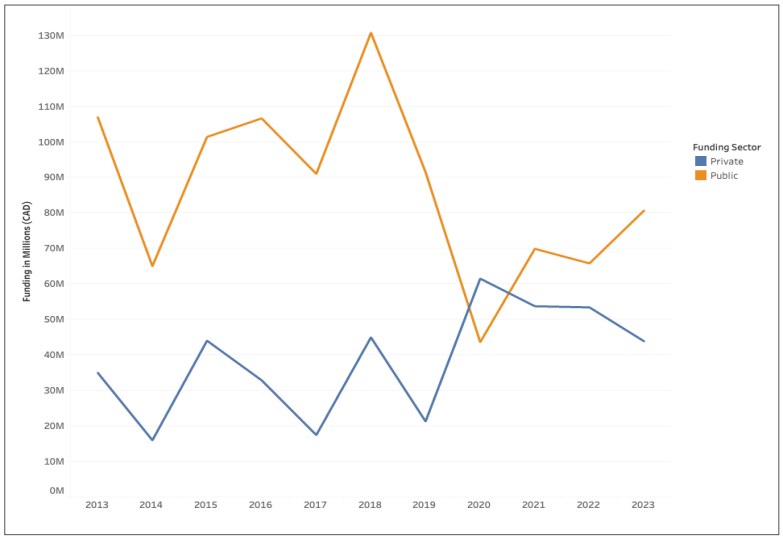
Over the past decade, research funding from both the public and private sectors, measured in real 2022–2023 CAD terms, has shown significant investment in agri-food research, particularly in the areas of protection and risk resilience, production and growth, and environmental stewardship. Notably, funding for research targeting protection and risk resilience increased at an average annual rate of 15.2% in the public sector and 2.63% in the private sector, demonstrating a growing emphasis on addressing threat and enhancing resilience within the agri-food system (see Figure 8).

Figure 8: Public and Private Investment for Protection and Risk Resilience Research, 2013-2014 to 2022-2023 (Real 2022-2023 terms)



In contrast, public sector funding for production and growth research declined at an average annual rate of 4.56%, while private sector investment in this area increased significantly, averaging an annual growth rate of 31.2% (see Figure 9). This trend highlights the critical role of private sector investments in driving innovation and promoting productivity and growth within the agri-food sector. By allocating substantial resources to research and development, the private sector is not only compensating for the reduction in public funding but also contributing to advancements in agricultural technologies and practices that enhance overall sector performance.

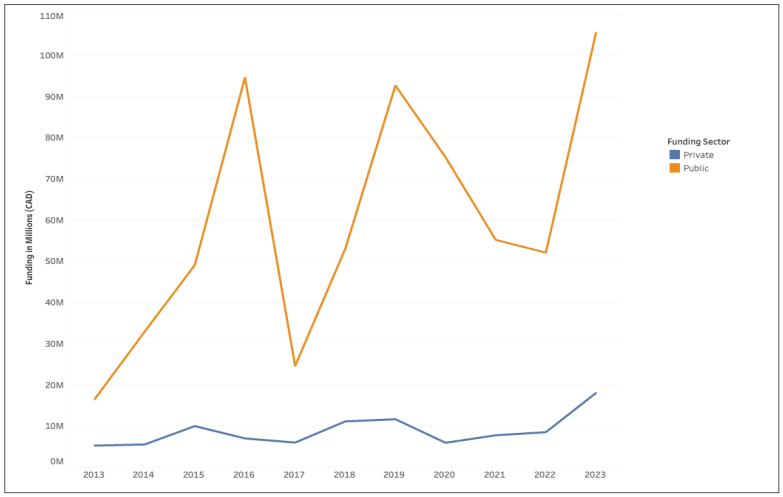
Figure 9: Public and Private Investment for Production and Growth Research, 2013-2014 to 2022-2023 (Real 2022-2023 terms)



Investments in environmental stewardship have shown remarkable growth in both the public and private sectors, with public funding increasing at an average annual rate of 41.2% and private funding rising by 23.5%. This significant expansion underscores a shared commitment to sustainability, with a particular focus on critical issues such as soil health, water resource management, and the mitigation of environmental impacts. These funding trends signal an important shift in research priorities, reflecting an acknowledgment of the urgent need to balance agricultural productivity with environmental sustainability.

While the public and private sector continues to play a dominant role in driving protection and risk resilience and production-focused research, this joint emphasis on environmental sustainability demonstrates a broader, more integrated approach to addressing the multifaceted challenges facing agriculture today. Such alignment between public and private initiatives is essential for tackling global concerns such as climate change, resource scarcity, and food security. By fostering innovation and sustainable practices, these investments position the agri-food sector to meet current demands while ensuring long-term environmental and economic resilience (see Figure 10).

Figure 10: Public and Private Investment for Environmental Stewardship Research, 2013-2014 to 2022-2023 (Real 2022-2023 terms)



2.2 PUBLIC AND PRIVATE SECTOR INVESTMENT UNDER GF2 REGIME.

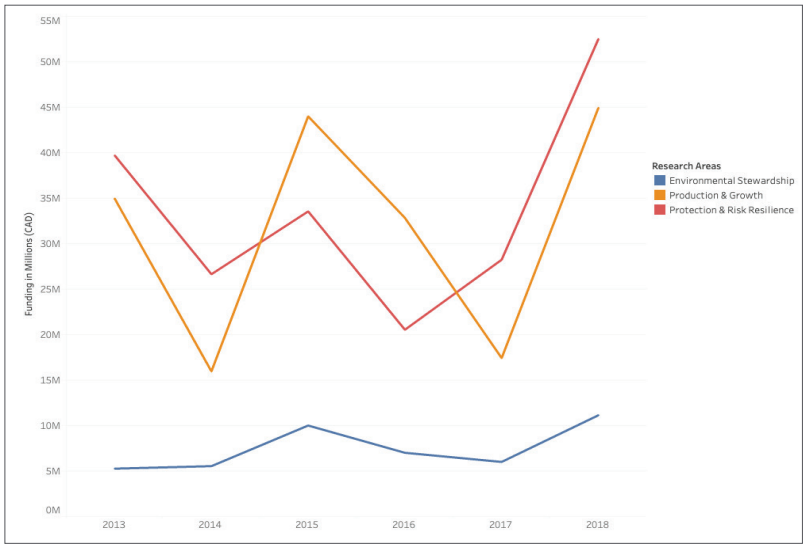
During the GF2 period (2013–14 to 2017–18), agri-food research in Canada received funding through three newly introduced federal strategic initiatives: *AgriInnovation*, *AgriMarketing*, and *AgriCompetitiveness* (OECD, 2013). These programs aimed to promote industry-led research and development, facilitate the adoption and commercialization of novel technologies in the agriculture and food sectors, and support marketing initiatives.

The funding trends during the GF2 regime indicate a public sector emphasis on enhancing protection and risk resilience in the agri-food sector by investing in research related to animal health and welfare, plant health and protection, and food safety. Additionally, the public sector increased its investment in research and innovation targeting environmental stewardship to ensure sustainability. A notable development during this period was the implementation of the Safe Food for Canadians Act in 2015, which focused on food safety and the strengthening of regulations related to food traceability (OECD, 2015). Furthermore, in the 2016 federal budget, the government of Canada allocated CAD 1 billion over four years for clean technology investments, including those in the agriculture sector (OECD, 2016) (see Figure 11).

Figure 11: Public Sector Investment for Agri-Food Research under GF2 Regime, 2013-2014 to 2017-2018

Similarly, the trend for private sector during the GF2 regime concentrated its investments on research supporting both in production and growth and protection and risk resilience. However, after 2015, we observed that the investment for research projects promoting protection and risk resilience was higher than production and growth. Although we noticed differences in the research priorities for public and private sector during GF2 regime, but we observe that investment for research supporting environmental stewardship was low. This suggests that in GF2 regime both sectors made significant investment contributed to increased research funding targeting productivity enhancements, and competitiveness (see Figure 12).

Figure 12: Private Sector Investment for Agri-Food Research under GF2 Regime, 2013-2014 to 2017-2018 (Real 2022-2023 terms)

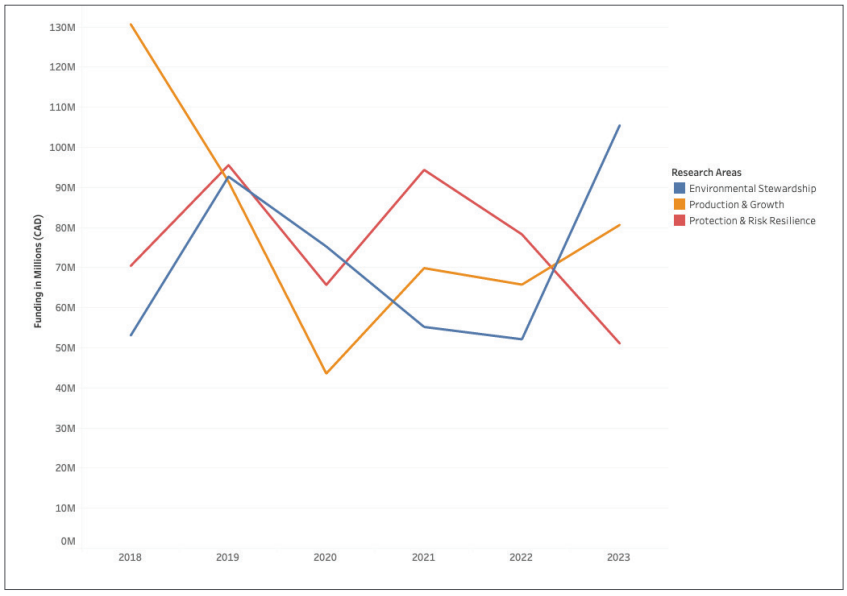


2.3 PUBLIC AND PRIVATE SECTOR INVESTMENT IN CAP REGIME

During the CAP regime, public sector funding trends indicate an increase in investments for research areas related to environmental stewardship, while private sector funding focused on both production and growth as well as environmental stewardship. This trend can be attributed to the *AgriInnovate program* under CAP, which emphasized fostering industry-led research and development, with a strong focus on adopting innovations in food and agriculture, as well as marketing initiatives (OECD, 2018). Through the *AgriInnovate program*, industry-led research priorities shifted towards production and growth, resulting in increased funding for research categories such as innovation, product enhancement, and trade and market development.

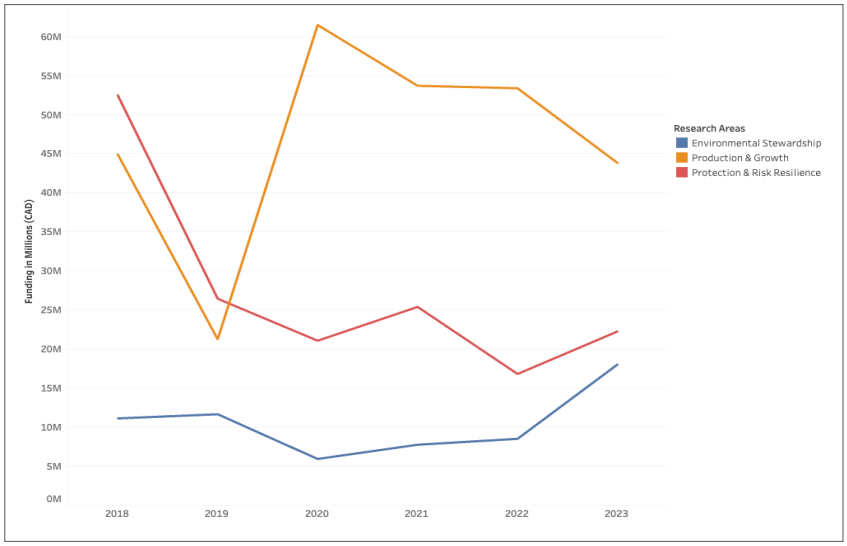
Additionally, in 2019, provincial governments introduced farm-level environmental programs, such as the *Environmental Farm Plans* (EFP) and *Environmental Stewardship Incentive Programs*. These initiatives aimed to advance environmentally sustainable agriculture by assessing and mitigating on-farm environmental risks and promoting the adoption of best management practices (BMP), including nutrient management, manure storage, and soil erosion control. A significant policy development contributing to the increased focus on environmental stewardship was the launch of the *A Healthy Environment and a Healthy Economy plan* in December 2020. This framework provided a seven-year roadmap to support the development of clean technologies, reduce emissions, and advance climate-smart agricultural practices, further driving funding towards sustainability-focused research (OECD, 2019). The effect of this framework can be observed in Figure 13, which shows a significant increase in public sector investment in research projects focusing on soil health, water quality and quantity, and sustainability. This trend highlights a growing emphasis on environmental sustainability in research funding.

Figure 13: Public Sector Investment for Agri-Food Research under CAP Regime, 2018-2019 to 2022-2023 (Real 2022-2023 terms)



Private sector investment, compared to the GF2 regime, demonstrated a significant increase in funding for research related to production and growth, reaching CAD 60 million in 2020. This shift highlights the private sector's prioritization of promoting production and growth within the agricultural sector. Our results do not provide evidence of difference in trends for investments targeting research on protection and risk resilience, as well as environmental stewardship. These trends reflect a broadened focus by the private sector, promoting productivity goals with long-term sustainability and risk management considerations (see Figure 14).

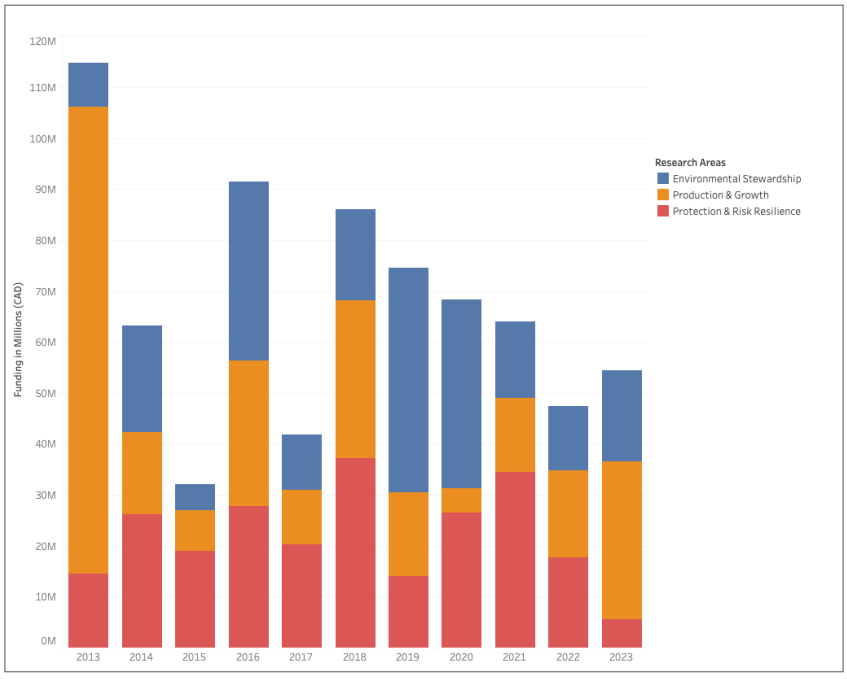
Figure 14: Private Sector Investment for Agri-Food Research under CAP Regime, 2018-2019 to 2022-2023 (Real 2022-2023 terms)



2.4 A FOCUS ON TRI-COUNCIL INVESTMENT FOR AGRI-FOOD SECTOR

The Tri-Council of Canada, comprising the Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC), and the Canadian Institutes of Health Research (CIHR), plays a pivotal role in advancing agri-food research. These organizations collectively invest in interdisciplinary projects that enhance agricultural productivity through innovation, address food security, and support research related to sustainable practices. Funding is directed toward initiatives like climate-resilient crop development, precision agriculture technologies, and the socio-economic aspects of agri-food systems. Through grants and strategic programs, the Tri-Council fosters collaboration between academia, industry, and policymakers, aiming to leverage innovation for long-term food system resilience and competitiveness. Our data shows that over the past ten years, Tri-Council invested around CAD 228 million on the research that focuses on productivity and growth that includes projects on promoting competitiveness of the sector, innovation, trade and market policies, and strengthening rural communities. Similarly, the spending for research that promoting protection and risk resilience and environmental stewardship was around CAD 200 million and CAD 195 million respectively (see Figure 15).

Figure 15: Tri-Council (NSERC, SHHRC, and CIHR) Investment for Agri-Food Research, 2013-2014 to 2022-2023 (Real 2022-2023 terms)



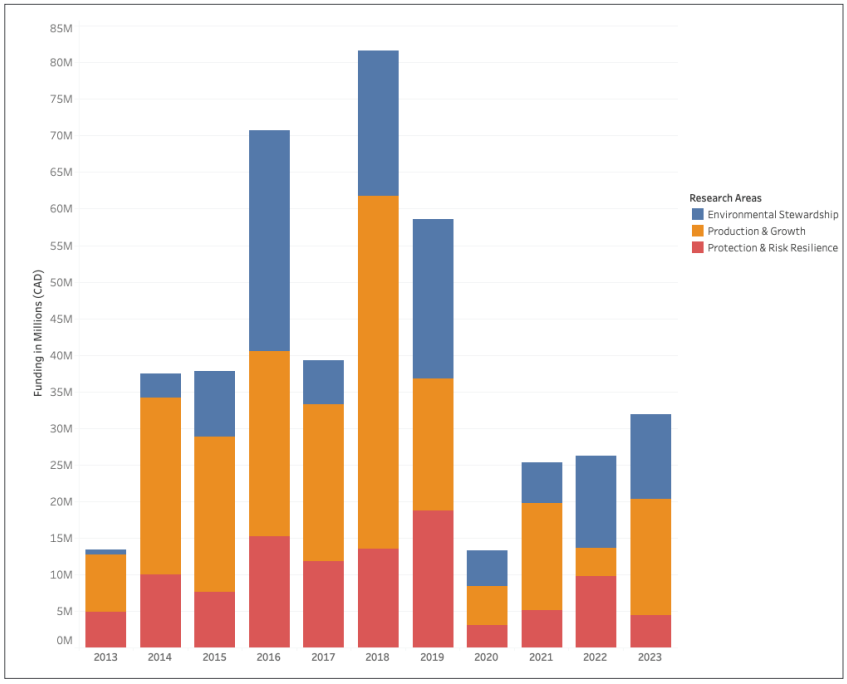
2.5 A FOCUS ON AGRICULTURE AND AGRI-FOOD CANADA SPENDING FOR AGRI-FOOD RESEARCH

Agriculture and Agri-Food Canada (AAFC) plays a central role in advancing agri-food research through funding, innovation, and collaboration with stakeholders across the agricultural value chain. Key areas of focus include crop breeding for climate adaptability, pest and disease management, soil health, and precision agriculture technologies. Recent trends indicate a shift toward integrating digital tools and data-driven approaches in agri-food research, emphasizing sustainability and reducing environmental impacts. Furthermore, AAFC fosters partnerships between academic institutions, private industry, and international organizations to drive innovation and commercialization of research outcomes. These efforts align with Canada's broader goals to position its agri-food sector as a global leader in sustainable agriculture.

Our database includes 1,382 agri-food research projects shared by Agriculture and Agri-Food Canada (AAFC) and other research institutions. While this dataset represents a snapshot of research supported by AAFC, it does not capture the full scope of projects funded by the organization due to privacy and confidentiality constraints.

Our analysis reveals that over the past decade, AAFC invested approximately CAD 186 million in research focused on productivity and growth, CAD 97 million in research addressing protection and risk resilience, and CAD 112 million in research promoting environmental stewardship (see Figure 16). This reflects AAFC's commitment to advancing research across critical areas to enhance the sector's sustainability, resilience, and economic impact.

Figure 16: AAFC Investment for Agri-Food Research, 2013-2014 to 2022-2023, (Real 2022-2023 terms)

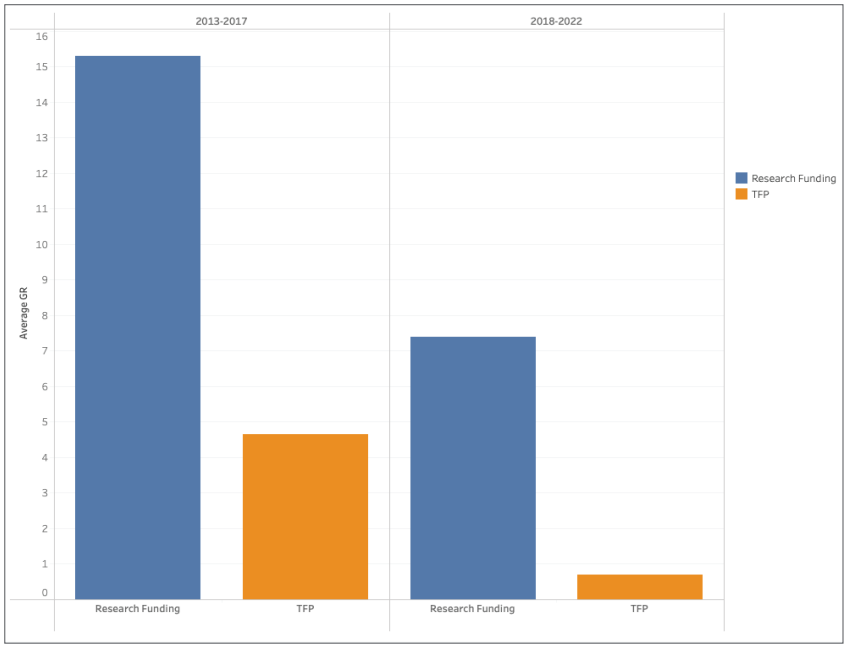


2.6 AGRI-FOOD RESEARCH AND TOTAL FACTOR PRODUCTIVITY

Research funding impacts Total Factor Productivity (TFP)[1] by driving innovation, technological advancements, and improved practices that enhance efficiency in resource use. Specifically, funding supports the development of new technologies, the creation and dissemination of agricultural knowledge, and solutions to challenges like climate change, pest resistance, and soil degradation. We used the multifactor productivity data from statistics Canada to measure the average growth rates for productivity.

We compared the average growth rate[2] of agri-food research funding and total factor productivity (TFP) across two periods: 2013-2017 (GF2 regime) and 2018-2022 (CAP regime). Research funding experienced a significant decline, dropping from approximately 16% in GF2 to 9% in CAP. Similarly, TFP growth, which was already lower than funding growth, fell from around 5% in GF2 to near-zero levels in CAP. The decline in research funding during the CAP regime has likely contributed to the dramatic slowdown in TFP growth, as reduced investment limits the scope for innovation and the adoption of productivity-enhancing practices. The widening gap between funding and TFP suggests inefficiencies in translating investments into tangible outcomes. If the goal is to focus on increasing TFP, reversing this trend and prioritizing higher research funding is crucial to enable sustained productivity growth and address the challenges facing the agricultural sector (see Figure 17).

Figure 17: Agri-Food Research and Total Factor Productivity under GF2 and CAP Regime



[1] see multifactor productivity on StatCan website

[2] The average annual growth rate for TFP is calculated using multi-factor productivity data from Statistics Canada website (Statistics Canada, 2024).

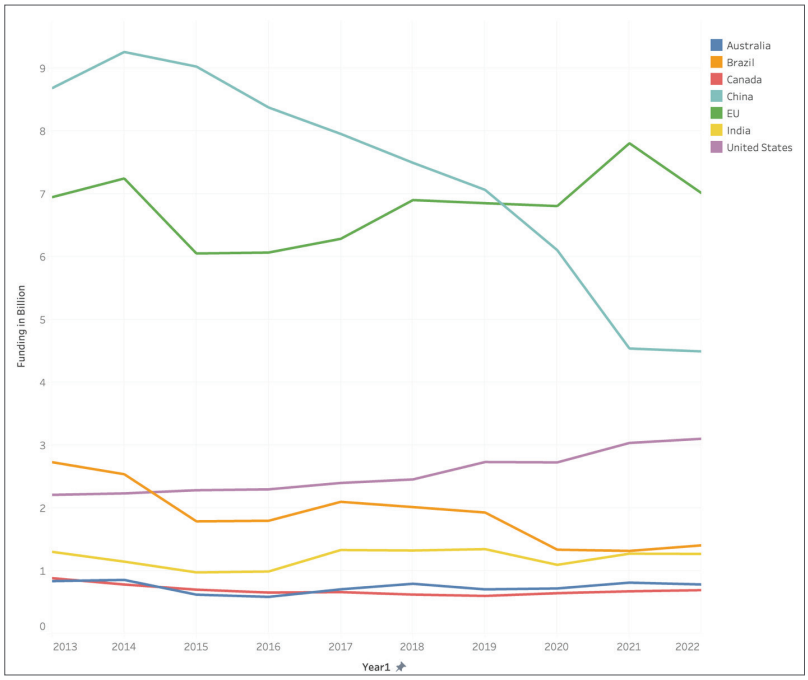
PART 3. TRENDS IN GLOBAL AGRICULTURE RESEARCH SPENDING

3.1 OVERVIEW

According to the IFPRI report from September 2020, global agriculture research spending increased significantly, rising from $31 billion to $47 billion between 2000 and 2016 (IFPRI, 2020). On average, total global spending on agricultural research grew by 2.5% annually during the 2010-2016 period (Bientema et al., 2020). However, this growth rate was slightly lower than the preceding decade, 2000-2010. The deceleration in growth was primarily attributed to reduced spending in middle-income countries such as Brazil and China, alongside negative growth in high-income countries, including the United States. In the OECD countries, public spending on agricultural innovation systems is 1.1% of the value of agriculture production (OECD, 2022). In 2018, five countries each invested over $1 billion in agricultural research, collectively accounting for nearly two-thirds of global spending that year. The top five contributors were China ($8 billion), the United States ($5 billion), India ($4 billion), Brazil ($3 billion), and Japan ($3 billion), followed by EU countries, with investments ranging from $1 to $2 billion (OECD, 2022).

Figure 18 presents the trend in spending in agricultural knowledge and innovation[3] in leading OECD countries providing evidence that China and EU countries are leading in agricultural R&D. Beside China and EU, the United States, Brazil are investing in research and innovation in agricultural sector followed by India. However, Australia stands as the country with reduce spending in agriculture R&D. Canada, stands the lowest among these seven countries with reduction in spending from $0.86 billion in 2013 to $0.68 billion in 2022. This shows that Canada is lagging behind top seven OECD countries with lowest spending on agricultural R&D.

Figure 18: Public Spending on Agricultural Knowledge and Innovation Systems



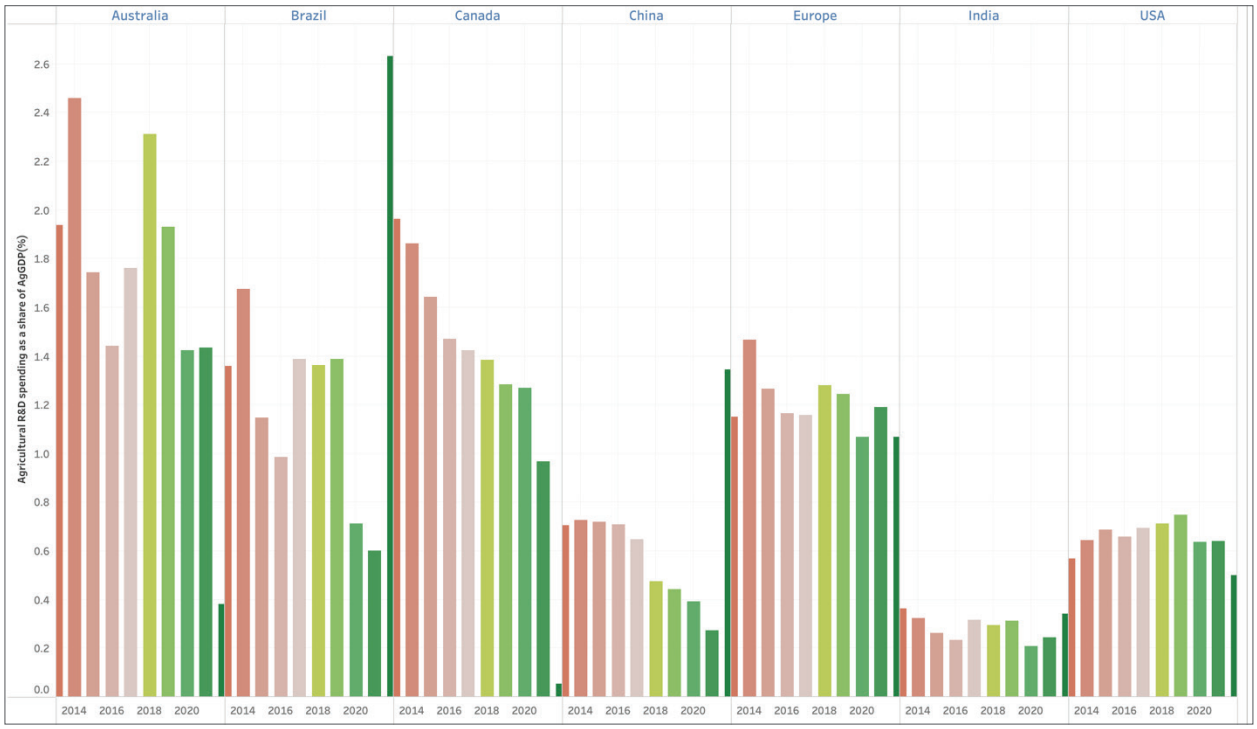
Source: OECD, 2022

[3] Budgetary expenditure financing R&D activities related to agriculture, and associated data dissemination, irrespective of the institution (private or public, ministry, university, research center or producer groups) where they take place, the nature of research (scientific, institutional, etc.), or its purpose (OECD,2024). It includes spending on both agriculture knowledge transfer and generation.

3.2 AGRICULTURAL RESEARCH AND DEVELOPMENT SPENDING AS A SHARE OF AGRICULTURE GROSS DOMESTIC PRODUCT (AGGDP)

Absolute spending is not the sole measure for comparing agricultural research investments across nations or regions. An alternative approach involves assessing a country's agricultural research spending as a proportion of its agricultural gross domestic product (AgGDP), a metric referred to as the research intensity ratio. This ratio enables cross-country comparisons and has become a widely used tool for tracking investment trends over time and across different nations. Additionally, it serves as a benchmark for setting international investment targets (Figure 19). Over a ten-year period, Australia recorded the highest agricultural R&D spending as a share of AgGDP, with an average of 1.68%. This is followed by Canada, with an average of 1.33%, slightly surpassing Brazil's average of 1.32%. Although China and EU countries lead in total agricultural R&D expenditure, their average spending as a share of AgGDP stood at 0.64% and 1.2%, respectively. Similarly, the United States allocated a relatively low share of its agricultural R&D budget, averaging 0.64%, while India recorded the lowest value, at just 0.29%.

Figure 19: Agricultural R&D Spending as Share of AgGDP (%)

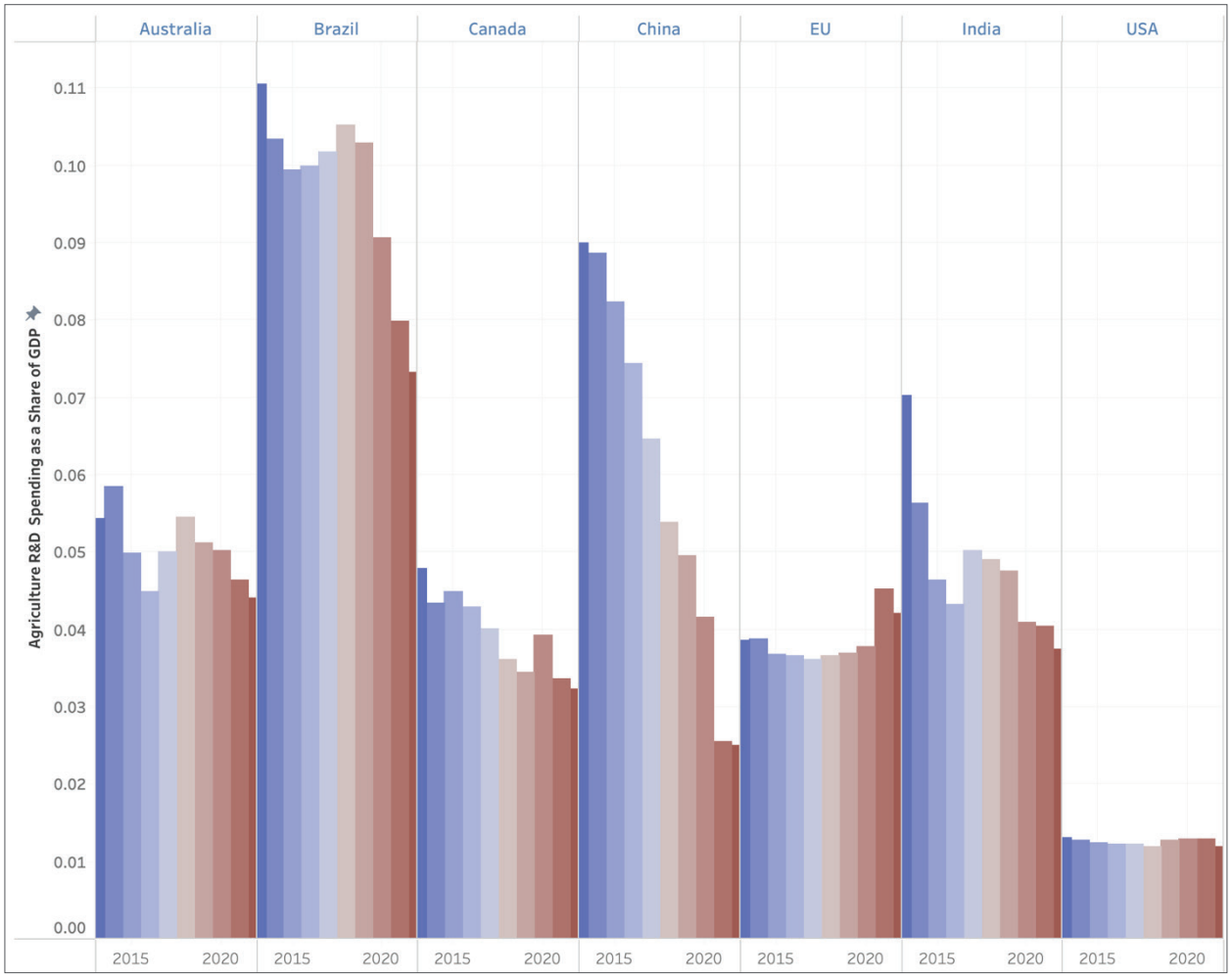


Sources: OECD,2022; Ag-Production Data from FAO,2022

3.3 AGRICULTURE R&D SPENDING AS A SHARE OF OVERALL GROSS DOMESTIC PRODUCT

Data from the OECD on spending on agricultural knowledge and innovation as a percentage of GDP shows that among middle income countries, Brazil stands as the highest in spending on agricultural R&D as a percentage of GDP followed by China and India. Similarly, among high income countries Australia has contributed highest in spending for agricultural R&D as a percentage of GDP. Canada remains relatively stable, with minor fluctuations and a slight increase post-2020, while the United States consistently has the lowest percentages with minimal change (Figure 20).

Figure 20: Spending on Agricultural Knowledge and Innovation as a Percentage of GDP



Source: OECD, 2022

3.4 FOCUS ON POLICIES AND PROGRAMS IN LEADING COUNTRIES

This section explores the agricultural research and development (R&D) trends, policies and programs implemented in key countries such as China, India, the United States, Australia and Brazil. The goal is to analyze trends, frameworks and structures of policies that have largely driven their R&D spending in agriculture and food over the past decade.

This jurisdictional scan aims to provide an international comparison of these policies and programs, shedding light on the strategies that enabled higher R&D investments in these leading nations. Insights drawn from this analysis will serve as a foundation for policy recommendations tailored to Canada's context. These recommendations will support the development of robust agricultural R&D policies to enhance competitiveness, productivity, and sustainability in the sector.

3.4.1 China

Agriculture R&D Landscape

In China, both central and local governments play pivotal roles in formulating, implementing, and managing policies, developing institutions and infrastructure, and attracting and harnessing investments for agricultural innovation. The country's agricultural R&D system is predominantly public-sector-driven. According to a World Bank report, 88.4% of the R&D funds received by public agricultural research institutes in 2019 were sourced from the government.

The private sector in China also contributes to agricultural R&D but primarily focuses on areas with high returns on investment, such as food processing, agricultural chemical inputs, farm machinery, hybrid seeds, and genetically modified crop breeding (Zhao et al., 2015).

China's agricultural R&D system operates as an integral part of the broader governance of its national innovation system. Oversight is provided by the National Science and Technology Leading Group of the State Council, which reviews science and technology (S&T) strategies, plans, and policies while coordinating efforts across ministries and local authorities. The Ministry of Finance (MOF) prepares the national budget and allocates funding for agricultural research, while the Ministry of Agriculture and Rural Affairs (MARA) implements agricultural R&D policies and supervises the national agricultural research institutes.

China's agricultural R&D system is recognized as one of the largest globally. Its defining features include:

A high number of researchers engaged in agricultural research.

1. A research institute-dominated structure.
2. An independent system that is institutionally separate from the education sector.
3. A highly decentralized governance structure.
4. A strong focus on crop-dominated research (Chen and Zhang, 2011; Chen et al., 2012).

Funding for agricultural R&D in China comprises two main components:

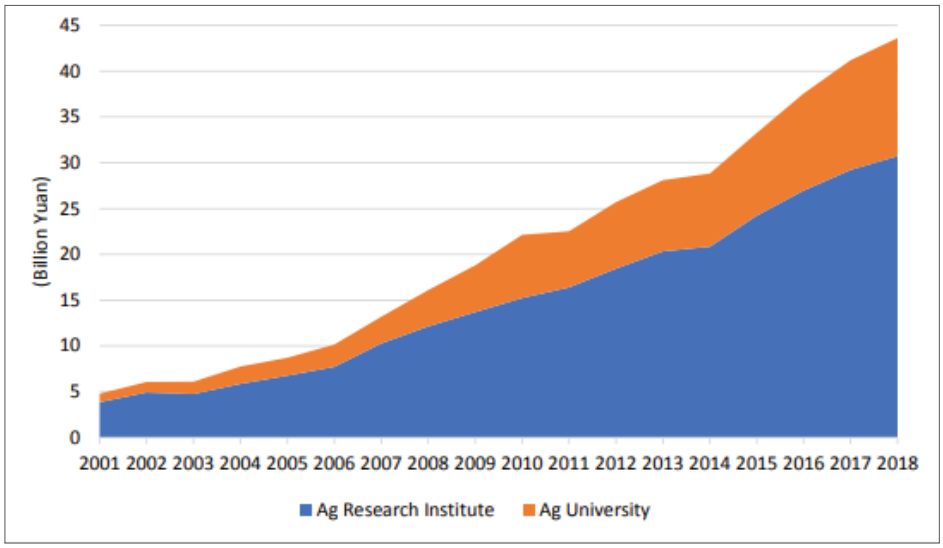
a) Core funds, which are allocated for salaries and welfare.

b) Program-specific funds, which support research projects conducted by various actors.

Trends in Agricultural R&D Expenditures

China's investment in agricultural R&D has grown significantly over the past two decades. According to the World Bank, the total S&T spending by agricultural research institutes increased from 4.8 billion yuan in 2001 to approximately 43.6 billion yuan in 2018, representing an average annual growth rate of 13.9% (see Figure 21). Similarly, agricultural universities saw their spending grow from 0.93 billion yuan in 2001 to 12.9 billion yuan in 2018, reflecting an annual average growth rate of 16.7%.

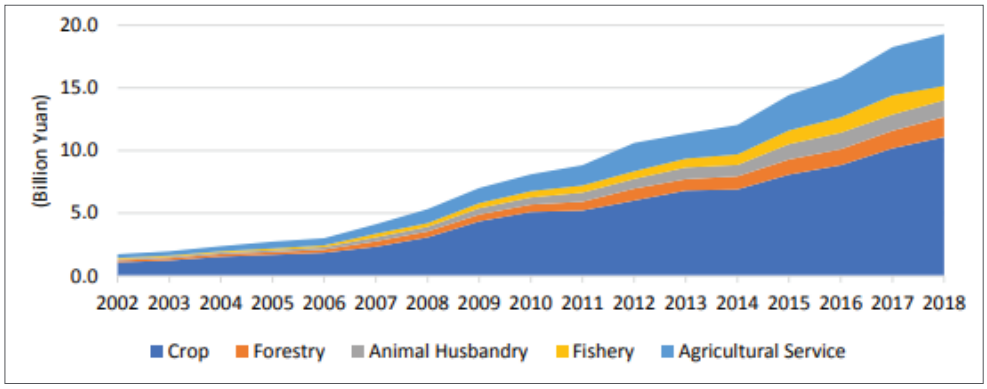
Figure 21: China's Public Sector Agricultural S&T Spending



Source: World Bank, 2021

Over time, the allocation of research funding in China has shifted gradually. While crop research remains the largest area of expenditure, its growth rate has slowed since 2002, increasing from 10.1 billion yuan in 2002 to 11.1 billion yuan in 2018. In contrast, investments in animal husbandry research have risen, highlighting a diversification of research priorities. Figure 22 illustrates the funding allocation mechanisms and trends across different research sectors, respectively.

Figure 22: R&D Expenditure of China's Agricultural Research Institutes by Subsector



Source: World Bank, 2021

China's commitment to agricultural R&D demonstrates its strategic focus on innovation and technological advancement to address national food security and global agricultural competitiveness. This system, supported by robust governance and significant public investment, serves as a model for large-scale agricultural innovation.

Key Policies and Programs for Agriculture in China

In response to the growing challenges of climate change and food security, the Ministry of Agriculture and Rural Affairs (MARA) and the Ministry of Science and Technology (MOST) have introduced a range of policies and programs aimed at advancing agricultural science and technology. These initiatives include:

The 13th Five-Year Plan for Agricultural Science and Development and the Innovation-Driven Rural Revitalization and Development Special Plan (2018-2022): Designed to promote sustainable rural development through innovation and advanced technologies.

Opinions on Innovating Systems and Mechanisms to Promote Agricultural Green Development: A policy framework emphasizing systemic and institutional innovations to achieve green agricultural growth.

Technical Guidelines for Agricultural Green Development (2018-2030): A long-term roadmap that outlines technical approaches for sustainable agricultural practices.

These policies prioritize key areas of agricultural green development, including:

Efficient Use of Agricultural Resources: Enhancing the sustainable utilization of land and water resources.

Agricultural Eco-Environmental Restoration: Promoting efforts to rehabilitate ecosystems affected by agricultural activities.

Biodiversity Conservation: Protecting and restoring biodiversity within agricultural landscapes.

Together, these programs aim to address the dual challenges of ensuring food security and mitigating the impacts of climate change by integrating sustainability into the heart of agricultural development.

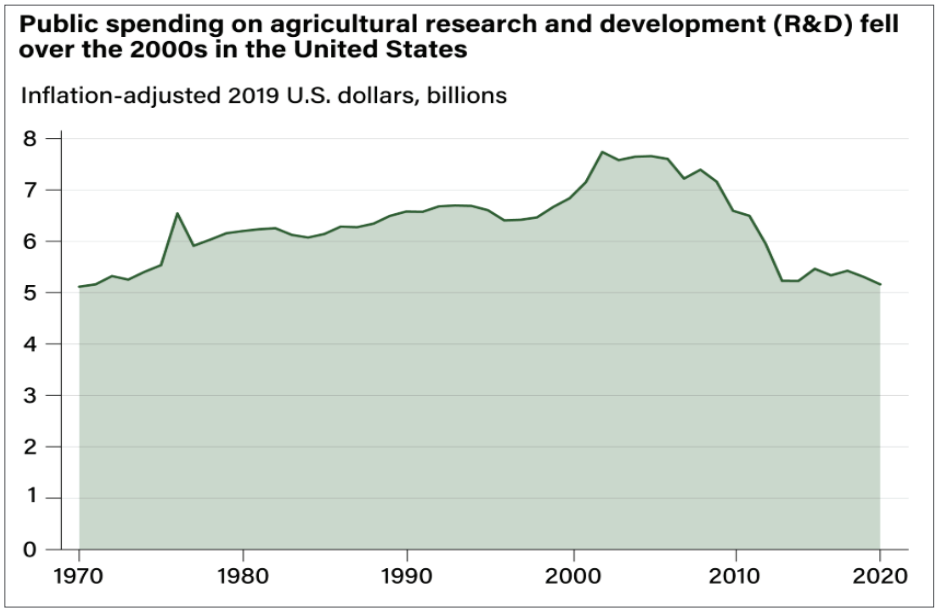
3.4.2 USA

Agricultural R&D Landscape

In the United States, federal-state partnerships form the backbone of agricultural R&D efforts conducted at universities and government research centers. These partnerships are crucial drivers of productivity growth in U.S. agriculture. Additionally, they support improvements in natural resource and forestry management, advance rural development, ensure food safety and quality, and inform market policies.

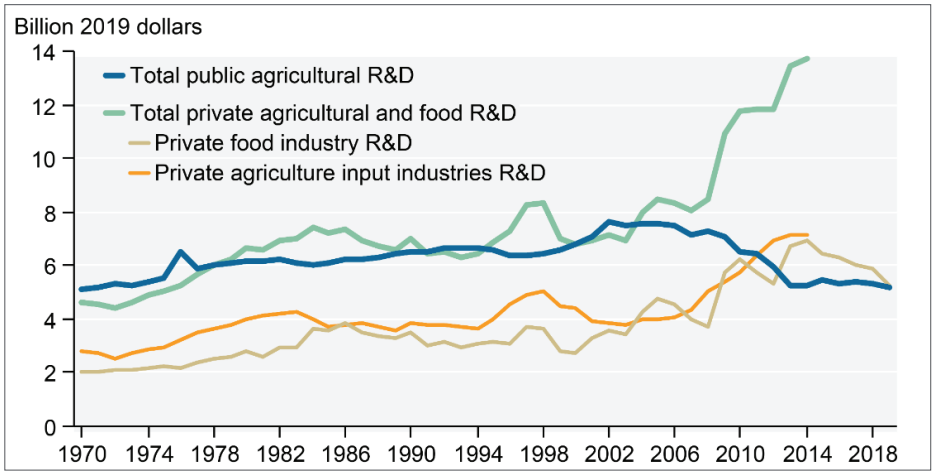
According to the USDA, public agricultural R&D spending in the United States was $5.16 billion in 2019, a decline from its peak of $7.64 billion in 2002 (adjusted to 2019 dollars). Unlike other countries that have increased agricultural R&D spending, the United States. has experienced a downward trend. Of the 2019 total, federal funding accounted for $3.2 billion (64%), state governments contributed $1.06 billion, and non-governmental sources funded $741 million (Nelson and Fugile, 2022) (see Figure 23 and 24).

Figure 23: Public Spending on Agricultural Research and Development (R&D), 2000-2020



Source: (Fugile and Nelson, 2022)

Figure 24: Public and PrivateAgricultural and Food Research and Development (R&D) Expenditure, (1970-2019)



Source: (Fugile and Nelson, 2022)

Trends in Agricultural R&D Spending

In 2019, the USDA funded 85% of all federal agricultural R&D expenditures, dividing the funds evenly between intramural and extramural research.

Intramural Research: Conducted at USDA agencies like the Agricultural Research Service (ARS), this research focuses on providing scientific tools and innovative solutions for American farmers, producers, industries, and communities. Key areas include sustaining agroecosystems, conserving natural resources, and enhancing the economic competitiveness of U.S. agriculture.

Extramural Research: Administered primarily by USDA's National Institute of Food and Agriculture (NIFA), this research involves grants to universities, nonprofits, companies, and other institutions. A significant portion of these grants is allocated through the Agriculture and Food Research Initiative (AFRI), the largest federal competitive grant program supporting research, extension, and education in food and agricultural sciences.

In FY2021, 48% of NIFA's budget was dedicated to plant and animal health and production, while ARS allocated $776 million (56% of its total research funding) to crop and livestock production.

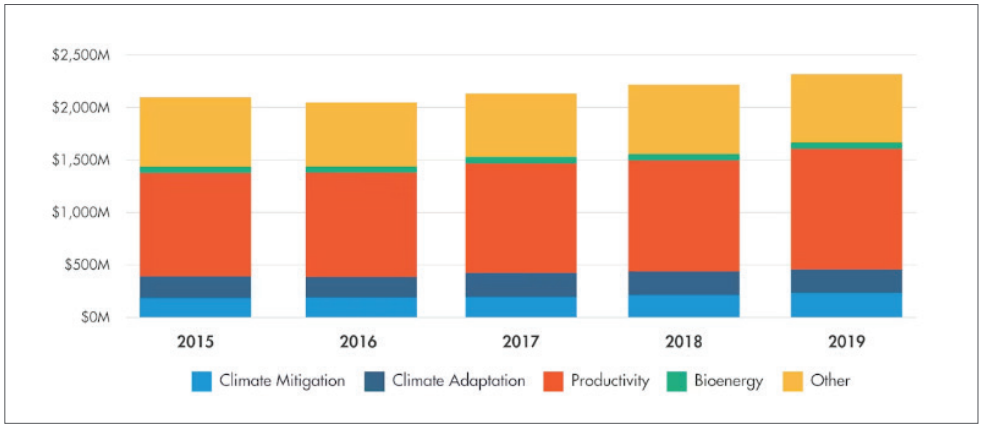
Agriculture Policies and Programs in USA

The U.S. government proposes a Farm Bill every five years to establish a comprehensive framework for agricultural spending. The most recent Farm Bill, enacted in December 2018 and expiring in 2023, was valued at $428 billion. One of its central themes was research, extension, and education, designed to foster innovation from federal labs and state university-affiliated research, as well as to provide vital training for farmers and ranchers.

Despite its broad scope, the allocation for agricultural research, education, and extension under the 2018 Farm Bill was less than $5 billion (USDA, 2018). This modest investment underscores the need for sustained funding to maintain the United States' competitive edge in agriculture.

The article from BreakThrough Institute in 2022 reported that the largest share of federal agricultural R&D spending is directed toward increasing productivity and production. Key priorities include improving crop and livestock yields and promoting pest and disease management. These efforts aim to address the challenges posed by climate change, global food security, and the evolving needs of rural communities (see Figure 25).

Figure 25: Breakdown of Research Funds by USDA ARS and NIFA funding to Productivity and Growth



Source: (BreakThrough Report, 2022)

3.4.3 Brazil

Agriculture R&D Landscape

Brazil is a major player in global agricultural trade, and its investments in agricultural research and development (R&D) significantly influence global food security and commodity prices. Historically, substantial public sector investments in agricultural R&D have driven innovation and productivity in Brazil's agriculture sector.

The Brazilian government is the largest contributor to agricultural innovation, allocating more than USD 2 billion annually. This funding far exceeds the private sector's contribution of approximately USD 800 million per year. Unlike other countries, a significant share of Brazil's public funding is directed toward research rather than the promotion of new technologies (Asia, 2021).

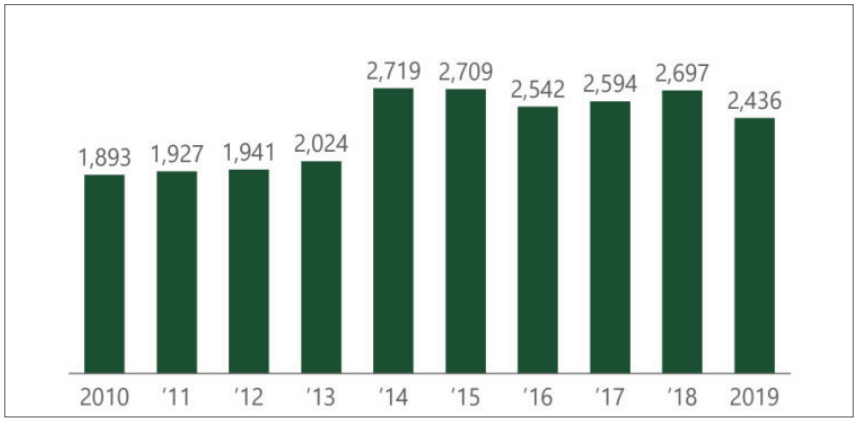
Public funding is primarily channeled through the following institutions:

EMBRAPA (Brazilian Agricultural Research Corporation): A state-owned research organization receiving approximately USD 700 million annually.

Federal Research Organizations and Government Agencies: These institutions implement agricultural extension programs and support knowledge dissemination and capacity building.

Government funding supports various aspects of agricultural innovation, including policy development, knowledge generation, research activities, and financing mechanisms facilitated by fostering systems and institutions (see Figure 26).

Figure 26: Brazil's Public Sector Funding for Agriculture Innovation in USD (2010-2019)

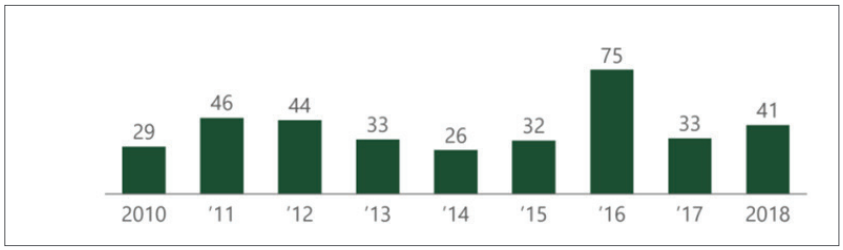


Source: Asia, 2021

Private Sector and Development Partner Funding

The private sector accounts for approximately 30% of agricultural innovation funding in Brazil, supporting research initiatives within private R&D sectors and fostering collaborations with public research institutions .In addition to public and private investments, development partners provide supplementary funding. However, their contributions are relatively small in comparison (see Figure 27).

Figure 27: Funding by Development Partners on AG Innovation USD millions (Constant 2019 prices), 2010-2018



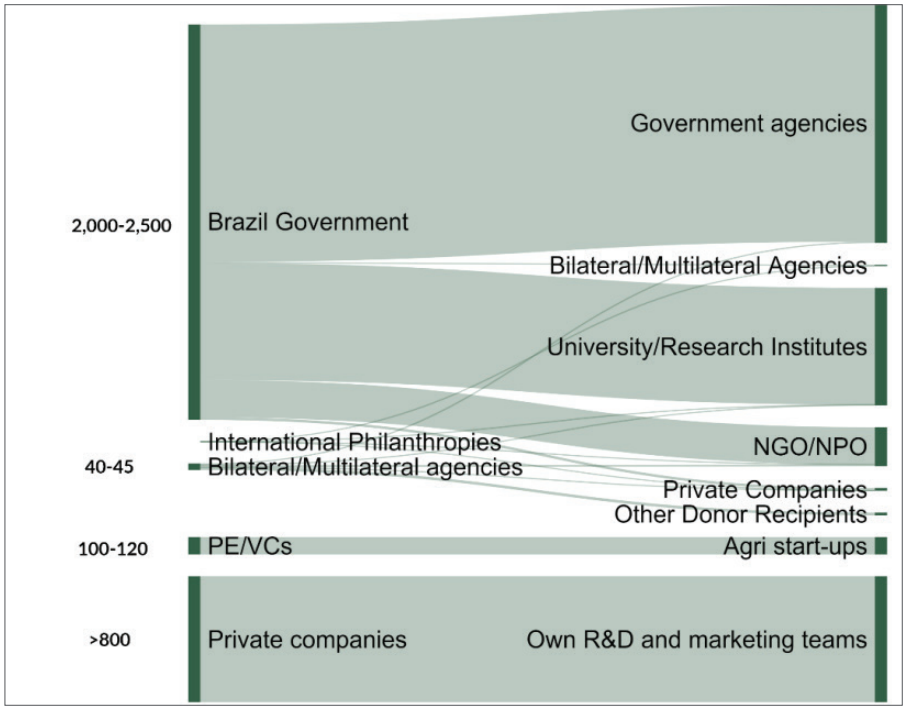
Source: Asia, 2021

Allocation of Innovation Funding

Funding for agricultural innovation in Brazil is distributed across various stakeholders as follows:

- Over 50% is directed to government agencies.
- 20–25% supports research institutes.
- 20–25% is allocated to private companies.
- Less than 10% is allocated to NGOs and NPOs (see Figure 28).

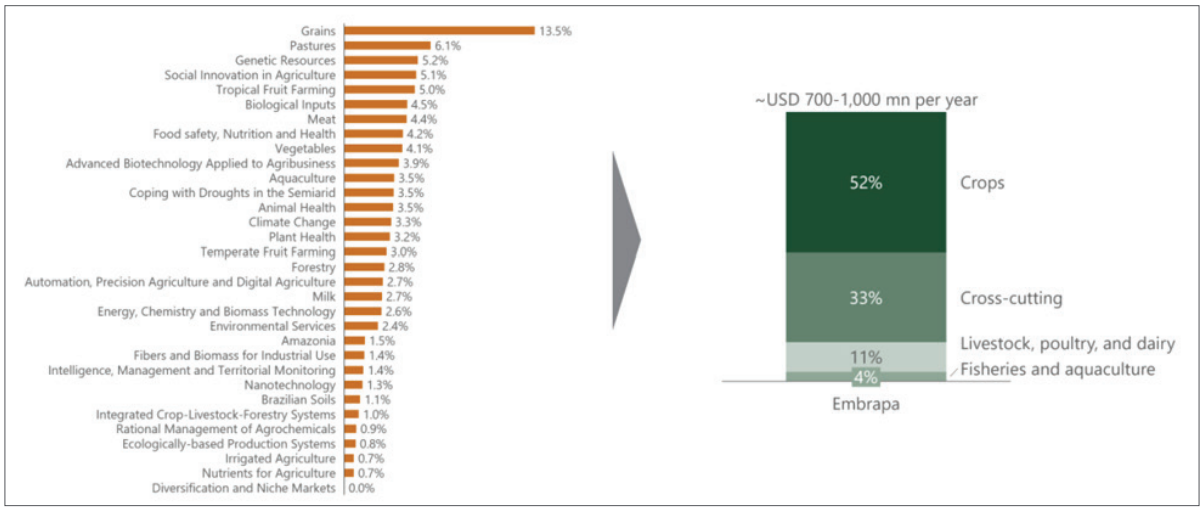
Figure 28: Funding Towards Innovation



Source: Asia, 2021

Across the innovation lifecycle, approximately 75% of public innovation funding in Brazil focuses on research and the development of new technologies, with a strong emphasis on crop-related advancements. An analysis of EMBRAPA's budget indicates that more than 50% of its funding is dedicated to crop research, while a significant portion supports cross-cutting themes such as sustainable practices and resource efficiency (see Figure 29).

Figure 29: EMBRAPA Budget Breakdown for 2020



Source: Asia, 2021

Key Agriculture Programs and Policies in Brazil

Brazil has implemented a range of agriculture programs and policies to support the sector, including:

1. Agricultural Financing, Marketing, and Income Warranty Policies
2. Rural Insurance
3. Climate Risk Agricultural Zoning
4. Agricultural and Livestock Activity Guarantee Program
5. Agroenergy Initiatives

In recent years, there has been a significant focus on sustainability-driven programs in both the public and private sectors. For example, the Sustainable Agriculture Intensification Innovation Program receives funding in the range of USD 200–300 million annually.

Since 2010, Brazil has also developed one of the most comprehensive Low Carbon Agriculture Programs. This initiative focuses on enhancing climate resilience while promoting agricultural practices that prevent deforestation.

In 2023, the Ministry of Agriculture, Livestock, and Food Supply (MAPA), in collaboration with the National Development Bank (BNDES), launched a new initiative for the 2023/24 period. This includes the Program to Incentivize Technological Innovation in Agricultural Production (INVOGRO), which aims to:

1. Support investments in technological innovation on rural properties.
2. Enhance productivity.
3. Promote the adoption of sustainable agricultural practices.
4. Commitment to Sustainability

These programs and policies demonstrate Brazil's commitment to addressing climate change and reducing greenhouse gas (GHG) emissions. Through substantial investments in research and development, Brazil prioritizes innovation, sustainable resource management, and the adoption of best agricultural practices to conserve natural resources and build a resilient agricultural sector (USDA, 2024).

3.4.4 India

Agriculture R&D Landscape in India

India boasts one of the largest and most institutionally complex agricultural research systems in the world. The foundation of its research framework was laid in 1929 with the establishment of the Imperial Council of Agricultural Research (ICAR), which has since been renamed the Indian Council of Agricultural Research. ICAR is the central body responsible for planning, conducting, and promoting agricultural research, education, training, and the transfer of technology across agriculture and allied sciences.

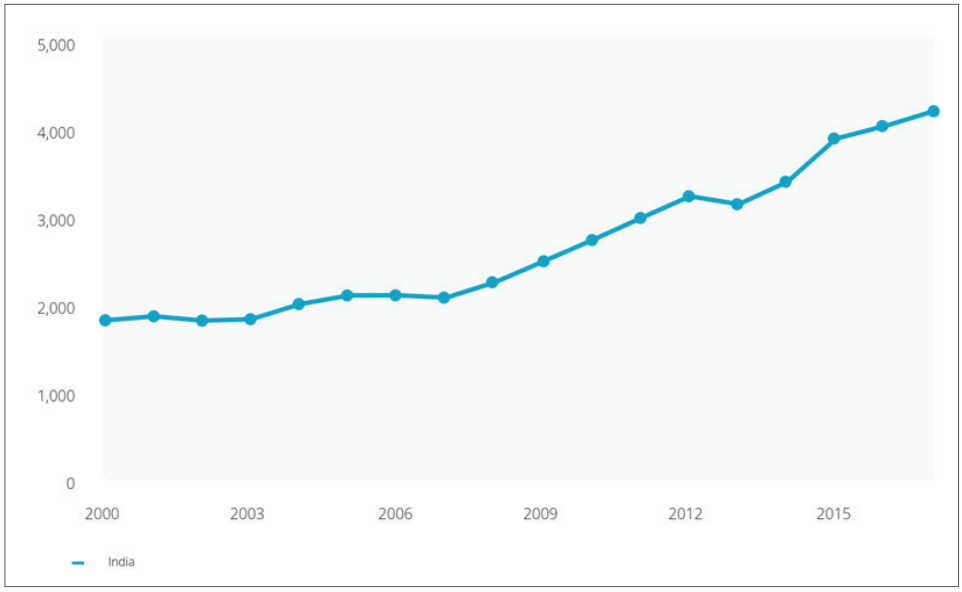
Despite having a well-established institutional structure, government support for agricultural R&D in India remains limited. Currently, approximately 1% of agricultural GDP is allocated to research and development, a proportion that falls short of international standards. Allocation for specific commodities is typically guided by their relative value in the total agricultural production.

Trends in Agricultural R&D Spending in India

India's agricultural R&D spending nearly doubled between 2000 and 2014, reflecting a growing emphasis on research and innovation. However, agricultural R&D expenditures as a share of Agricultural GDP (AgGDP) fell slightly during this period, from 0.34% to 0.30%.

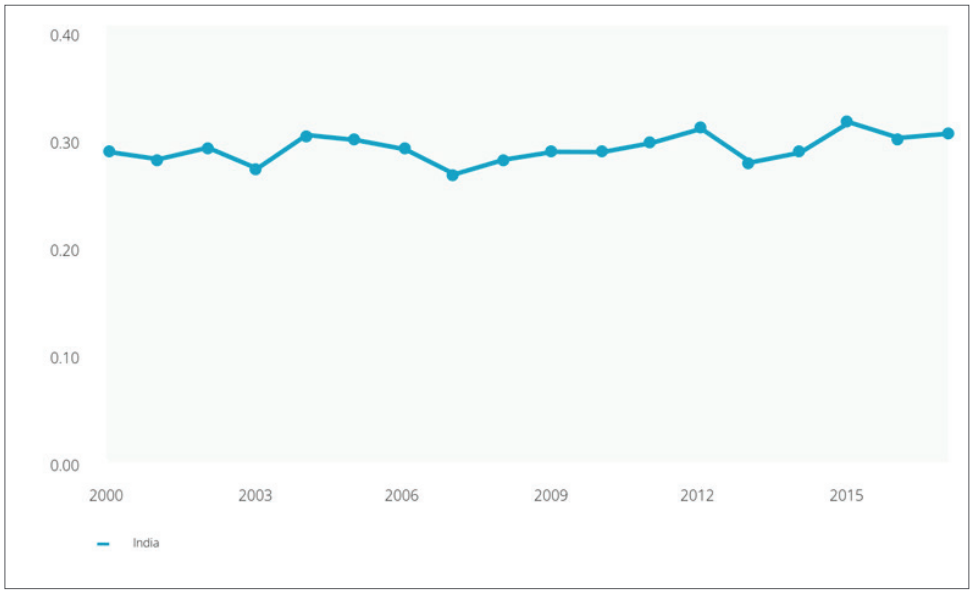
The Agricultural Science and Technology Indicators (ASTI) India Report highlights that total agricultural R&D spending has increased steadily between 2000 and 2015. (See Figure 30 for total spending and Figure 31 for trends in agricultural R&D as a percentage of AgGDP.)

Figure 30: Total Agriculture R&D Spending in US Million Dollars (adjusted for 2011 USD)



Source: ASTI India, 2024

Figure 31: Total Agriculture R&D Spending as a Share of AgGDP (%)



Source: ASTI India, 2024

According to the Press Information Bureau (2021), the government's budget allocation for agricultural R&D continues to emphasize crop productivity, resource efficiency, and technology transfer.

Private Sector Investment in Agricultural R&D

Private sector investments in agricultural R&D in India remain limited compared to public investments (Ridhi and Nirmala, 2021). These efforts are predominantly small-scale and focus on specific domains, such as:

1. Selective crop research
2. Fertilizers
3. Pesticides

Although the private sector plays a supporting role, its contributions are primarily directed at areas with relatively higher returns on investment. Collaborative initiatives between the private sector and public research institutions are essential to bridge the existing gaps in agricultural R&D funding and innovation.

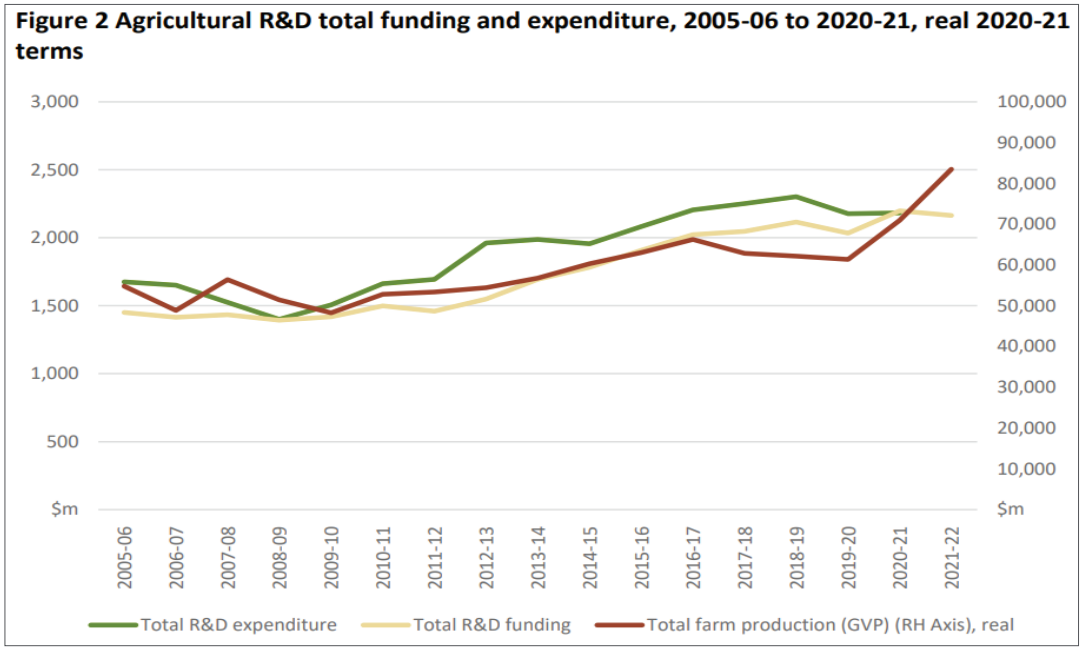
Key Agriculture Policies and Programs

India's agricultural policies are increasingly focused on fostering innovation to enhance productivity, sustainability, and economic growth in the sector. Key initiatives like the *National Agricultural Innovation Project (NAIP),* launched by the Indian Council of Agricultural Research (ICAR), aim to promote research, extension, and farmer-scientist linkages. The National Policy for Farmers (2007) emphasized the development and dissemination of agricultural technologies, including biotechnology, precision farming, and water management systems. More recently, the *Agriculture Infrastructure Fund (AIF) and Digital Agriculture Mission 2021-2025* aim to create a robust infrastructure and facilitate the adoption of emerging digital technologies such as AI, blockchain, and IoT in agriculture. Additionally, the Make in India initiative has spurred investment in agritech startups, enabling innovations in farm mechanization, supply chain optimization, and climate-resilient practices. Despite these efforts, challenges such as limited private sector participation in R&D and fragmented implementation frameworks persist, necessitating coordinated policy reforms to achieve transformative outcomes in Indian agriculture (ICAR, 2015; OECD, 2018).

3.4.5 Australia

The Australian agricultural R&D system comprises funders, intermediaries, and performers. Some research funds are transferred through intermediaries such as Research and Development Corporations (RDCs) and Cooperative Research Centres (CRCs). The RDCs procure and facilitate joint investment in R&D on behalf of primary industries and the Australian Government. Similarly, CRCs promote collaborative research between the public and private sectors (see Figure 32).

Figure 32: Total Agriculture R&D Spending as a Share of AgGDP (%)

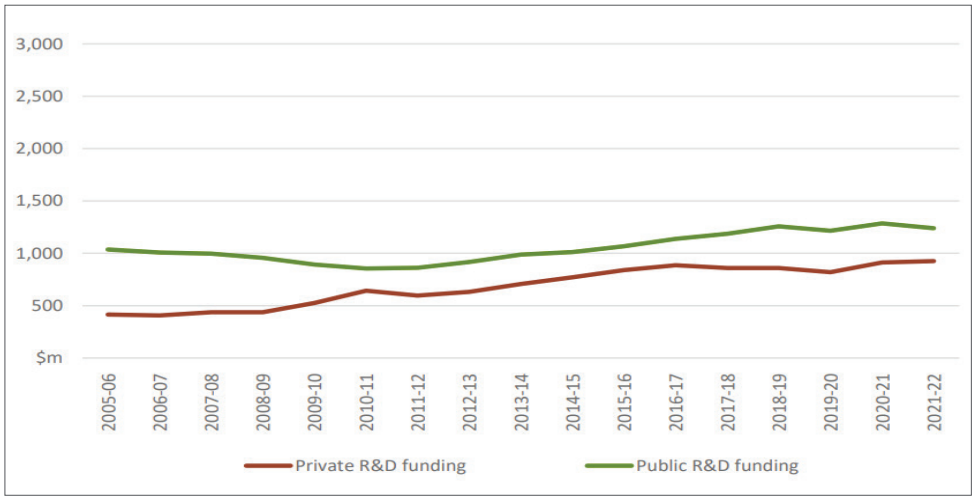


Source: Chancelor, 2023

Overall Trends in Australian Agricultural R&D

A recent report from the Department of Agriculture, Water and the Environment (DAWE) highlights that total agricultural R&D funding and expenditure in Australia have increased over the past ten years, with average annual growth rates of 4.35% and 2.56%, respectively. This trend reflects a rise in both public and private funding for agricultural R&D, which have grown at average annual rates of 2.02% and 5.63%, respectively. However, the report also notes a recent decline in public sector funding due to reduced contributions from universities (Chancelor, 2023) (see Figure 33).

Figure 33: Agricultural R&D Total Funding by Public and Private, 2005-06 to 2020-21 (Real 2020-21 terms)

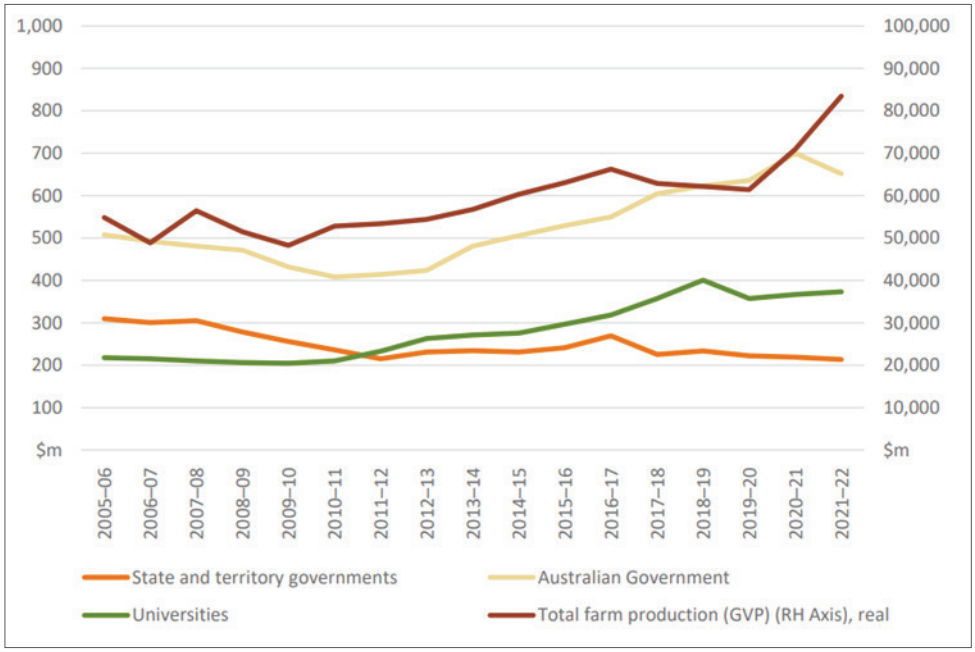


Source: Chancelor, 2023

Public Sector Funding

Public funding for agricultural R&D in Australia is primarily driven by the federal government and universities, while state and territory contributions have declined, largely due to budget constraints and a shift toward environmental research. Growth in federal funding has been fueled by increases in CSIRO core funding and the R&D tax incentive, which has risen significantly since 2005-06, becoming the second-largest funding source by 2021-22. After a decline from 2005-06 to 2014-15, funding for Cooperative Research Centres (CRCs) has rebounded, with a notable spike in 2020-21 attributed to substantial payments made to large CRCs (See Figure 34).

Figure 34: Agricultural R&D Total Funding, Public Sector, detailed 2005-06 to 2020-21 (Real 2020-21 terms)

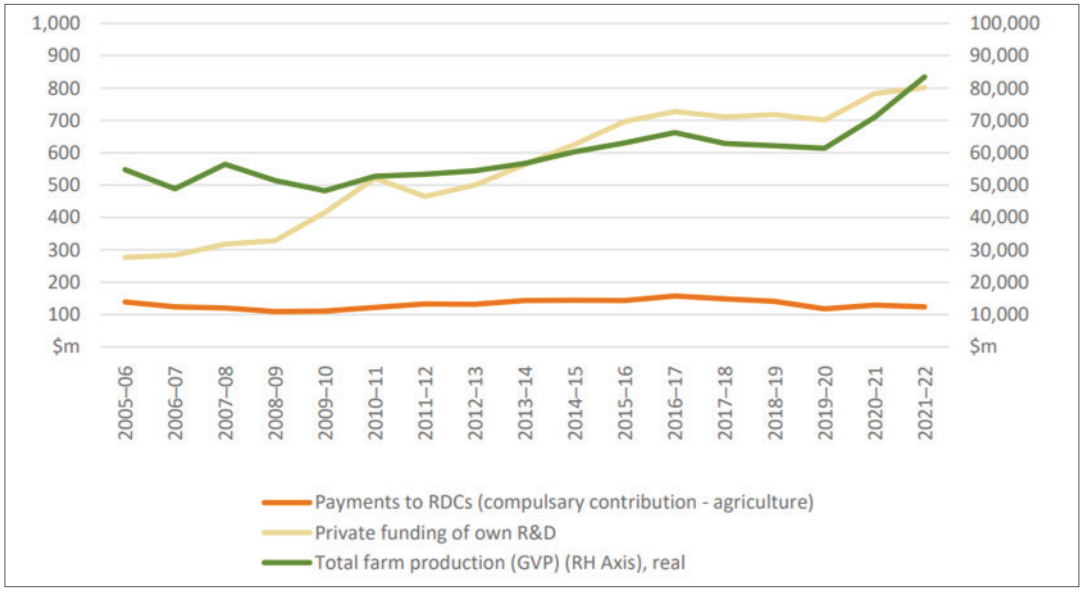


Source: Chancelor, 2023

Private Sector Funding

The private sector funds agricultural R&D primarily through two channels: direct investment in their own R&D and contributions to Research and Development Corporations (RDCs) via levies and voluntary payments. Between 2005-06 and 2021-22, private R&D investment grew at an average annual rate of 6.98%, driven by the unique needs of Australian agriculture, such as tailored agronomic solutions and high rates of innovation adoption. Farmers, processors, and input manufacturers are key contributors to this growth. However, while the gross value of farm production has increased significantly in recent years, payments to RDCs have shown minimal growth, particularly in the "agriculture" component, which averaged an annual growth rate of just 0.67%. This discrepancy is partly due to funds being allocated across diverse priorities such as climate research and value chain development, which are not fully captured in the observed data (see Figure 35).

Figure 35: Agricultural R&D Total Funding Private Sector, 2005-06 to 2020-21 (Real 2020-21 terms)



Source: Chancelor, 2023

Key Policies and Programs Supporting Agricultural R&D

The Department of Agriculture, Water, and the Environment (DAWE) recently published the National Agricultural Policy, outlining four ambitious priorities to address key challenges in the agricultural sector. These priorities include:

1. Establishing Australia as a trusted exporter of premium food and agricultural products.
2. Championing climate resilience to enhance productivity, profitability, and sustainability in agriculture.
3. Becoming a global leader in preventing and responding rapidly to significant pests and diseases by strengthening the biosecurity system.
4. Advancing as a mature adopter, developer, and exporter of digital agriculture technologies.

Australia has already achieved notable progress through its reforms, such as:

- Developing R&D outcome platforms to attract investments and foster partnerships with domestic and international private sectors.
- Promoting the adoption of R&D-driven knowledge and technologies by farmers and other stakeholders through the establishment of Innovation Hubs across the country.

It is important to note that Australia boasts a well-developed Agricultural Innovation System, comprising numerous organizations with diverse roles and responsibilities (DAWE, 2021)

3.4.6 EU Countries

The European Union (EU) adopts a forward-looking approach to agricultural research and innovation, emphasizing sustainable land use and fostering rural development. In 2018, the European Commission proposed a €10 billion program for 2021–2027 to fund projects in food, agriculture, rural development, and the bioeconomy. More recently, an additional €600 million was allocated for initiatives in agroecology and animal health and welfare (EU Commission, 2024).

EU Strategy for Agricultural Research and Innovation

The EU's agricultural strategy focuses on five key areas:

Resource Management: Sustainable use of natural resources.

Healthier Plants and Animals: Improving agricultural resilience and productivity.

Integrated Ecological Approaches: Promoting environmentally harmonious farming practices.

New Opportunities for Rural Growth: Strengthening rural economies.

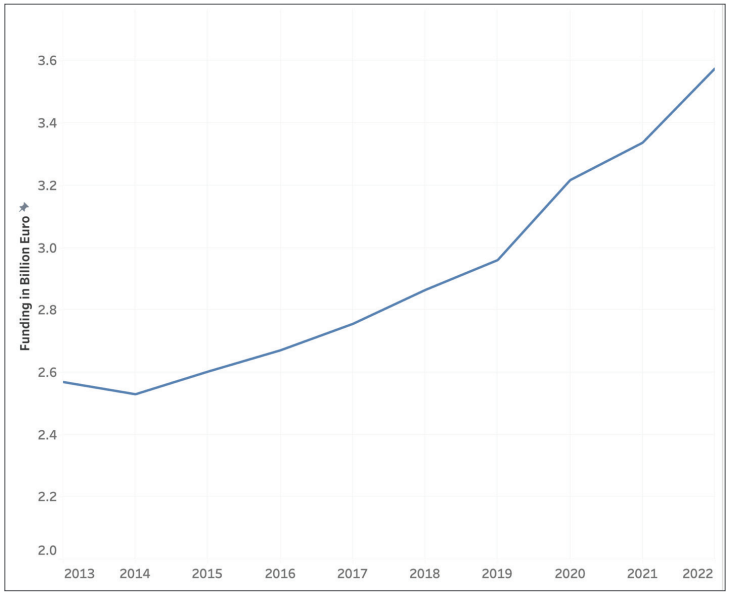
Enhancing Human and Social Capital: Building stronger rural communities through education and collaboration.

Trends in Agricultural R&D Spending

Public sector spending

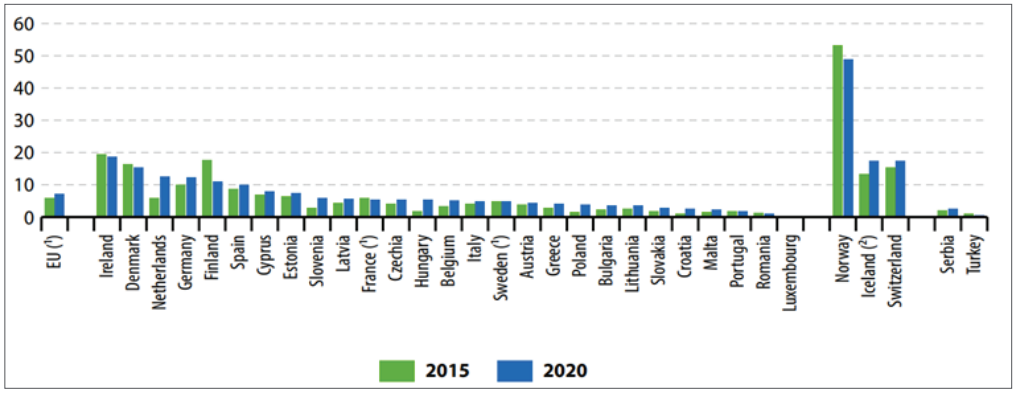
Another report by Naujokaitytė (2022) states that EU countries have steadily increased investments in agricultural R&D since 2013. Between 2013 and 2022, funding grew from €2.6 billion to €3.2 billion (see Figure 36) led by nations such as the Netherlands, Slovenia, Hungary, Poland, and Croatia. In 2020, Ireland, Denmark, and the Netherlands emerged as leaders in agricultural R&D, while Norway topped overall investments within the European Economic Area (see Figure 37).

Figure 36: Governments Spending on Agricultural R&D



Source: Eurostat, 2022

Figure 37: European Countries Spending on Agricultural R&D



Source: Naujokaitytė, 2022

Private sector spending

A study by Delvuax et al. (2018) part of the Impact of research on EU Agriculture (IMPRESA) project, explores the impact of corporate R&D on firm performance in the food-processing industry, emphasizing its role in boosting productivity and addressing global food security. While R&D significantly influences productivity, its magnitude varies, with limited studies focusing on low- to medium-tech sectors like food processing. The agro-food sector, dominated by SMEs, invests less in R&D than high-tech industries, often relying on external innovations. Methodological challenges, such as data availability, time lags, and attributing firm performance to R&D, complicate analysis. Using data from 307 global firms (1991–2009), the study confirms R&D reduces inefficiency and highlights regional differences, with EU firms generally less profitable but efficient. Findings emphasize R&D's potential to enhance firm performance, particularly in underperforming regions, though nuanced policy support is needed to address sectoral and regional disparities**.**

Key Programs Supporting Research and Innovation

Horizon Europe: Aims to amplify the impact of EU research and tackle global challenges through innovation.

EIP-AGRI (European Innovation Partnership): Promotes sustainable farming and forestry aligned with resource conservation.

AKIS (Agricultural Knowledge and Innovation Systems): Enhances knowledge transfer and support for rural stakeholders.

Agriculture, Forestry, and Rural Areas: Facilitates the transition to sustainable farming systems and bolsters rural resilience.

This comprehensive strategy positions the EU to address evolving challenges while fostering innovation and sustainability in agriculture.

PART 4: POLICY RECOMMENDATIONS

Agricultural R&D is a cornerstone for fostering sustainable growth and resilience in the agri-food sector. Countries like China, the EU, and Australia have demonstrated how strategic investments in agricultural innovation can tackle modern challenges such as climate adaptation, productivity enhancement, and food security. While Canada's agricultural R&D investments remain stable, they lag behind global leaders in scaling efforts to meet rising demands. To strengthen its sector, Canada can learn from these nations by emphasizing research intensity, innovation transfer, and integrated strategies for sustainability and resilience.

Increasing investment in agricultural R&D is critical for addressing emerging challenges and boosting competitiveness. Countries like China, the EU, and Brazil prioritize innovation in precision agriculture, biotechnology, and climate-smart farming, offering valuable lessons for Canada. Adopting a research intensity approach, similar to Australia, ensures funding reflects the sector's economic significance. Additionally, fostering public-private partnerships, as practiced in the EU and Brazil, can drive innovation transfer and commercialization. Integrated strategies like the EU's focus on sustainability, rural development, and ecological resilience could also serve as a roadmap for Canada to address environmental and economic challenges holistically.

Canada can achieve these goals through a multi-pronged strategy to increase funding and foster innovation. Establishing dedicated funding mechanisms, such as targeted grants or tax incentives, will encourage public and private sector investments in agricultural research. Collaboration with industry stakeholders, including agri-businesses and farmers, can ensure research outcomes align with practical needs. Inspired by the EU's Horizon Europe, Canada could launch large-scale funding

initiatives targeting climate resilience, sustainable farming, and food security. Strengthening institutional capacity by supporting universities and research centers is essential for advancing cutting-edge agricultural technologies and practices. Moreover, adopting a clear policy framework that prioritizes R&D investment as a proportion of agricultural GDP will ensure steady growth and sustained competitiveness in the sector.

Finally, investing in research focused on technology adoption is pivotal for advancing Canada's agricultural sector. Studies on technology adoption can identify barriers such as high costs, skill gaps, and lack of infrastructure, informing policies to mitigate these challenges. Countries like the United States and the EU demonstrate that rapid technology adoption enhances productivity, reduces input costs, and supports sustainability. For Canada, prioritizing technology adoption can enable farmers to optimize yields while addressing issues like climate change and labor shortages. Targeted investments in extension services, training programs, and innovation hubs can further assist farmers in integrating advanced tools into their practices. By bridging the gap between research and practical application, Canada can accelerate innovation diffusion and establish itself as a global leader in sustainable and competitive agriculture.

Next, fostering public-private partnerships (PPPs) is critical to leveraging the complementary strengths of public institutions and private-sector ingenuity. Similarly, diversifying and sustaining research funding is equally essential to address potential funding gaps and ensure continuity. Establishing a robust agricultural innovation ecosystem—supported by investments in digital technologies, data infrastructure, and capacity-building initiatives—will accelerate technology adoption and amplify economic impact. Together, these strategies will enhance Canada's competitiveness and position the country as a global leader in sustainable agri-food systems.

Meeting the evolving needs of the agricultural sector also requires a focus on workforce development and practical applications of research. Revamping agricultural programs to include hands-on training will equip individuals with the skills needed to adopt advanced technologies and sustainable practices. Collaborative initiatives between academic institutions and industry can align training with market demands. Moreover, revitalizing extension research is vital to bridge the gap between innovation and real-world application. Establishing dedicated extension units focused on knowledge dissemination, farmer engagement, and localized problem-solving will ensure that research outcomes translate into measurable productivity gains. These efforts will create a skilled workforce and enhance the uptake of cutting-edge agricultural practices, securing Canada's leadership in the agri-food sector.

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APPENDIX 1: MATERIAL & METHODS

This section outlines the methodology employed in developing our database, detailing the steps involved, including the inclusion criteria, sources, coding protocol, and category definitions. The inclusion criteria and the categorization of research were informed by several key documents, such as the Sustainable Agriculture Strategy 2021, the Guelph Statement 2023, and the OMAFRA research priorities. Additionally, the Sustainable Development Report 2017 was utilized to assess the alignment of Canadian agri-food research priorities with the Sustainable Development Goals.

I. INCLUSION CRITERIA

At first step we defined the scope of the inclusion of agri-food research studies/projects, that will be included in the inventory. For the purpose of analyzing research activities in the agri-food sector, we determined inclusion criteria for two main dimensions:

1. Identification of the sector in the agri-food industry
2. Identification of the Research area/priorities.

1.1 Identification of the Sector in the Agri-food Industry

For the inclusion of research activities in this report we only focused on the research that focuses on the production of agricultural commodities, food industry and rural communities that are engaged with agricultural practices.

Agricultural Production includes the process processes involved in cultivating plants and raising animals for various purposes, including food, fiber, and other products essential for human survival and well-being" (FAO, 2021). The production of animal encompasses the system that raise livestock, such as beef cattle, poultry, sheep, and hogs; farms that produce animal products like such as dairies; eggs farms, and honey; and animal specialty farms such as horse and fish. Crop production covers the growing of grains, such as wheat, corn and barely; field crops, such as cotton and tobacco; vegetables and melons; fruits and nuts; and horticultural specialties, such as flowers and ornamental plants. (U.S. Department of labor, Bureau of Labor Statistics, 2008)

The food industry is responsible for the production, processing, distribution of food products that meet consumer needs and safety standards. In this report we have included the research projects that focuses innovation in food production, preservation techniques to extend shelf life, enhance flavor, and food safety.

Rural Communities are communities where individuals are primarily engaged with agricultural production.

After Inclusion of the above areas, we further defined the type of research and development activities (R&D) for the inclusion criteria. Research and Development is defined as "The creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2015 p.30).

The funding institution provides financial support to researchers, enabling them to conduct work ranging from basic research to product enhancement.

a) **Basic Research:** Identifying research potentials in specific areas, collecting data, and defining research scopes.

b) **Applied Research:** Further improving results using advanced techniques, allocating resources, and exploring in-depth priorities.

c) **Development:** Creating prototypes and lab-grown results based on mathematical and theoretical processes.

d) **In-Field Testing:** Bringing results from the previous phase to real-world environments for testing.

e) **Enhancement:** Conducting further research and development to create value-added consumer products and services.

Based on these phases, the inclusion criteria set the scope for each research project. For instance, topics focusing on distribution, marketing, value-chain improvements and consumer focused research were excluded. This exclusion criteria were also maintained for the projects that were not related to the agri-food sector.

1.2 Identification of Research Categories/Priorities

To ensure the sustainability of the agri-food sector both public and private sector are contributing significantly through focusing on various programs.

Moving forward, in 2021 government of Canada introduced Sustainable Agriculture Strategy (SAS) that encompasses collective action towards key areas such as Climate change mitigation, adaptation and resilience, biodiversity, and conservation of environmental resources like water and soil health.

The federal and public institutions are directly involved in financing research by providing targeted funding to post-secondary institutions, researchers and students that help in building research capacity.

The private sector such as commodity specific groups, industry associations representing farmers, ranchers and producers provide funds according to their preset research priorities to support overall sector.

To understand the distribution of funds and assess whether public and private funding aligns with the Sustainable Agriculture Strategy mandate, this report focuses on key research priority areas and categories within the agri-food sector. The key research priorities were drawn from the OMAFRA research priorities, as these encompass all relevant areas of agri-food research, which are explained below:

a. Ensuring protection and risk resilience in the agri-food sector

b. Providing environmental stewardship of the provincial capacity of produce food

c. Fostering the productivity and growth of the agri-food sector.

There are also 11 high-level research priority areas and each of these research priority areas has a set of goals and a few research focus areas (Figure 1).

Research Priority Areas	Sub-Fields
Protection and Risk Resilience	Food Safety
	Animal Health and Welfare
	Plant Health and Protection
Environmental Stewardship	Soil Health
	Water Quality and Quantity
	Sustainable Production Systems
	Productive Land Capacity
Productivity and Growth	Competitive Production Systems
	Innovative Products and Product Improvement
	Trade Market and Targeted Sector
	Strong Rural Communities

The priorities under '**protection and risk resilience**' are:

Food safety – Research that focuses on enhancing public confidence in the sector's ability to deliver food safety, including anticipating, detecting, mitigating, and/or reducing food safety hazards along the supply chain.

Animal health and welfare – Research that focuses on food safety, animal health, emergency management, and meeting animal welfare expectations and demands, including anticipating, detecting, mitigating, and/or reducing animal health hazards and antimicrobial use along the supply chain.

Plant health and protection – Research that focuses on plant health, emergency management, and meeting expectations and demands regarding animal welfare, including strengthening the agri-food sector's sustainability and social license through increased utilization of integrated pest management (IPM) and other pest mitigation strategies.

The priorities under '**environmental stewardship**' are:

Soil health – Research that focuses on improving soil health and conservation to support agricultural productivity.

Water quality and quantity – Research that focuses on water quality, supporting improved public confidence in the sector's ability to deliver on sustainability expectations. This includes research aimed at strengthening the agri-food sector's sustainability and social license through improved water use and water quality.

Sustainable production systems – Research that strengthens the sustainability of the agri-food sector through (1) soil health and conservation, (2) improved water quality (e.g., reduced phosphorus runoff and pesticides), (3) increased water/waste/energy efficiency and reduced greenhouse gas (GHG) emissions, and (4) increased utilization of 4Rs Nutrient Stewardship.

Productive land capacity – Research that focuses on land use policy to secure a land base that allows the agri-food sector to thrive and reach its full potential.

The priorities under **'productivity and growth of the agri-food sector**' are:

Competitive production system – Research that focuses on improving production efficiency, productivity, competitiveness, and public trust through technology adoption, innovation, and technology development, such as labor-saving practices, automation, waste reduction, recycling, increased water/waste/energy efficiency, and reduced GHG emissions.

Innovative products and product improvement – Research that enhances competitiveness, profitability, and growth of the agri-food sector through the development of new or improved products.

Trade, market, and targeted sector growth opportunities – Research that drives growth in the overall agri-food sector by expanding existing markets, accessing new domestic and international markets, improving the economic performance of priority sub-sectors, and increasing the production of niche or value-added products.

Strong rural communities – Research that focuses on enhancing the competitiveness, profitability, resilience, and growth of rural/farming communities.

II. CODING CATEGORIES:

We coded the research projects to create a searchable database of relevant research projects. Details of the relevant categories and definitions applied are described in the following sections. Descriptive information such as jurisdiction, research project title, funding institution, funding amount, and institution name were taken directly from original data provided by funding agencies and from the online public data base.

1.1 Sector

We categorized research projects according to the specific agriculture sector in which the researchers were conducting their work. The projects were classified into three primary sectors: Animal, Plant, and Environment. For research projects targeting multiple sectors, we categorized them based on the primary focus of the research.

1.2 Jurisdiction

We categorized research projects according to the jurisdiction of the academic institute and research centers where research funding for the projects is allocated.

1.3 Timing

Every year both public and private funding institutions are allocating funds for the research projects. To track past and current research projects we coded research projects based on their funding allocation timing. Additionally, we coded research projects according to their start date and end dates, where available. The start date refers to the years during which funding was received by research institutions and end years refers to the year when research project concluded or the last known date that funding has been allocated for a research project, where information is available.

1.4 Funding Institution

We coded research projects according to the funding Institution which provide funds. This information was crucial for us to understand the contribution of public and private sector in agri-food research ecosystem. Once the information was received from the funding institution, we categorized them as public and private institution.

1.5 Funding Amount

To identify the money spent by each funding institution on the research projects we coded research projects according to the funding amount allocated for each research project. Some funding institutions allocated total amount of the money at once for the whole duration of the research project while others allocated money every year for the duration of the research project.

To analyze the overall ecosystem of the agri-food research landscape and trends in research funding in both the public and private sectors, we designed a multi-stage methodology. Figure 5 provides an overview of the stages involved in the development of the research database.

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