University of Saskatchewan Crop Development Centre

Economic Footprint Assessment

Final Report

EY

Building a better working world

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Disclaimer

Ernst & Young LLP ("EY") was engaged by the University of Saskatchewan ("University") to conduct an economic footprint assessment of the Crop Development Centre ("CDC") in Western Canada. In preparing this document ("Report"), EY relied upon unaudited data and information from the CDC, Statistics Canada, consultations with stakeholders as well as other third-party sources (collectively, the Supporting Information). EY reserves the right to revise any analyses, observations or comments referred to in this Report, if additional Supporting Information becomes available subsequent to the release of this Report. EY has assumed the Supporting Information to be accurate, complete and appropriate for the purposes of the Report. EY did not audit or independently verify the accuracy or completeness of the Supporting Information. Accordingly, EY expresses no opinion or other forms of assurance in respect of the Supporting Information and does not accept any responsibility for errors or omissions, or any loss or damage as a result of any persons relying on this Report for any purpose other than that for which it has been prepared.

Executive Summary

1. Executive Summary

Economic Footprint of CDC's Plant Breeding Activities

Economic Contributions

$17.78 B
gross farm output from 1991-2022

85%
of harvestable pulse[i] acres seeded with CDC varieties

Benefits contributed to Western Canada's[ii] economy as of 2022

$1.2 B in GDP

6,938 FTE jobs

$254 M in Wages and Salaries

Benefits to Farmers

CDC expenditures on plant breeding generates economic returns for key stakeholders. Below is an overview of key benefits from 1971 to 2022.

Internal Rate of Return	Benefit-Cost Ratio	Net Benefits
14.9%	10.8	$10.2 B

Growth in Benefits

Since CDC's last study in 2016, total benefits of plant breeding have grown considerably, demonstrating the pivotal role played by CDC's plant breeding in Western Canada's agri-food industry. Such benefits are expected to continue growing over time through ongoing innovation in key Canadian crops.

Spotlight: Lentils

20%	Internal Rate of Return
37	Benefit-Cost Ratio
$4.2 B	Net Benefits

Socioeconomic Benefits

500+
CDC varieties have been released in over 40 crop types since 1971

428+
students, alumni, or faculty have trained at CDC since 1971

531
peer-reviewed publications since 2016

Select Initiatives

CDC actively promotes research findings through outreach and extension, aligning its research priorities with growers to enhance sustainability in agriculture.

Through the College of Agriculture and Bioresources, and partnerships with government, growers and industry groups, the CDC undertakes agricultural research, education, and outreach for students and the broader agriculture ecosystem.

Sources: Statistics Canada, CDC, and EY Analysis.

[i] For the purposes of this analysis, pulse crops include dry beans, lentils, chickpeas and field peas. [ii] Western Canada is defined as the provinces of Saskatchewan, Manitoba and Alberta.

Notes: Net Benefits showcase the present value of benefits minus the present value of CDC expenditures. The Internal Rate of Return represents the annual discount rate at which an investment breaks even, reflecting its profitability. The Benefit-Cost Ratio showcases total benefits as a ratio of total costs (in present value terms). Please note that this Benefit-Cost ratio is a summary-level estimate of benefits to farmers as a result of CDC's activities and may not reflect the full spectrum of costs and benefits that may be considered in a comprehensive Cost-Benefit Assessment.

Introduction

2. Introduction

Project Objectives

The University of Saskatchewan engaged Ernst & Young LLP (EY) to conduct an economic footprint assessment of the Crop Development Centre (CDC), including the following three areas of assessment:

Economic Contribution Assessment

Assessment of key economic contributions including Gross Domestic Product (GDP), Wages and Salaries, Full Time Equivalent (FTE) jobs and Government Revenues.

Return on Investment (ROI) Analysis

Evaluation of the benefits of CDC's plant breeding activities for farmers in Western Canada.

Socioeconomic Benefits Assessment

Assessment of broader socioeconomic impacts through channels such as research and innovation, human capital development, support to the industry, and broader collaboration efforts.

Background and History

The CDC boasts a rich 52-year history as a renowned crop research centre dedicated to advancing crop breeding and seed development in Canada. Since its founding in 1971, the CDC has supported the diversification of crop production in Canada by releasing over 500 commercial varieties across over 40 crop types.[1]

- **CDC focuses on a diverse range of crops,** including (but not limited to) spring wheat, chickpea, dry beans, durum, canary seed, barley, oat, flax, forages, field peas and lentils. These crops are of strategic importance in Canada's agricultural economy and the global food supply chain.
- **CDC plays a pivotal role in enhancing crop genetics** such as deciphering the DNA of the wheat plant and improvement in crop traits such as yield and disease resistance.

Through its activities, the CDC supports a resilient agricultural sector, benefiting both Canadian farmers and the agri-food sector.

Key Crops in Focus

The economic footprint of the CDC was assessed in the three provinces which lead Canada's agriculture activity; Saskatchewan, Alberta and Manitoba. These three provinces account for 82.3% of total farm area in Canada.[2]

EY selected 10 key crops based on CDC's variety acreage share and crops which have substantial production volumes in Western Canada. **Table 1** below lists the 10 key crops in the scope of the analysis and their production volumes in each province in 2022.

Table 1: Crop Production Volumes, 2022 (millions of bushels)[3]

Crop	Saskatchewan	Alberta	Manitoba
Barley	131	198	24
Lentils	72	12	-
Field Peas	58	57	9
Spring Wheat	392	366	172
Oats	94	39	43
Chickpeas	4	0.5	-
Flax	13	3	2
Durum	166	44	2
Canary Seed	5	-	-
Winter Wheat	3	7	1
Total	938	727	253

[1] Success Grows Our Future 2021, CDC; [2] Statistics Canada; [3] CDC and EY Analysis.

2. Introduction

Industry Overview

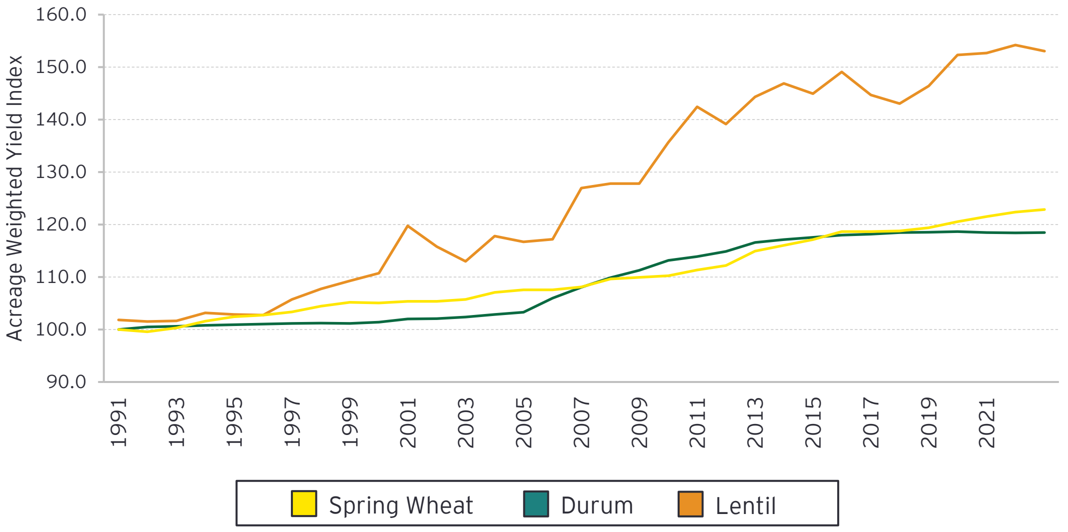
Yield Improvement Attributable to Plant Breeding

Since 1991, crop yields have steadily increased across the three provinces. This is due to a number of factors such as improvements in agronomy, soil management and plant breeding. The Acreage Weighted Yield Index uses annual performance trial yield data and variety acreage share data to produce an index which measures yield improvement attributable to plant breeding.

The improvement in yield plays a critical role in the economic impact of the CDC. Higher yielding crops generate larger production volumes for farmers which stimulates further economic activity and improves farmer's profitability.

Figure 1 below provides a graphical representation of selected historical Acreage Weighted Yield Index series which demonstrate the long-term trend of crop yields in Western Canada.

Figure 1: Selected Western Canada Acreage Weighted Yield Index Series

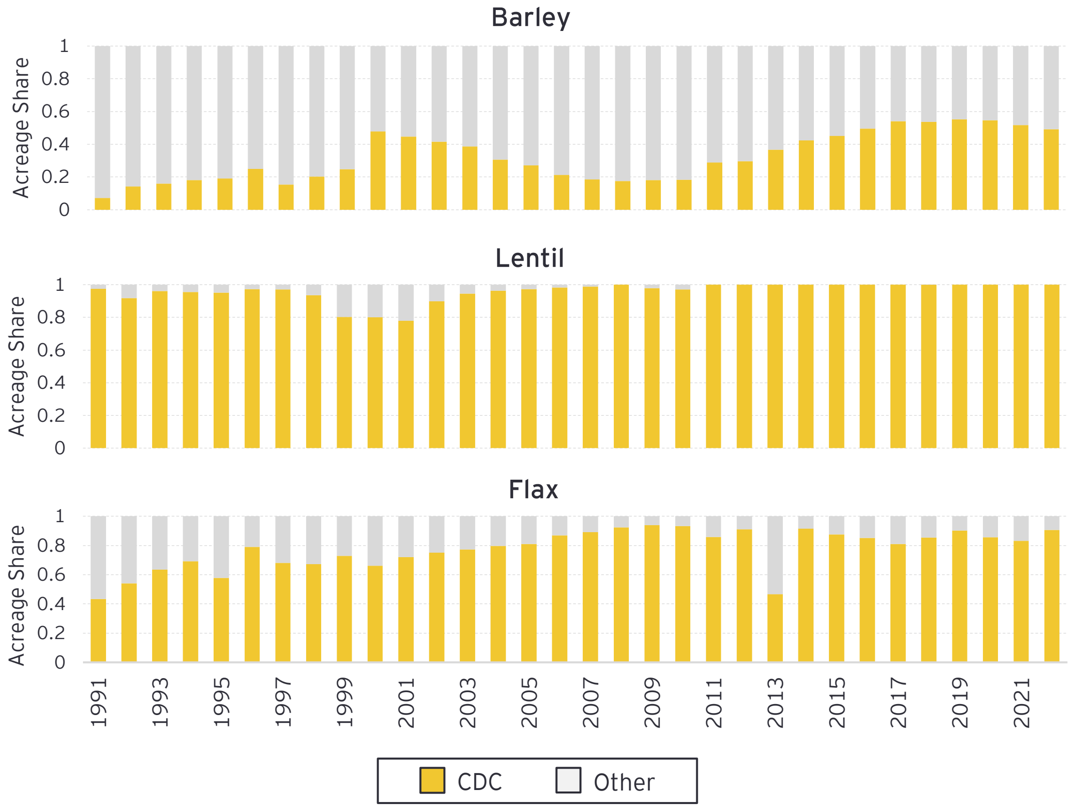


Note: The Acreage Weighted Yield Index is indexed to a baseline of 100. The baseline occurs at different time periods for each crop.

Share of Acreage

The CDC acreage share shows the portion of total acreage which is seeded with CDC crop varieties. This reflects the importance of CDC varieties to crop production in a province. **Figure 2** provides a graphical representation of CDC's market share for select crop types.

Figure 2: Selected Western Canada CDC Acreage Share Trends



Note: All acreage weighted yield index series are provided in Appendix A.1. All historical CDC acreage charts are provided in Appendix A.2

Approach and Methodology

3. Approach and Methodology

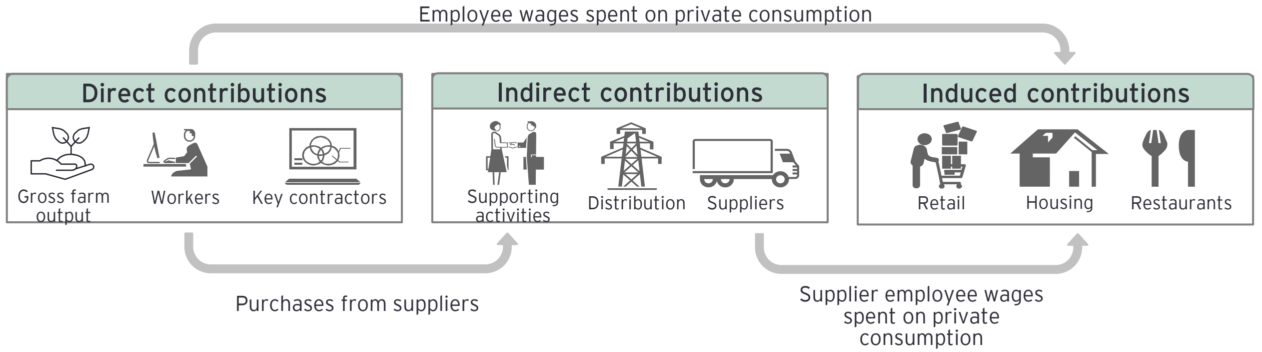
Economic Footprint Assessment

Economic Contributions from Plant Breeding Activities

EY's proprietary economic model was used to assess the economic contributions sustained by additional gross farm output associated with CDC's activities. The gross farm output is the additional output produced as a result of improved crop yields attributable to CDC's plant breeding activities. This is calculated using agricultural output data and inputs provided by the CDC (please see a description of the methodology used in Appendix A.1.

The model is constructed based on the principles of the input-output (I-O) framework, which captures economic contributions through three distinct channels: direct, indirect, and induced contributions. These contributions individually, and collectively represent how business activity ripples through the economy, as shown in Figure 3. The key economic indicators considered for this assessment are Gross Domestic Product (GDP), Wages and Salaries and Full-Time Equivalent Jobs (FTEs). Please see detailed descriptions of the key economic indicators in Appendix A.3. For assumptions and restrictions of the I-O model, please see Appendix A.4.

Figure 3: Economic Contribution Illustration



Broader Socioeconomic Benefits

EY also consulted with select stakeholders from different organisations within the Canadian agricultural ecosystem. A series of stakeholder consultations were undertaken, and EY leveraged the findings to understand the broader socioeconomic benefits of the CDC for the agricultural sector.

Benefits to Farmers

A tailored ROI framework was used to assess the benefits generated by the CDC for farmers and the total cost involved in CDC plant breeding research to generate these benefits. The net benefits and costs are defined in **Table 2** below.

Table 2: Farmer Benefits and Costs

Metric	Description
Farmer Benefits	The impact of CDC-attributable gross farm output on the profitability of Canadian farmers – calculated using Statistics Canada data on average crop production profit margins
Costs	Annual expenditure on plant breeding research activities at the CDC from 1971 to 2022
Benefit-Cost Ratio	The ratio of benefits to discounted costs (in present value)

EY estimated the ROI for farmers by calculating ROI metrics such as the internal rate of return, the present value of net benefits, and the benefit-cost ratio. A discount factor was selected to adjust benefits and costs from different time periods to a consistent measurement. The key metrics were calculated as follows:

- Net benefits – this is the difference between the discounted benefits and discounted costs. The net benefits are in present value (PV) terms.
- Internal rate of return – this represents the annual discount rate at which an investment breaks even, reflecting its profitability.
- Benefit-cost ratio – this represents the return to farmers for every dollar invested by the CDC in plant breeding research.

Note: Please note that this Benefit-Cost ratio is a summary-level estimate of benefits to farmers as a result of CDC's activities, and may not reflect the full spectrum of costs and benefits that may be considered in a comprehensive Cost-Benefit Assessment.

Economic Contribution Assessment

4. Economic Contribution Assessment
Overview of Results

Economic Contributions of CDC Plant Breeding

CDC's Impact in the Agricultural Sector

The economic impact of CDC plant breeding and research programs relies on the yield improvement of CDC-released varieties, as well as the adoption of CDC varieties by farmers.

- **Improved Crop Yields:** Since 1991, crop yields have been increasing due to plant breeding organisations such as the CDC. This increase in crop yields generates additional gross farm output for farmers across Canada.
- **Significant Market Share:** CDC acreage shares reflect the importance of CDC varieties to Canadian agriculture, as farmers seek to maximise their profits by selecting the optimal seed variety. In Western Canada in 2022, CDC varieties accounted for **36%** of harvestable acres.

From 1991 to 2022, the gross farm output attributable to plant breeding at the CDC is estimated at **$17.78 billion.** In 2022, the gross farm output attributable to plant breeding at the CDC was **$1.58 billion.** This gross farm output stimulates additional economic activity in Western Canada as outlined in **Table 3**.

$17.78 B
of gross farm output is attributable to plant breeding at the CDC from 1991 to 2022

85%
of pulse harvestable area in Western Canada is seeded with CDC varieties in 2022

Economic Contribution Results

Table 3 provides an overview of the economic benefits sustained by CDC-attributable gross farm output in Western Canada, as well as in the wider Canadian economy in 2022. Estimated contributions in Western Canada are benefits that are expected to remain in the Western Canadian provinces, and do not include leakages to the national economy. Western Canada contributions are therefore lower than national contributions. The results are as follows:

- **Western Canada:** Plant breeding at the CDC is estimated to contribute **$1.2 billion** to the Western Canadian economy (in GDP), **$254 million** in wages and salaries, and **6,938** FTE jobs.
- **National:** Plant breeding at the CDC is estimated to contribute **$1.5 billion** to the Canadian economy (in GDP), **$300 million** in wages and salaries, and **9,141** FTE jobs.

The economic benefits supported by CDC's plant breeding activities have grown considerably over time, illustrating the compounding effect of CDC's economic footprint in the Canadian agri-food industry. Compared to results from the last study in 2016, the economic contributions to GDP grew from **$668** million to **1.2 billion.**

Table 3: Economic Contribution Results[4]
Supported by CDC plant breeding in 2022

Western Canada	GDP ($ mill)	Wages & Salaries ($ mill)	FTEs
Direct	$792	$131	4,018
Indirect + Induced	$421	$123	2,921
Total	**$1,213**	**$254**	**6,938**

National	GDP ($ mill)	Wages & Salaries ($ mill)	FTEs
Direct	$792	$131	4,018
Indirect + Induced	$730	$169	5,124
Total	**$1,522**	**$300**	**9,141**

Note: Figures may not sum due to rounding. All dollar figures provided are in 2022 Canadian dollars.

[4] Statistics Canada, CDC, and EY Analysis.

4. Economic Contribution Assessment
Breakdown by Province

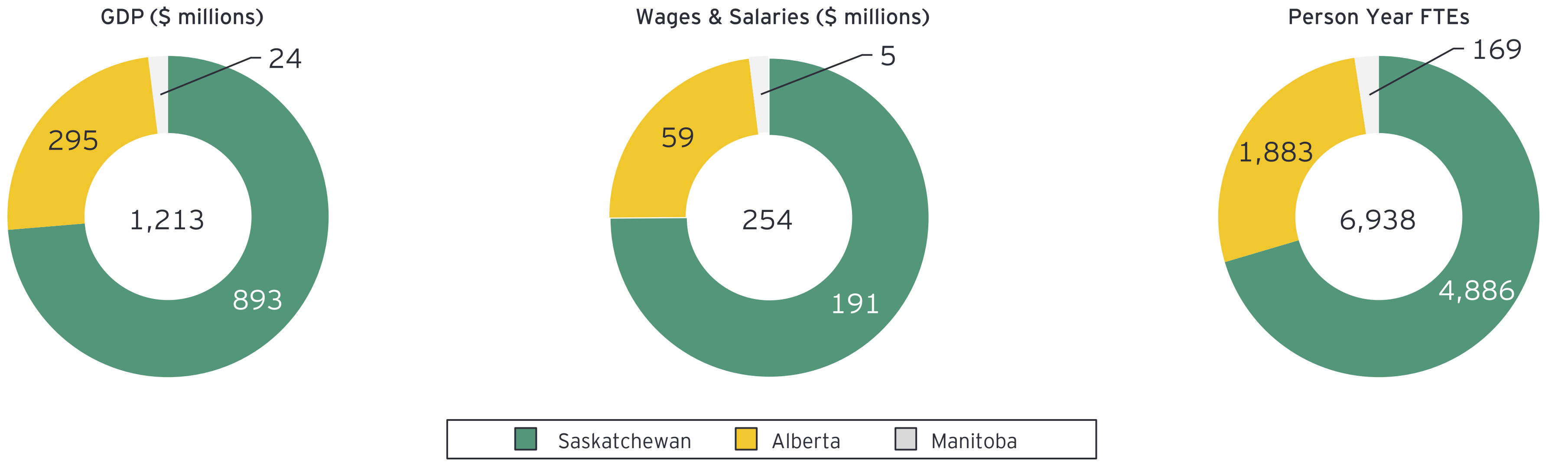
Economic Contributions of CDC Plant Breeding

Plant breeding activities at the CDC stimulate economic activity in the Saskatchewan, Alberta and Manitoba agricultural sectors. The largest economic contribution is in the province of Saskatchewan due to large harvestable acreage of key crops and a significant CDC variety market share in lentils, barley, field peas and chickpeas. The economic contribution results by province are as follows:

- **Saskatchewan:** Plant breeding at the CDC is estimated to contribute **$893 million** to Saskatchewan's economy (in GDP), **$191 million** in wages and salaries, and **4,886** FTE jobs. The key crops which drive the CDC's contribution in Saskatchewan are lentils, barley and spring wheat.
- **Alberta:** Plant breeding at the CDC is estimated to contribute **$295 million** to Alberta's economy (in GDP), **$59 million** in wages and salaries, and **1,883** FTE jobs. The key crops which drive the CDC's contribution in Alberta are lentils and field peas.
- **Manitoba:** Plant breeding at the CDC is estimated to contribute **$24 million** to Manitoba's economy (in GDP), **$5 million** in wages and salaries, and **169** FTE jobs in 2022. The key crops which drive the CDC's contribution in Manitoba are oats and field peas.

Figure 4 shows the Western Canada contributions broken down by by province. A detailed breakdown of the direct, indirect and induced contributions in all three provinces is available in Appendix A.5.

Figure 4: Economic Contributions in 2022 - Provincial



Note: Provincial figures show impacts that are generated in the respective provinces and do not include supply chain leakages to the rest of Canada. A detailed breakdown of provincial and national impacts are available in Appendix A.5. Figures include direct, indirect, and induced impacts. All dollar figures provided are in 2022 Canadian dollars.

Return on Investment Analysis

5. Return on Investment Analysis

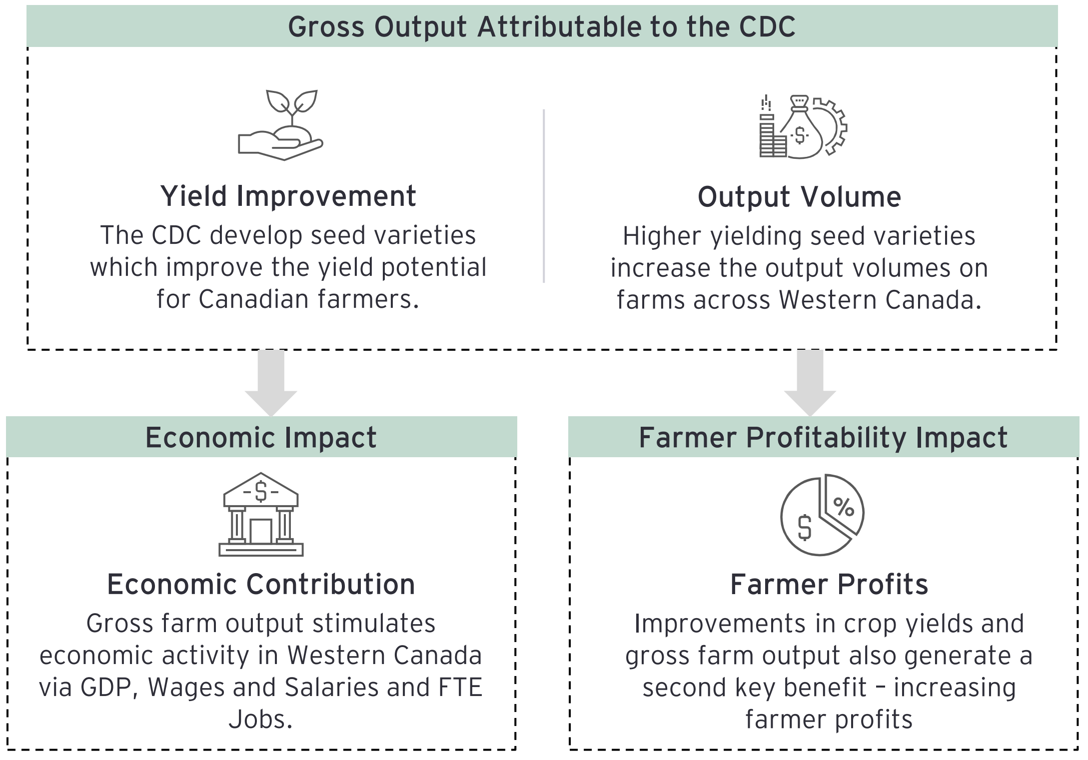
Benefits to Farmers

CDC Impact on Farmer Profitability

A ROI analysis is important to understand the economic returns for a key stakeholder of the CDC, i.e. the farmers. The CDC strives to generate economic returns for Canadian farmers through its activities in plant breeding research.

This investment improves crop yields, which in turn stimulate economic activity while impacting farmer profitability, as illustrated in **Figure 5.**

Figure 5: Benefits to the Agriculture Sector



ROI Framework

The ROI framework involves an evaluation of the returns for Canadian farmers as a result of CDC's plant breeding research. EY evaluated the incremental costs and benefits of seed breeding research at the CDC for the following purpose:

- Determine the net benefit of the CDC to Canadian farmers
- Evaluate the incremental net impacts over the timeframe under analysis

All historical and future incremental costs and benefits are converted to 2022 $CAD. The discounted costs and benefits are used to provide conventional measures of economic performance including the internal rate of return, the Benefit-Cost Ratio, and the PV of net benefits.

The key inputs are outlined below in **Table 4**:

Table 4: ROI Framework

Item	Input	Description
Real Discount Factor	3.5%	Reflects the time value of money and the societal opportunity costs for plant breeding research. Rate is selected for consistency with CDC's 2016 report "Economic Impact of Plant Breeding at the Crop Development Centre"
Appraisal Period	1971 - 2022	Timeframe selected based on availability of benefit and cost data.
Base Year	2022	All nominal values are adjusted to 2022 Canadian dollars as this is the most recent year under analysis.

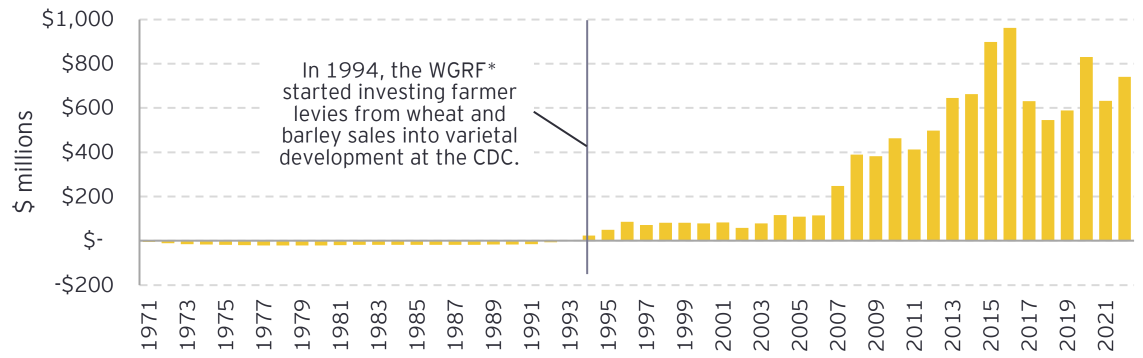
5. Return on Investment Analysis

Benefits to Farmers

Return on Investment – All Crops

The results suggest that following the year 1994, the incremental net impact of CDC expenditures on farmer profits is positive. **Figure 6** provides a graphical illustration of the incremental net benefits of plant breeding research at the CDC on farmer benefits.

Figure 6: Discounted Net Impact (All Crops)[5]



The consolidated ROI results show that from 1971 to 2022, plant breeding research at the CDC delivered estimated **PV of net benefits of $10.2 billion** for Canadian farmers, an **internal rate of return of 14.9%**, and a **Benefit-Cost Ratio of 10.8**. The estimates showcase that across CDC's plant breeding programs, each dollar of plant breeding expenditures were estimated to provide $10.8 dollars of benefit across the three prairie provinces.

As shown in **Table 5** below, the impacts generated by the CDC have grown considerably over time, demonstrating the pivotal role played by CDC's plant breeding in Western Canada's agri-food industry. Such benefits are expected to continue growing over time through ongoing innovation in key Canadian crops.

Table 5: ROI Results[6]

	Internal Rate of Return	Benefit-Cost Ratio	PV of Net Benefits
Current Study (1971-2022)	14.9%	10.8	$10.2 B
Previous Study (1971-2015)	13.9%	7.1	$4 B*

* The PV of net benefits in CDC's 2016 report "Economic Impact of Plant Breeding at the Crop Development Centre" represent the period 1991 to 2015 and are likely higher than the Net Benefits that would be observed from 1971-2015.

Return on Investment – Breakdown by Crop

As CDC variety adoption and breeding impact varies by crop, this leads to varying returns for farmers based on crop type. The largest increase in the PV of net benefits to farmers was realized in lentils ($4.2 billion), followed by field peas ($2.4 billion) and spring wheat ($1.5 billion). The Benefit-Cost Ratio across all crop varieties is estimated at 10.8, with the highest ratio observed for lentils (at 37.4). **Table 6** below provides a summary of the ROI results broken down by crop.

Table 6: ROI Analysis Outputs by Crop Type (1971-2022)

Crop	Internal Rate of Return	Benefit-Cost Ratio	PV of Net Benefits
Barley	14.1%	7.5	$966 M
Lentils	20.1%	37.4	$4.2 B
Field Peas	15.5%	18.0	$2.4 B
Spring Wheat	14.9%	9.0	$1.5 B
Oats	15.3%	5.4	$364 M
Chickpeas	11.1%	4.9	$180 M
Flax	11.3%	4.5	$321 M
Durum	8.5%	2.7	$267 M
Canary Seed*	n/a	n/a	n/a
Winter Wheat	6.9%	1.6	$47 M
All crop varieties	**14.9%**	**10.8**	**$10.2 B**

* Older canary seed varieties had higher yields than current varieties. In this case, the benefit of plant breeding created varieties which were easier to harvest and approved for the human food market as opposed to higher yielding crops. Hence, canary seed is excluded from the ROI analysis.

[5] CDC and EY Analysis, [6] CDC and EY Analysis; Note: *WGRF stands for the Western Grains Research Foundation. Notes: The internal rate of return the annual discount rate at which an investment breaks even, reflecting its profitability. Please note that the Benefit-Cost ratio is a summary-level estimate of benefits to farmers as a result of CDC's activities, and may not reflect the full spectrum of costs and benefits that may be considered in a comprehensive Cost-Benefit Assessment.

Socioeconomic Benefits Assessment

6. Assessment of Socioeconomic Benefits
Overview

Summary of Key Pillars

In addition to the assessment of economic impacts to the agriculture sector, EY conducted a review of the broader socioeconomic benefits attributable to the CDC's activities across four key pillars: Research and Innovation, Human Capital Development, Market Development, and Collaboration and Sustainability Efforts.

The assessment involved data collection, consultations with industry stakeholders such as seed companies and distribution partners, as well as detailed analyses to gain insights into the broader impacts on the agriculture and agri-food industry in Canada. These findings will highlight the CDC's contributions to the growth and development of the industry, while underscoring the CDC's role in shaping industry trends, fostering a competitive landscape, talent development, and knowledge sharing.

Research and Innovation

- **Innovation to Tackle Issues:** CDC's crop development research and innovation activities seek to address current issues facing farmers, such as climate change, production costs, diseases and nutrition.
- **Aligning with Farmers' Needs:** The CDC's strategic objectives focus on achieving increased crop productivity.
- **Strategic Relationships:** The CDC partners with government, growers and industry to achieve tangible benefits.
- **Infrastructure Capabilities:** The CDC provides necessary facilities to conduct comprehensive research and testing.

Human Capital Development

- **Unique Positioning:** Situated within the University of Saskatchewan, the CDC benefits from access to talent and research sources.
- **Cultivating Talent:** Experience with CDC teaching, research and mentorship programs helps cultivate a talent pool with theoretical and practical industry knowledge.
- **Enriching through Research:** Research participation ensures students and faculty are prepared to make meaningful contributions to industry activity.

Market Development

- **Influencing Market Dynamics:** The CDC's market development strategy focuses on initiatives aimed to grow the Canadian market through developing productive crop varieties.
- **Maximizing Profitability and Returns:** The CDC's research output aims to improve the profitability of farmers and seed distributors.
- **Driving Global Trade:** CDC's crop varieties support Canada's position in global trade by enhancing the competitiveness of Canadian agricultural products.

Collaboration and Sustainability Efforts

- **Disseminating Knowledge:** Knowledge sharing spreads information, discoveries, and best practices to industry stakeholders.
- **Resource Hub:** The CDC collaborates with research institutions, government agencies, and industry stakeholders as a hub for sharing information and resources.
- **Advancing Sustainability Initiatives:** Aligning with government initiatives, the CDC shares information on sustainable practices in response to climate change.

6. Assessment of Socioeconomic Benefits
Research and Innovation

Advancements in Agricultural Research

The CDC's objective is to support farmers to diversify and farm more productively through innovative crop varieties.[7] Below is a summary of benefits of CDC research and innovation.

Addressing Key Challenges

The CDC conducts research on key issues faced by farmers including areas such as (but not limited to) crop breeding, quality, and disease management. Below is an overview of key challenges anticipated by farmers in the coming years:[8]

- **52%** foresee threats from climate change impacts, such as extreme weather and natural disasters
- **35%** expect rising production and input costs to be the main challenge in their operations
- **12%** express concerns about disease and pests in their crops

Below is an overview of notable achievements as a result of CDC research:[9]

531 peer-reviewed publications since 2016	**83+** major awards received by CDC faculty since 2002	**$23.2 M** from commercialization agreements since 2016	**500+** new crop varieties released in over 40 crop types since inception in 1971[10]

Proposed cultivars and new research publications offer solutions such as enhancing crop resistance to common diseases like fusarium head blight and root rot, and improve tolerance to environmental stressors, such as drought and extreme weather.

Through collaboration with seed companies and distribution partners, the CDC's advancements in crop breeding boosts yield and profitability by mitigating future challenges. This strategy has garnered notable commercial agreements, demonstrating the CDC's unique leadership role in agriculture activity.[11]

Innovation for Future Growth

A recent CDC-led study on wheat genomes showcases its commitment to innovative research to bolster wheat productivity.

Source: Stakeholder Consultations

Landmark Genome: Improvements for Wheat and Field Crops

The CDC has accomplished significant milestones in wheat genetics.

- Applying the latest technology, the CDC identified genetic variations improving adaptability and bolstering disease resistance to increase yield potential.
- As wheat production projections expect a 50% increase by 2050, this research enables breeders to help meet future demand and to better address future challenges in global wheat cultivation.
- A notable achievement is the development of multiple wheat genomes, which serves as a genetic blueprint for wheat improvement.

Access to extensive facilities through University of Saskatchewan's Department of Plant Sciences such as labs, test beds, and trial sites supports research and development activity in Saskatchewan and Western Canada. This leads to a better understanding of plant performance across a range of environmental conditions, assuring farmers that crop varieties are reliable before becoming available. The infrastructure includes:[12]

- **91 labs,** such as breeding labs, plant growth chambers, and genetics labs
- **12 facilities,** including greenhouses and research farms

[7,10] Success Grows our Future; [8] 2021-2022 Strategic Issues Survey with Producers; [9,11] CDC Annual Reports; [12] Stakeholder Consultations and CDC

6. Assessment of Socioeconomic Benefits
Human Capital Development

Talent Development

The CDC is integrated into the University's department of plant sciences, enriching student experiences, and fostering the future generation of quality talent in agriculture and related disciplines. Below is a summary of CDC's contributions to human capital development.

Addressing Workforce Challenges through Research

Canada's agriculture and agri-food industry is shifting its emphasis from manual labour to roles requiring specialized skills and knowledge. However, the increasing demand combined with skills shortages could lead to potential workforce gaps, which could threaten the industry's growth. Below is an overview of key challenges highlighted by stakeholders in the agricultural industry:[13]

- **64%** of employers in Canada state that workers do not have the right skills necessary to be successful in the industry
- **50%** of employers indicated recruitment challenges to attract workers, such as perceived attractiveness of the industry
- **More than 12,300 jobs** in the agricultural industry are expected to be unfulfilled within 10 years in Saskatchewan[14]

Crop research at CDC equips students with essential skills, leading to successful career outcomes in industry as well as at research organizations. A focus on enriching academic experiences helps to cultivate relevant skills for industry.[15] Key outcomes include:[16]

428+
students, alumni network, and faculty members involved with CDC research

58%
of alumni with CDC research experience place into either government or industry

42%
of CDC alumni in industry place into technical specialist/professional, breeder, management, and corporate leadership roles

Integrated Teaching Opportunities

The CDC, operating within the Department of Plant Sciences in the College of Agriculture and Bioresources, prioritizes teaching undergraduate and graduate students through a multidisciplinary approach for success in the agriculture sector.

Select Programs

Undergraduate and Graduate Programs

- Students have access to an array of undergraduate and graduate programs, including agricultural sciences, food systems, and agribusiness, among others.
- These programs provide students with opportunities to build the expertise needed to innovate and drive advancements in the agriculture sector.

Crop Diagnostic School

- The Crop Diagnostic School, organized by industry leaders and the Saskatchewan's Ministry of Agriculture, provides hands-on training for agronomists, producers, and professionals.
- Supported by CDC researchers, attendees enhance their skills in areas such as weed identification, insects, herbicide, and soils.
- Participants learn how to address agricultural challenges by applying research concepts in a practical setting, gaining a deeper understanding of their real-world applications.

Source: CDC, Sask Wheat

[13] What We Heard Report - Agriculture Labour Strategy, 2023; [14] How Labour Challenges Will Shape the Future of Agriculture in Canada; [15] Success Grows our Future; [16] CDC Annual Reports and CDC

6. Assessment of Socioeconomic Benefits
Market Development

Supporting Agricultural Developments

The CDC directs research initiatives to improve crop performance, which ultimately benefits Canadian farmers. Below is a summary of the role that the CDC plays to support growth in the agriculture and agri-food sector across the value-chain.

The Agriculture Sector in Canada

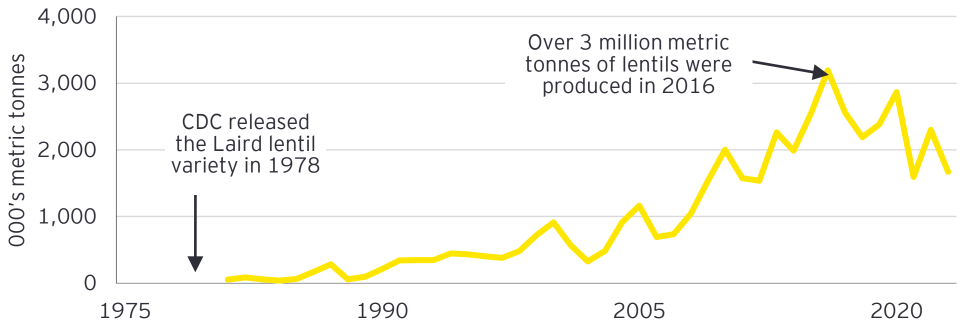
The agriculture and agri-food sector contributes to a notable portion of Canada's GDP and plays a critical role in exports. In 2022, the sector generated:[17]

- **$143.8 B** or **7%** of Canada's GDP,
- Employment for **2.3 million workers,** and
- **$92.8 B** of agriculture and food products exported from Canadian farms.

Lentils, which are part of the pulse crop group, are a key crop in CDC's research portfolio and in the agriculture sector in Canada. The significant improvement in lentil yields by CDC varieties highlights its impact in supporting growth in the agriculture sector.

Figure 7 provides an overview of lentil production in Canada from 1975 to 2023. Before the introduction of the Laird lentil variety in 1978, lentil production had been minimal in Canada.

Figure 7: Lentil Production Canada[18]



Key statistics of lentil trade in Canada:

#1 Exporter of lentils in the world as of 2022[19]

1.6 million tonnes of lentils are expected to be exported from Canada from 2023 to 2024[20]

99.8% of lentil harvestable area in Western Canada consists of varieties developed by the CDC[21]

Through lentil production and exports, Canada's position has been solidified as a global leader in this crop. CDC-developed varieties remain instrumental in supplying fulfilling this export demand, while also supporting Canadian consumption of lentils grown in Western Canada.

Transforming the Pulse Landscape in Saskatchewan

Source: Stakeholder Consultations

As pulses, including lentils, have become a profitable crop for farmers, the CDC has maintained its efforts to further improve disease resistance and promote crop rotations.

A key focus for pulse researchers at the CDC is pulse pathology, where researchers develop solutions to emerging diseases in peas, lentils and other prominent pulse crops in Canada. This helps to ensure stability in the long-term supply of pulses.

Consumer demand for alternative protein sources is growing due to changing dietary preferences, health-consciousness, and sustainability concerns.[22] This positions CDC-developed lentils to be a staple source of high-quality protein, with the potential for widespread market adoption and scalability of these varieties.

[17] Overview of Canada's agriculture and agri-food sector; [18] Statistics Canada; [19] Food and Agriculture Organization; [20] Canada: Outlook for Principal Crops; [21] CDC; [22] Plant-based Protein Market: Global and Canadian Market Analysis, 2019

6. Assessment of Socioeconomic Benefits
Collaboration and Sustainability Efforts

Knowledge Sharing and Outreach Initiatives

The CDC actively engages and collaborates with farmers and the broader agriculture ecosystem to share research outcomes and farming practices. Below is an overview of key insights regarding CDC's strategies and initiatives of information dissemination, including its commitment to sustainable cropping systems.

Serving as a hub for agronomical knowledge and resources, the CDC fosters collaboration with research institutions, governments, and industry partners to achieve shared research objectives aimed to increase farmers' yields and economic outcomes.

Farmers gain valuable insights through CDC's knowledge sharing initiatives, also known as extension outreach activities. These activities, which include (but are not limited to) conferences, workshops, and seminars, are designed to share the latest research outcomes with key stakeholders. This knowledge enables farmers to make informed decisions on their agricultural operations, such as selecting crops for cultivation and rotation, as well as optimizing farming practices.

To highlight the CDC's collaboration efforts, the centre has achieved the following:[23]

542

conference publications or presentations since 2016

820+

extension and outreach activities, including presentations, published articles, and workshops since 2016

30+

partners / stakeholders in the agricultural ecosystem

Feedback from Stakeholders

- In its engagement with the agriculture ecosystem, the CDC actively seeks feedback from farmers and industry stakeholders on its research.
- The feedback not only affirms the effectiveness of the CDC's achievements but also initiates a continuous cycle of improvement.
- This "feedback-loop" refines the CDC's strategic objectives to deliver farmers with relevant solutions that address their specific needs.

Global Priorities, Regional Impact: Cultivating Sustainability

The CDC's role in developing sustainable crop varieties tailored to regional conditions, combined with its global collaborations, highlights its significant contribution to global agricultural, sustainability and food security.

A key aspect of the CDC's mission is the development of crop varieties tailored to the unique conditions of Western Canada. CDC's crop varieties enhance the resilience of local agriculture and promote sustainable farming practices by reducing inputs such as water and pesticides. For instance, the CDC's durum wheat and barley have significantly bolstered yields for prairie farmers and other markets globally. The superior quality of our durum wheat is sought after for pasta production, while our barley varieties are used by beer brewers for their flavor and consistency.

Beyond its regional impact, the CDC's collaborations extend globally. By partnering with international research institutions and agricultural organizations, the CDC shares expertise and technology, empowering farmers worldwide to improve productivity while minimizing environmental impact. By promoting regenerative farming practices and providing resources for precision agriculture, the CDC empowers farmers to optimize resource utilization and mitigate climate-related risks. These efforts are essential for ensuring safe and nutritious food while maintaining the long-term viability of agricultural communities.

Source: CDC

[23] CDC Annual Reports

Appendix

Appendix A.1
Technical Note – Gross Farm Output Methodology

Introduction & Overview:

Gross farm output attributable to the CDC is the additional farm output which is attributable to improved yields due to plant breeding research at the CDC. This metric serves as the key input to EY's proprietary economic contribution model which estimates the economic contribution of the CDC's plant breeding activities. The scope was defined as follows:

- ***Assessment Timeframe:*** The starting date is 1991, based on the availability of harvestable area and performance trial data. The final year in the timeframe is 2022, as this is the most recent year in which complete data is available.
- ***Geographical Coverage:*** The geographical area is the provinces of Saskatchewan, Alberta and Manitoba.
- ***Crop Types:*** EY selected 10 crop types based on the CDC variety acreage share and crops which have substantial production volumes in Western Canada; barley, lentils, field peas, spring wheat, winter wheat, oats, chickpeas, flax, durum wheat and canary seed.

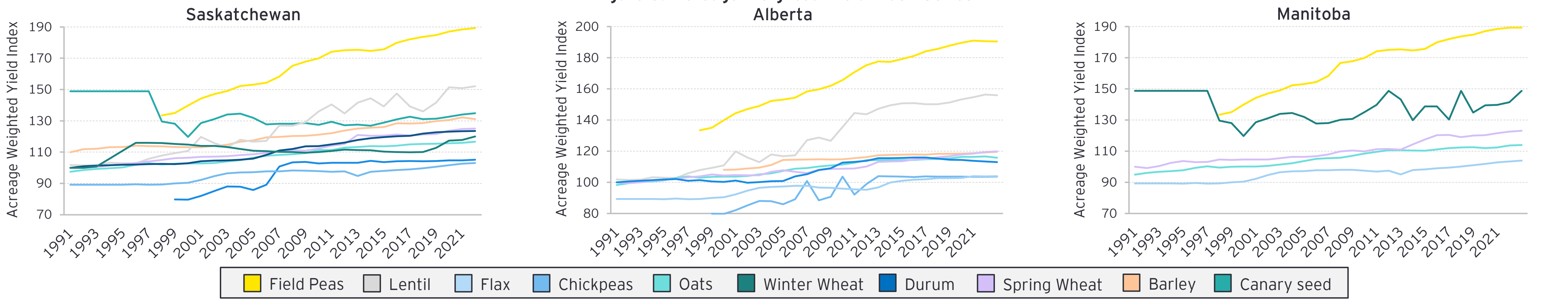
Below is a detailed overview of the key inputs and the methodology used to estimate gross farm output attributable to plant breeding at the CDC.

1. Acreage Weighted Yield Index Series:

An acreage weighted yield index series was provided by the CDC. The acreage weighted yield index uses performance trial data to assign a yield index to each crop variety – this index indicates the relative yield of this variety in comparison to a pre-defined base variety. For each prominent variety, the variety acreage share is calculated – this is the portion of total harvestable area of a given crop which is seeded by this particular variety.

For each province, an acreage weighted yield index series is calculated based on the yield index and the variety acreage share of all prominent varieties. This index denotes the yield improvement attributable to all plant breeding in a given year. **Figure 8** provides an overview of the acreage weighted yield index series for all key crops:

Figure 8: Acreage Weighted Yield Index Series



Note: The Acreage Weighted Yield Index is indexed to a baseline of 100. The baseline occurs at different time periods for each crop.

Appendix A.1
Technical Note – Gross Farm Output Methodology

2. Yield Attributable to Plant Breeding:

Using the acreage weighted yield index series, EY calculated a proportion yield gain for each crop type in each year. The proportional yield gain identifies the portion of yield which is attributable to plant breeding in a given year. This was calculated using the following formula:

$$Proportional\ Yield\ Gain_{C\,t} = \frac{AWYI_{C\,t} - Check\ Variety\ Index*_{C}}{AWYI_{C\,t}}$$

where C is the crop type and t is a given year, and AWYI is the Acreage Weighted Yield Index

The CDC provided historical provincial yield data broken down by crop type. The proportional yield gain above was multiplied by the provincial yield (bushels per acre) of all crop types each year. This provided an estimate of the bushels per acre attributable to plant breeding.

3. Gross Output Attributable to Plant Breeding

Data on harvestable area for each province was provided by CDC. The estimate of yield attributable to plant breeding (bushels per acre) was multiplied by total harvestable area. This provided an estimate of the total volume of output (bushels) attributable to plant breeding in Western Canada in a given year.

Please see below in **Table 7** the additional gross farm output in Western Canada due to yield improvement attributable to plant breeding:

Table 7: Gross Farm Output Attributable to Plant Breeding (1991-2022, in millions of bushels)

Type of Crop	Saskatchewan	Alberta	Manitoba	Western Canada
Barley	304.2	218.1	-	**522.3**
Lentils	322.3	30.5	-	**352.8**
Field peas	257.3	158.3	37.7	**453.4**
Spring Wheat	1,022.9	665.3	474.9	**2,163.1**
Oats	192	74.7	83.2	**349.9**
Chickpeas	24.6	2.4	-	**27**
Flax	40.4	4.8	3.5	**48.8**
Durum	450.2	66.6	-	**516.9**
Canary seed	-14.4*	-	-0.2	**-14.5****
Winter Wheat	25.4	-	-	**25.4**
Total	**2,624.9**	**1,220.8**	**599.2**	**4,444.9**

*A check variety is a designated seed variety indexed at 100 which all other seed varieties in the performance trials are indexed relative to. **The negative estimations for canary seeds in Saskatchewan and Manitoba are the result of decreasing acreage weighted yield indexes between 1997-2014 and 1998-2017, respectively.

Appendix A.1
Technical Note – Gross Farm Output Methodology

4. Value of Output

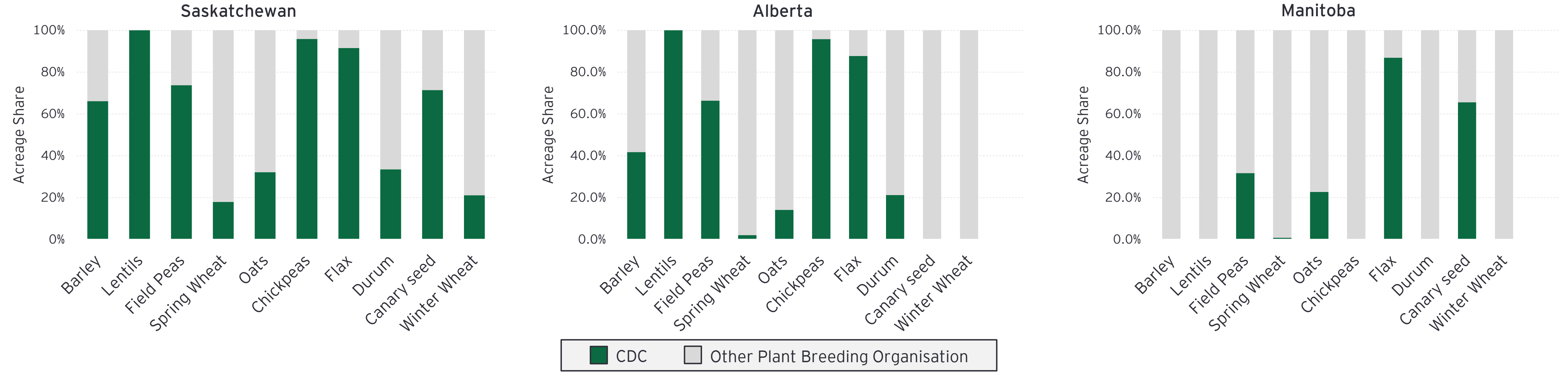
The additional volume attributable to plant breeding was converted to a monetary value using historical market prices for each crop. Historical crop prices were provided by the CDC.

5. Gross Output Attributable to the CDC

To calculate the gross farm output attributable to the CDC, EY used historical CDC acreage share data provided by the CDC. The CDC acreage share data details what portion of the total provincial acreage of each crop type is seeded with CDC-developed varieties in a given year. The total output attributable to plant breeding is multiplied by the CDC acreage share of that crop type in a given year. This calculates the monetary value of gross farm output attributable to the CDC.

The CDC acreage share reflects the importance of CDC varieties to production agriculture, as farmers seek to maximise their profits by selecting the optimal seed variety. Please see below in **Figure 9** the CDC acreage share of each crop type in 2022:

Figure 9: CDC Acreage Share by Crop (2022)



The annual gross farm output calculated above is valued in nominal terms. All values were converted to 2022 Canadian dollars using CPI inflation data from Statistics Canada. The result is the estimate of the gross farm output attributable to plant breeding at the CDC in Western Canada.

Appendix A.2

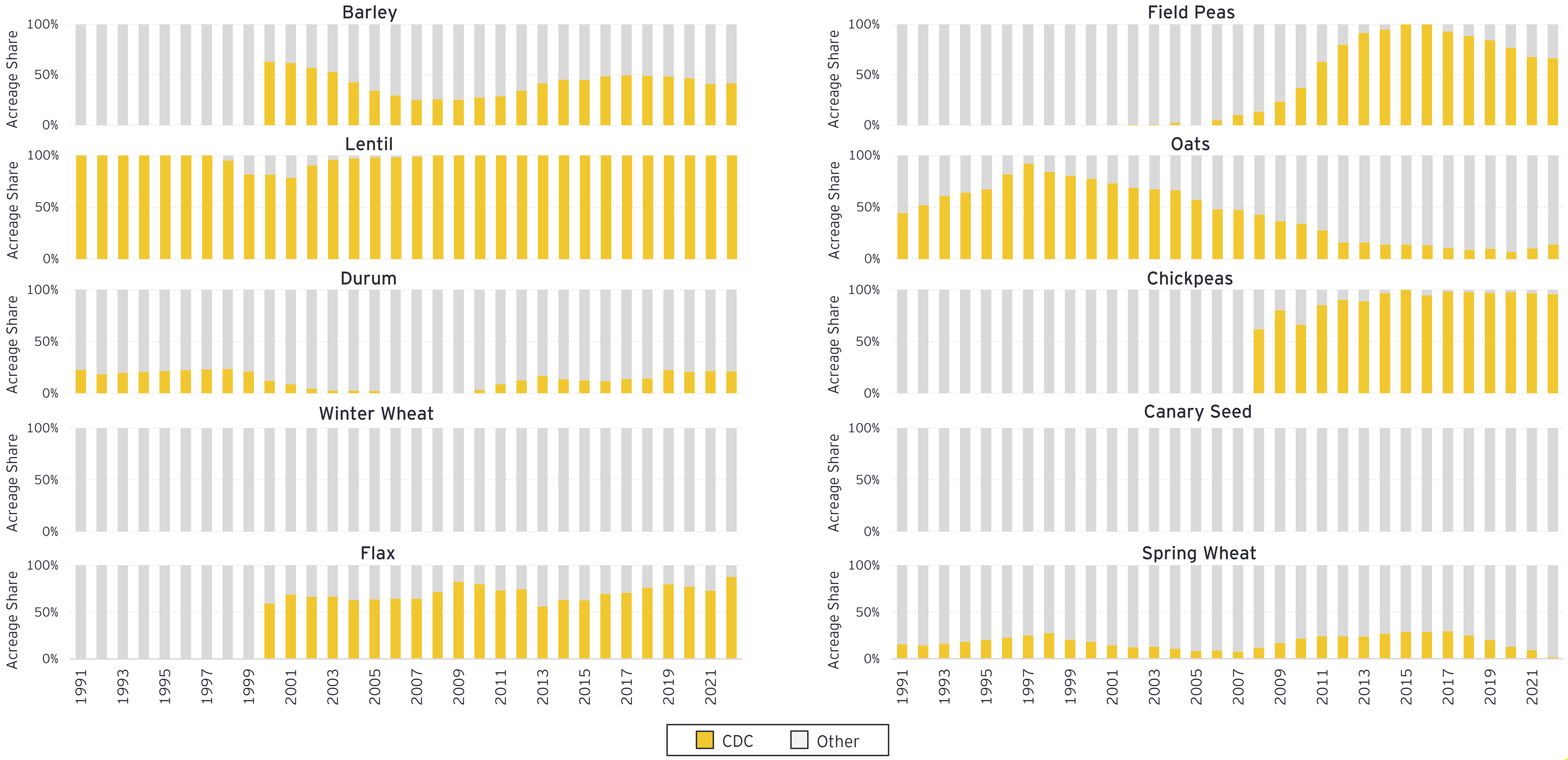
CDC Acreage Share - Saskatchewan

Below is the historical CDC acreage share for all prominent crops in Saskatchewan.

Appendix A.2

CDC Acreage Share - Alberta

Below is the historical CDC acreage share for all prominent crops in Alberta.



Appendix A.2

CDC Acreage Share - Manitoba

Below is the historical CDC acreage share for all prominent crops in Manitoba.

Appendix A.3
Economic Contribution Indicators

EY's proprietary economic contribution model produces key economic indicators, which assess the economic contribution of gross farm output attributable to the CDC:

Macroeconomic Indicators for Economic Contributions

Gross Domestic Product (GDP)
GDP contributions represent value added generated through stimulated economic activity from additional gross farm output in the Western Canadian provinces.

Wages and Salaries
Wages and salaries sustained as a result of economic activity stimulated by additional gross farm output. (These form a part of GDP contributions).

Full-time equivalent (FTE) Employment
Jobs supported across Canada. Jobs metric is measured in "person-years", as in the number of hours needed for individuals to work over a period of time in order be classified as a FTE.

The outcomes have been assessed through three different categories of economic contributions: direct, indirect, and induced contributions.

- **Direct contributions** include the economic contributions directly supported directly by economic activity stimulated by gross farm output attributable to the CDC.
- **Indirect contributions** include the economic contributions from supporting industries that supply goods and services to support crop production activities. The indirect contributions include the contributions from suppliers' spending when purchasing goods and services from other suppliers; and,
- **Induced contributions** include the economic contributions that occur when employees in direct or supplier industries that benefit from the economic activity spend their incomes on goods and services throughout the provincial economy. The induced activities are assumed to be primarily in service or consumer-related industries, such as retail, transportation, accommodation, restaurants, housing and finance. The jobs and incomes that result from this consumer spending are also considered induced contributions. Induced contributions can be estimated based on a number of rounds or iterations of recycled income due to increased spending, economic activity, and additional income.

Appendix A.4
Input Output Model Assumptions and Restrictions

The following section outlines the assumptions and restrictions associated with the I-O model used to perform the economic impact assessment in the Report. The I-O model is subject to limitations both in concept and implementation. Like any economic model, the I-O model is conceptually an abstraction that attempts to be complex enough to accurately capture and estimate the most significant impacts to the real-life economy caused by economic activities, yet simple enough to be analytically and intuitively meaningful.

An I-O model reflects the observed interdependency between all sectors of the economy. For Canada, Statistics Canada reports on the 236 industrial sectors in the economy: (1) how each sector relies on the other 235 sectors for inputs to their production; and (2) how each sector supplies its products and services to each of the remaining 235 sectors. While an I-O model provides a consistent and innovative way of measuring the economic effects of an economic activity, one should be aware of the assumptions and limitations of the model's underlying approach. Some of these assumptions include:

- The relationship between industry inputs and outputs is linear and fixed, meaning that a change in demand for the outputs of any industry will result in a proportional change in production.
- The model assumes constant returns to scale and cannot account for economies/diseconomies of scale or structural changes in production technologies; an assumption that does not necessarily hold in the actual economy.
- Prices are fixed in the model; thus, the model is unable to account for elasticities, (how one economic variable changes in response to another).
- I-O models are static, and therefore do not consider the amount of time required for changes to happen. Changing the timeframe would not affect the magnitude of the estimates.
- There are no capacity constraints, and all industries are operating at full capacity. This implies that an increase in output results in an increase in demand for labour (rather than simply re-deploying existing labour). It also implies that there is no displacement that may occur in existing industries as new projects complete.
- I-O models assume that the technology and resource mix (ratios for inputs and production) is the same for all firms within each industry, i.e. the 236 industry categories reported in Statistics Canada's input-output table. As such, the analysis describes industry average effects.
- The model assumes that the structure of the economy remains unchanged, and any structural changes in the economy since 2020 will therefore lead to changes to the multipliers, which could be implemented once Statistics Canada release updated input-output tables. As such, the further the year of analysis is away from the year of the input-output tables used, the greater the uncertainties.
- The model does not consider the economic impacts or opportunity costs associated with using resources elsewhere. Using these funds for alternative uses would generate their own economic impacts, which could potentially be larger or smaller. However, the model will not be able to capture this difference.
- Results from the I-O model should not be interpreted as causal impacts, that is, users should not take the economic impacts presented in this report at verbatim. It cannot be said with certainty that X dollars of capital or operational spending will produce X number of FTEs or have an X amount of impact on GDP.
- The model does not consider substitutions amongst inputs, and each industry in the model is regarded as having a single production process.

Per the assumptions above, the structure and limitations of I-O models lend themselves to measuring the impacts of projects that are shorter term in nature. Generally, they are used to look at shocks to the economy.

Appendix A.5

Economic Contribution Breakdown by Province: Saskatchewan

Economic Impact of Plant Breeding at the CDC by Province

Below in **Table 8** is an overview of the economic benefits sustained by CDC-attributable gross farm output in Saskatchewan, as well as in the wider Canadian economy in 2022. The provincial impacts are economic contributions that are expected to remain in Saskatchewan, and do not include leakages to the national economy. Contributions in Saskatchewan are therefore lower than national contributions. The economic contribution results are as follows:

- **Saskatchewan:** As of 2022, plant breeding at the CDC was estimated to contribute **$893 million** to Saskatchewan's economy (in GDP), **$191 million** in wages and salaries and **4,886** FTE jobs.
- **National:** When benefits to the rest of Canada are considered, these activities were estimated to contribute **$1.1 billion** to the Canadian economy (in GDP), **$225 million** in wages and salaries and **6,611** FTE jobs.

Table 8: Economic Contribution 2022[24]

Supported by additional gross farm output attributable to the CDC in 2022

Provincial	GDP ($ mill)	Wages and Salaries ($ mill)	FTEs
Direct	$610	$98	2,932
Indirect + Induced	$283	$93	1,953
Total	**$893**	**$191**	**4,886**
National			
Direct	$610	$98	2,932
Indirect + Induced	$528	$127	3,679
Total	**$1,138**	**$225**	**6,611**

Note: Figures may not sum due to rounding. All dollar figures provided are in 2022 Canadian dollars.

[24] Statistics Canada, CDC, and EY Analysis

Appendix A.5

Economic Contribution Breakdown by Province: Manitoba

Economic Impact of Plant Breeding at the CDC by Province

Below in **Table 9** is an overview of the economic benefits sustained by CDC-attributable gross farm output in Manitoba, as well as in the wider Canadian economy in 2022. The provincial impacts are economic contributions that are expected to remain in Manitoba, and do not include leakages to the national economy. Contributions in Manitoba are therefore lower than national contributions. The economic contribution results are as follows:

- **Manitoba:** As of 2022, plant breeding at the CDC was estimated to contribute **$24 million** to Manitoba's economy (in GDP), **$5 million** in wages and salaries and **169** FTE jobs.
- **National:** When benefits to the rest of Canada are considered, these activities were estimated to contribute **$32 million** to the Canadian economy (in GDP), **$5 million** in wages and salaries and **220** FTE jobs.

Table 9: Economic Contribution 2022[25]

Supported by additional gross farm output attributable to the CDC in 2022

Provincial	GDP ($ mill)	Wages and Salaries ($ mill)	FTEs
Direct	$16	$2	99
Indirect + Induced	$9	$2	70
Total	**$24**	**$5**	**169**

National			
Direct	$16	$2	99
Indirect + Induced	$17	$3	121
Total	**$32**	**$5**	**220**

Note: Figures may not sum due to rounding. All dollar figures provided are in 2022 Canadian dollars.

[25] Statistics Canada, CDC, and EY Analysis

Appendix A.5
Economic Contribution Breakdown by Province: Alberta

Economic Impact of Plant Breeding at the CDC by Province

Below in **Table 10** is an overview of the economic benefits sustained by CDC-attributable gross farm output in Alberta, as well as in the wider Canadian economy in 2022. The provincial impacts are economic contributions that are expected to remain in Alberta, and do not include leakages to the national economy. Contributions in Alberta are therefore lower than national contributions. The economic contribution results are as follows:

- **Alberta:** As of 2022, plant breeding at the CDC was estimated to contribute **$295 million** to Alberta's economy (in GDP), **$59 million** in wages and salaries and **1,883** FTE jobs.
- **National:** When benefits to the rest of Canada are considered, these activities were estimated to contribute **$352 million** to the Canadian economy (in GDP), **$69 million** in wages and salaries and **2,310** FTE jobs.

Table 10: Economic Contribution 2022[26]
Supported by additional gross farm output attributable to the CDC in 2022

Provincial	GDP ($ mill)	Wages and Salaries ($ mill)	FTEs
Direct	$166	$31	986
Indirect + Induced	$129	$28	897
Total	**$295**	**$59**	**1,883**
National			
Direct	$166	$31	986
Indirect + Induced	$186	$39	1,325
Total	**$352**	**$69**	**2,310**

Note: Figures may not sum due to rounding. All dollar figures provided are in 2022 Canadian dollars.

[26] Statistics Canada, CDC, and EY Analysis