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# Strengthening the Agri-Food Sector Post-COVID-19

## Opportunities for research and innovation after COVID-19

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# EXECUTIVE SUMMARY

While navigating a substantial amount of uncertainty, the COVID-19 pandemic is expected to have long-lasting effects on the whole food system—from production, processing, and manufacturing to distribution, retail, and foodservice.

The health crisis triggered significant changes in the structure of demand for agri-food products, as reflected in shifts in consumer patterns and behaviour that are anticipated to transform food purchasing preferences in the long-run.

As consumers continue to embrace e-commerce, technology-enabled solutions and digital services will provide multiple opportunities for the sector to fully understand the new market dynamics. Purchasing decisions will continue to be assessed around shelf-life, which may direct demand towards shelf-stable and frozen options.

The agri-food sector needs to rebalance its priorities, making resilience—the ability to recover from disruptions and quickly adapt to change in the face of uncertainty and risks—as important to long-term growth as efficiency and productivity. The survival of agri-businesses, particularly small and medium-sized ones, hinges on the sector's ability as a whole to explore new ways of building a stronger and more resilient food system. Creating a more resilient agri-food supply chain beyond COVID-19 will help the sector prepare for the "new normal" as well as future emergencies, thus reducing vulnerability to future supply shocks and trade disruptions. Moreover, this transformation has the potential to integrate economic recovery and sustainability goals while prioritizing food safety and mitigating risks.

Plugging gaps in the value chain and supporting interventions that secure the production, processing, and distribution of agri-foods will become a key priority for the sector beyond the crisis. Fostering innovation can strengthen the sector's capacity to respond to emergencies and disasters in a timely manner. Recovering revenue, rebuilding operations, rethinking organizational structures, and accelerating the adoption of new technologies—including data analysis and forecasting, risk management strategies, and knowledge exchange platforms—will certainly help agri-businesses ease liquidity pressures post-COVID-19. Still, moving towards a more resilient food system at all levels will largely depend on expanding and upgrading capacity, particularly for domestic food processing.

From the implementation of tools and infrastructure to allow continuing operations with minimal health risk to the digitalization of market transactions, the integration of the entire

value chain into the contact-free economy should be considered a research priority in the years to come.

Automation—farm machinery automation, traceability technologies, and digital logistics services—and other digital technologies—mobile devices, data analytics, artificial intelligence (AI), e-commerce, and digitally-delivered services have the potential to eliminate supply chain bottlenecks by ensuring the continued manufacturing of agri-food products despite barriers to labour mobility. A highly automated sector entails less exposure to COVID-19 while ensuring the uninterrupted flow of agri-food products. While attracting more domestic workers remains a critical need for the sector, increased automation and mechanization can also address labour shortages arising from the health crisis in the long run. From pruning, seeding, weeding, and harvesting to food processing, packaging and transporting, automation can optimize process flow, reducing turnaround times and preventing losses. Yet, to harness these benefits, the sector must respond to a twofold challenge: improving access to broadband infrastructure in rural and remote areas and meeting the demand for high-skilled workers in the agri-food sector.

Efforts to build resilience along the food supply chain can ensure food access to locally-, regionally- and globally-produced food to prevent a future food security crisis. In addition, well-functioning food donation systems, innovative mechanisms for sourcing and distributing food to vulnerable groups, and innovative food hubs or e-commerce platforms for smallholders can reduce food losses along the supply chain. Moreover, biotechnology, including gene editing, genetic replication, and other synthetic biology techniques, may offer novel solutions to address food security issues. On the consumer side, ongoing education campaigns for responsible food purchase behaviour may diminish food waste. While there is a need to avoid disruptions in international trade, local food systems can help Canadians endure and recover from global shocks by feeding regional economics, supporting the local labour market, protecting the environment, and ensuring affordable access to agri-food products.

The pandemic has exposed many systemic weaknesses in the agri-food sector, which, if not corrected, will most likely be compounded by climate change and associated phenomena in the years to come. Moving towards a more resilient agri-food system entails building a more sustainable value chain that efficiently reduces risk and vulnerabilities to a broad range of threats, including diseases, climate change, water scarcity, biodiversity loss, land degradation, and pests.

Environmental sustainability concerns should thus remain at the forefront of both scientific and technological development in the agri-food sector. Sustainable recovery post-COVID-19 would be possible by aligning productivity with environmental goals in agronomics, alternative feeds and additives, bioenergy, environmentally-friendly packaging, circular economy, and many others. Still, sustainable productivity growth to meet food security goals in a changing climate will require new agri-food extension and on-farm research physical distancing protocols to provide sustained support to farmers and producers.

After the pandemic, public health protocols that reduce the likelihood that harmful pathogens threaten the safety of the food supply will likely be integrated into the day-to-day operations of producers, processors, distributors, retailers, and foodservice operators. Ensuring compliance with measures to protect food workers and prevent food contamination calls for research on enhanced, cost-effective biosecurity protocols and specialized infrastructure to mitigate disease risk and maintain the Canadian agri-food system's integrity. Complying with these measures beyond the current crisis will undoubtedly contribute to maintaining trust and confidence in agri-food products.

# BACKGROUND

The COVID-19 crisis has enormously impacted Canada's agri-food sector—a rich and diverse system that plays a critical role in the economy. The direct impact on the food supply from containment measures has left the entire sector in an unprecedented fragile situation.

While navigating a substantial amount of uncertainty, the COVID-19 pandemic is expected to have long-lasting effects on the whole food system—from production, processing, and manufacturing to distribution, retail, and foodservice.

The post-COVID-19 world will force us to accelerate the transformation of Canada's agri-food sector into a more resilient, productive, and sustainable food system. This shift strongly relies on expediting the development and deployment of innovative agri-food products and related technologies along the supply chain.

A study conducted by the Agri-Food Innovation Council (AIC) found that the COVID-19 pandemic has impacted the organizations of 94% of survey respondents; from those, 55% reported a significant impact. A sharp drop in revenues, ongoing delays in operations, supply chain disruptions, and increased market uncertainty are some of the many reported effects of business closures and lockdowns on the sector. Likewise, fast-changing consumer behaviour and labour shortages arising from travel restrictions on temporary foreign workers have hit the sector particularly hard. In light of these effects, almost three-quarters of the stakeholders in the sector believe that their organization or sub-sector will emerge from this crisis with new ways of doing things. Yet, the majority of respondents (63%) mentioned that these changes might not be easy to achieve.

Based on the outcome of AIC's consultation and further research, a myriad of long-term changes in the sector is expected to occur in at least six emerging areas: the structure of demand for agri-food products, the functioning of the food supply, food security, sustainability, food safety, and demand for labour. In many instances, these areas are closely intertwined in complex ways along the whole agri-food value chain. Nonetheless, for purposes of analysis, these six areas are explored in this report separately, even if these overlap in practice. Moreover, overlap does not necessarily mean duplication, but rather a reflection of the sector's dynamics.

This report also delves into new potential areas of research and innovation in agri-food post-COVID-19 within the six emerging areas. Still, survey respondents indicated that ensuring continuing support for current priorities and maintaining existing capacity remains crucial for

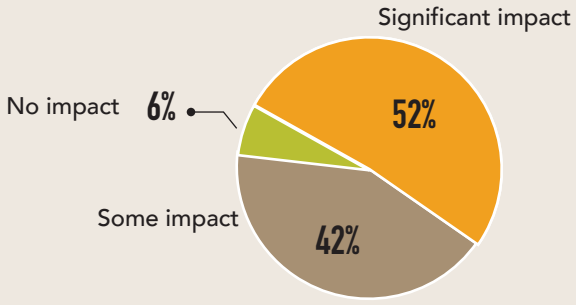
Canada's agri-food sector to build back better post-COVID-19 by capitalizing on our research and innovation capacity.

Most importantly, the COVID-19 crisis has brought together all stakeholders in the value chain, which demonstrated the value of collaboration and cooperation. Moving forward, the post-COVID-19 landscape offers a unique opportunity to continue working together in an inclusive partnership with all stakeholders—public and private sector partners, non-profit groups, academia, and all other stakeholders across the value chain.

Building on the agri-food system's interconnectedness, a strong, unified voice can maximize the impact of research efforts post-COVID-19. This value chain approach to R&D and innovation recognizes that collective problem solving can address the various issues arising from the fight against COVID-19 while allowing for specialization and efficiency in the sector.

# AGRI-FOOD RESEARCH & INNOVATION AFTER COVID-19

## Perceived impact of COVID-19 on the agri-food sector*

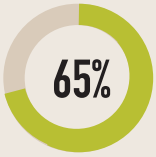




of agri-food stakeholders expect **long-term changes** in the sector post-COVID-19

## Expected long-term changes in food production*

- **Local food systems, trade and diversification** 25%
- **Automation & digitalization** 15%
- **Resilience & risk management** 13%
- **Consumer behaviour** 13%
- **Infrastructure** 7%
- **Operations** 7%
- **Food security** 6%
- **Food safety** 5%
- **Trade** 4%
- **Labour** 4%
- 2% **Sustainability**




of agri-food stakeholders believe that the **implementation** of these changes will be **hard** to achieve*

## Which are the most important factors in determining and implementing long-term changes in the agri-food sector in order to adapt post-COVID-19?*

| Accommodating changes in **supply** and **demand** | Increased focus on **food safety** | Renovating **production networks** | Driving innovation in **food processing** | Driving innovation in **logistics & transporation** |
|---|---|---|---|---|
| 18% | 13% | 12% | 12% | 12% |




*Based on AIC survey results "COVID-19 Impact on the Future of Agri-Food Research and Innovation."

# 1. FOOD DEMAND: ADAPTING TO CHANGING CONSUMER BEHAVIOUR

Since the onset of the COVID-19 crisis, a reduction in disposable income has led consumers to cut back on their spending on non-essentials while increasing spending on other basic categories. Because food is a basic necessity, demand for agri-food products, particularly non-perishable foods, should not be as affected by the crisis as other sectors (OECD, 2020). Still, the COVID-19 pandemic has changed the structure of demand for agri-food products significantly. These shifts in consumer

**EMERGING RESEARCH AREAS**

- E-commerce and digitalization of services
- Social media marketing
- Social analytics
- Digital consumer behaviour
- Customer experience and branding
- Product development
- Reduced-contact food sourcing
- Liquidity risk management

patterns and behaviour are anticipated to permanently alter food purchasing preferences as restrictions lift worldwide.

With the closure of foodservice operators—restaurants, hotels, bars, public venues, and catering—food demand from retailers grew abruptly. Months after the initial outbreak, many businesses along the agri-food chain have adapted their operations to this shift in demand by increasing capacities, incorporating e-commerce solutions, and switching production processes. For instance, many Canadian foodservice operators have adopted measures to manage potential liquidity risk exposure by offering basic grocery menus and meal kits, employing staff to deliver orders, and cutting back on takeout menus.

Stay-at-home orders have shifted consumption away from dine-in restaurants to home cooking from scratch, a habit that is likely to continue post-COVID-19. Through video, written recipes, or audio, social media platforms have become the primary source of recipes and inspiration worldwide. Recent polls reveal that Canadians are increasingly planning on reducing takeout (36%) and restaurant delivery (28%) by preparing more home-cooked meals (Weintraub et al., 2020). In fact, the adoption of digital activities will become a convenient means of connecting with others and entertaining consumers beyond the crisis.

The crisis has prompted people to seek innovative and more direct means of sourcing their food. For instance, movement restrictions resulting in the closure of multiple marketing channels and key selling points, such as restaurants, have influenced people to shift towards higher consumption of online and one-stop shopping options, which offer access to a wider variety of products at once.

Most importantly, evidence suggests that consumers are increasingly adopting reduced-contact ways of accessing agri-food products through digital commerce. In April 2020, 30% of Canadians shopped online for groceries—58% more than the previous month before COVID-19 was declared a global pandemic (Fernando, 2020). Consumer acceptance for online shopping platforms and digital technologies will likely continue to grow substantially post-COVID-19, including groceries, food takeout and delivery. As a result, the integration of the entire value chain into the contact-free economy, alongside the digitalization of agri-business models and the food supply chain, should be considered a key research area in the years to come.

Increasing consumer confidence may represent a challenge, particularly for multinational brands and global producers. In fact, post-COVID-19, consumers may refrain from purchasing imported products that may have been handled by numerous other people or travelled from afar. In this way, the digitalization of services offers new potential opportunities for the sector

to reach and engage consumers directly. Market research is needed to provide relevant information and design strategies to identify new target markets, enhance brand experience, and develop new products. Food brands will have the opportunity to reinvent their business models, to collaborate with local producers, and explore new routes to market through social media.

The experience of scarcity and under-preparedness for unforeseen events will also impact consumer behaviour post-COVID-19. More consumers are expected to restrict shopping trips and keep a safety stock inventory of staples such as food, household supplies, and personal care items (Blue, 2020). Consumers now assess purchasing decisions around what can be stored for long periods and what cannot, which may shift demand towards shelf-stable (i.e., grains, dried and canned foods) and frozen options. For instance, in mid-March 2020, Canadian retailers' revenues for rice increased more than 239% as compared to the 2019 average (Statistics Canada, 2020). With 21% of Canadians anticipating spending more on groceries post-COVID-19 (Weintraub et al., 2020), some fresh foods are forecasted to maintain their current demand levels, such as dairy, eggs, cheese, produce and fresh meat, and seafood.

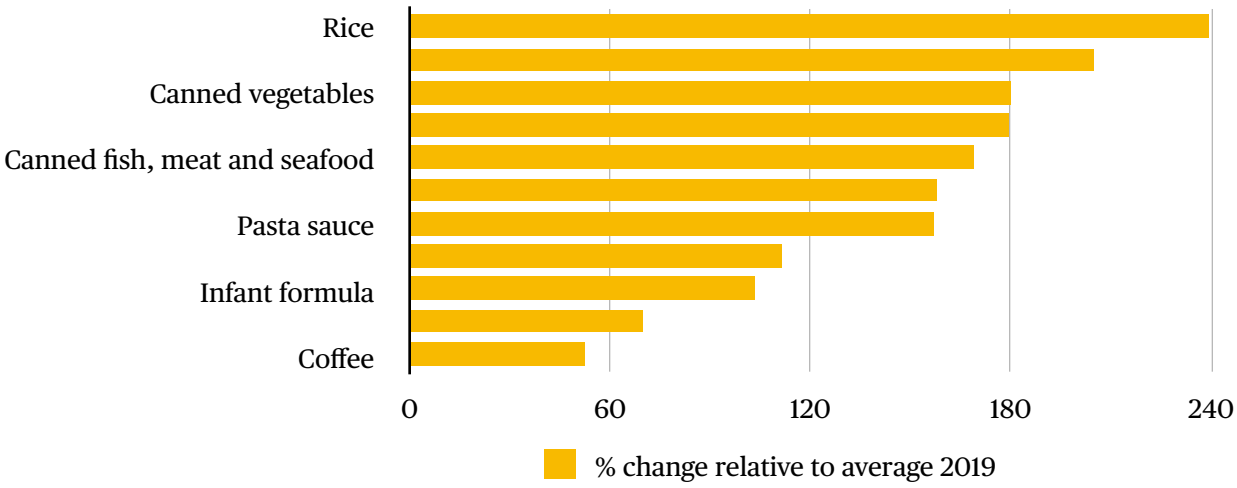



**Figure 1**. Dry goods and shelf-stable foods, percentage change in sales for the week ending March 14th relative to the average 2019.
***Source:*** Adapted from Statistics Canada (2020), Prices Analytical Series, Canadian Consumers Prepare for COVID-19.

As consumers become more acquainted with digital tools for shopping online, retailers will likely increase their online offerings and find innovative ways to address risk-resilience issues or implement appropriate procedures to prevent irrational stockpiling in coming crises. Retailers, for instance, could adopt AI technologies to identify and better understand

purchasing behaviour. In turn, producers and food processors could use this information to make decisions based on social media's real-time consumer insights. Most importantly, in a post-COVID-19 environment, digital connectivity will become an absolute necessity for the sector to harness the benefits of technology.


# 2. FOOD SUPPLY AND RESILIENCE: BUILDING A RESILIENT AGRI-FOOD SYSTEM

Food supply chains are comprised of a complex flow of people, inputs, and processes. Major disruptions affecting this web of interactions create economic uncertainty and significant price volatility. Without a doubt, movement restrictions, labour shortages, and slowdowns in operations due to COVID-19 threatened to halt the consistent supply of agri-food products and tradable agricultural inputs worldwide.

**EMERGING RESEARCH AREAS**

- Crisis and liquidity risk management
- Resilience planning
- Automation
- Sourcing models and distribution systems
- Digitalization of trade services
- Food processing
- Knowledge exchange
- Market diversification

Resilience is the ability to recover from disruptions and quickly adapt to change in the face of uncertainty and risks. This business-wide term encompasses crisis management and business continuity planning and post-crisis recovery that allows organizations to respond to all types of risks by securing financial stability, continuing operations and protecting their human capital in times of crisis.

The survival of Canadian agri-businesses, particularly small and medium-sized ones, hinges on the ability of the sector as a whole to explore new ways of building a stronger and more resilient food system. For that reason, plugging gaps in the value chain and supporting interventions that secure the production, processing, and distribution of agri-foods will become a key priority for the sector beyond the crisis.

**Reinventing business models**

Adapting operations to a new and rapidly changing environment is crucial to support agricultural production post-COVID-19. For instance, most retailers have long structured their operations based on a low-inventory, "just in time" sourcing model involving timing shipments that meet a relatively stable demand. This system has resulted in low-cost access to a diversity of foods from all over the world. Yet, the cost of a more interconnected food system is a loss of resilience in the supply chain. For instance, this model was insufficient to meet a sudden 46% increase in demand (Statistics Canada, 2020), as empty shelves at grocery stores revealed amid the pandemic. In a post-COVID-19 world, retailers may continue to divert agri-food products from foodservice operators and expand their shipping capacity to meet the surge in demand. As a result, food supply chains will be forced to adapt existing sourcing and distribution systems to this shift, from production to retail, in order to facilitate the efficient functioning of food supply chains.

Furthermore, agri-businesses are increasingly facing severe liquidity issues, while research-oriented companies in the sector are witnessing a sharp drop in growth and working capital. The COVID-19 liquidity gap, which is not restricted to the foodservice sector, is increasingly affecting other links in the agri-food value chain facing lower productivity and increasing liabilities with little or no business activity at all. The most pressing challenge for Canadian small agri-businesses is the lack of liquidity resulting from the economic downturn during and after the health crisis. Stakeholders suggest that new incremental expenses, such as the rising cost of personal protective equipment (PPE), add to existing liquidity issues. In addition, recent forecasts indicate that Canada's total farm cash receipts are set to decline substantially by about 3.4% in 2020, the worst year-over-year performance since 2003 (Pouliot, 2020).

Food tech and other high-growth companies in the sector have sharply cut non-essential expenditures, mainly research and innovation activities, in an effort to cope with a tight working capital environment. Moreover, as the COVID-19 crisis has escalated, growth capital markets—an essential component of innovation—have decreased substantially and are expected to slowly recover in the next several years. To counteract these pressures, emerging business models can be oriented towards recovering revenue, rebuilding operations, rethinking organizational structures, and accelerating the adoption of new technologies.

**Agricultural Trade**

Valued at $64 billion (CAD), the Canadian agri-food system exports account for more than a half of the sector's production, including half of the total beef production, 70% of soybeans, 70% of pork, 75% of wheat, 90% of canola, and 95% of pulses (Barichello, 2020). While Canada's agricultural trade is expected to be less significantly affected than trade in other sectors, forecasts estimate a reduction between 12 and 20% in real trade value for commodities. Overall, livestock, pulses, and horticulture will likely experience a larger drop as compared to cereals.

The anticipated effects of COVID-19 on agricultural trade remain an area of growing concern amongst stakeholders. Import restrictions, lower-income in trade countries, costly inspections, and food safety measures pose an enormous threat to our exporting potential post-COVID-19. As the current crisis can erode our position as a net food exporter, market diversification and resilience will become key factors to tackle permanent changes in trade patterns.

**Logistics and transportation**

A tremendous surge in demand for staple products due to panic-buying and pantry stockpiling over COVID-19 caused short supplies at grocery stores and numerous delivery delays. Fresh produce, fresh meat and seafood, eggs, bakery, pasta and pasta sauce, milk products, rice and some frozen products were some of the most out-of-stock food items in grocery stores during the pandemic. Despite the reported stable availability of agri-food products, these shortage issues raised concerns about the functioning of the food supply chain and, particularly, the effectiveness of its distribution system across the country.

Logistics operations in the agri-food value chain enable the flow of agriculture inputs, agri-food products, and other related services, such as transportation, warehousing, procurement, packaging, and inventory management. A delay in one of these components, such as movement restrictions, produces a chain effect that might impact the entire production

process, generating a supply shock in terms of logistics of movement of food. Disruptions in transportation and logistics impeding the shipment of agri-food products and other crucial agricultural inputs pose a threat to food security, market access, and affordability, particularly for the most vulnerable populations in Canada and abroad. In this area, our stakeholders and research indicated that innovation in the sector can help make it easier for the transportation sector to ensure strict observance of public health measures. For instance, implementing tools and infrastructure can allow continuing operations with minimal health risk, including the use of digital documentation or measures to protect the health and safety of workers handling tradable commodities and other products. The digitalization of trade services, such as digital platforms of agricultural inputs and electronic market transactions, may enhance the interaction between labour, production, and consumption, improving the flow of agri-foods along the supply chain.

**Food Processing**

The pandemic exposed limitations in the sector's processing capacity, a major barrier to growth for the sector identified by stakeholders even before COVID-19. For instance, 95% of Canada's beef production comes from just three processing plants, including two that were hit by outbreaks (Pinkerton & Emmanuel, 2020). Certainly, the maximization of the sector's efficiency hinges on its food processing capacity to move towards a more resilient food system at all levels.

**Making resilience a common goal**

The agri-food sector will need to rebalance its priorities, making resilience as important to long-term growth as efficiency and productivity. In this regard, novel technologies and research play a key role in accelerating the transition from a diverse, yet fragmented sector to a resilient and fully integrated agri-food system.

Innovation can strengthen the sector's capacity to respond to crises in a timely manner. For instance, continuous monitoring of global market conditions and early interventions can be performed through data analysis and forecasting. Future and emerging research could also help map the structure and flow of agri-food products along the supply chain while identifying potential vulnerabilities in the existing production system. As uncertainties in the agri-food sector increase, risk management strategies and tools that delve into organizational structures, processes and capabilities of agri-businesses will become essential resources to help stakeholders manage future risks. Further research in this area may enormously

contribute to formulating an efficient and effective approach to strengthening the sector's resilience to risks arising from health emergencies, global market shocks, and climate change.

Most importantly, in the wake of COVID-19, there is an emerging trend to develop, adopt and implement automation—farm machinery automation, traceability technologies, and digital logistics services—and other digital technologies—mobile devices, data analytics, artificial intelligence (AI), e-commerce, and digitally-delivered services. Moreover, the use of automated systems can eliminate supply chain bottlenecks by ensuring the continued manufacturing of agri-food products despite barriers to labour mobility.

Cross-sectoral collaboration can accelerate digitalization plans for the agri-food sector by improving the availability and dissemination of data. Efficiently functioning supply chains require access to timely data, as information reduces uncertainties and catalyzes adaptation to risks and disruptions. Information and knowledge exchange platforms can enable coordinated contingency planning for the entire value chain. Sharing information is thus critical for tackling supply chain disruptions while building long-run resilience.

Creating a more resilient agri-food supply chain beyond COVID-19 will help the sector prepare for the “new normal” as well as future emergencies, thus reducing vulnerability to future supply shocks and trade disruptions. Moreover, this transformation has the potential to integrate economic recovery and sustainability goals while prioritizing food safety and mitigating risks.

# 3. FOOD SECURITY

With large global supplies of staple crops, favourable production prospects, and cereal stocks close to reaching their third-highest level on record, according to global agencies such as the OECD, the current health crisis is not expected to evolve into a global food crisis. Yet, food security remains a key priority for all agricultural systems worldwide.

**EMERGING RESEARCH AREAS**

- Food access and hubs
- Regionalization of supply chains
- Food donation systems and platforms
- Sourcing and distribution
- Biotechnology solutions
- Local food systems and short supply chains
- Rural-urban linkages

Food insecurity occurs when people do not have access to quality healthy food due to financial constraints. During the COVID-19 pandemic, almost one in seven Canadians reported food insecurity (Statistics Canada, 2020b). Workers who were temporarily laid off due to a state of emergency that shut businesses were more likely to be food insecure (28.4%) than those who were working.

The expected economic impact of the COVID-19 pandemic—a severe global recession already depicted by international bodies, financial companies, and many research institutions—could rapidly and dramatically affect food security goals and exacerbate the risks of malnutrition and hunger in the most vulnerable populations. In Canada, the financial impacts of COVID-19 could result in an increasing number of Canadians experiencing food insecurity (Statistics Canada, 2020b). This risk is even more worrisome in the case of elderly, disabled, and chronically ill people, low-income households, people living in remote northern areas, and indigenous populations. Although our agri-food sector is a robust, strong system with enough resources to feed Canadians during and beyond COVID-19, the pandemic crisis has evidently put a strain on the food supply chain as a whole. Thus, it is imperative to optimize our food supply chain to ensure food security and avoid food shortages. Efforts to build resilience along the supply chain can contribute to ensuring access to locally-, regionally- and globally-produced food to prevent a future food security crisis.

**Food loss and waste**

Movement restrictions and lockdowns have reduced producers and processors' access to various markets where they buy inputs and sell agri-food products, causing surpluses to accumulate, overwhelming storage facilities, and, in most cases, increasing the loss of perishable products. For instance, some Canadian dairy farmers disposed of raw milk to address surplus production as demand from foodservice operators dropped during the outbreak of COVID-19 (Sagan, 2020). In this context, novel communication tools that ensure better coordination of existing food donation systems and innovative food hubs or e-commerce platforms for smallholders can help reduce food losses along the supply chain. Most notably, ICT platforms and informal networks—local farm markets—can become effective alternative distribution channels to directly connect consumers with retailers, caterers, and producers.

COVID-19 also has the potential to increase food waste. For instance, major shifts of consumer habits, such as limiting their grocery trips, can drastically increase household food waste as consumers may misinterpret best-before and expiration dates on labels when trying new products or bulk-buying. Innovative preservation techniques can help reduce waste while facilitating distribution. Likewise, new systems and technologies for retailers can also contribute to monitor changes in consumer behaviour and respond to emerging trends in a timely manner. Similarly, the development and dissemination of consumer education

resources for responsible food purchase behaviour may contribute to reducing food waste in this area.

Innovative mechanisms for sourcing and distributing food to vulnerable groups can create new food supply infrastructures and systems that facilitate access to food for all. Innovative ICTs can also be deployed to map vulnerable populations and their access to food, so governments and communities can mitigate the social costs associated with the pandemic. These maps could also identify gaps, mobilize actors, and prompt strategies in cases of public emergency.

**Local food systems**

The COVID-19 crisis has drawn attention to the various benefits of local food systems. Alongside online shopping, local products and brands have gained increased popularity during the pandemic. Hyperlocal food systems that reflect people's values, culture, and environment have become a more sustainable option for many Canadians amidst the current crisis. Consumers concerned about purchasing agri-food products from countries where COVID-19 has spread have found in locally produced products an opportunity to meet their expectations for transparency while supporting local businesses and family-run companies during these unprecedented times.

Some stakeholders suggest that local food systems can help Canadians endure and recover from global shocks by feeding regional economics, supporting the local labour market, protecting the environment, and ensuring affordable access to agri-food products. However, other members of the sector indicate that, while there is a need to avoid disruptions in international trade, short supply chains, and stronger rural-urban linkages could also help make the Canadian agri-food system more resilient to a future crisis.

Moving forward, the success of these emerging market structures will strongly rely on establishing sustained and direct communications with customers while adapting their business models to evolving consumer behaviour. A more direct relationship with consumers is also an opportunity for retailers and manufacturers to leverage the appeal of local agri-food products to mitigate consumer concerns.

**Biotechnology**

A genetically diverse portfolio of improved crop varieties, adaptable to a broad range of ecosystems, and resilient to climate change is the foundation for food security and nutrition. In this context, biotechnology, including gene editing, genetic replication, and other synthetic biology techniques, may offer novel solutions to address food security issues.

# 4. SUSTAINABILITY: BUILDING A FUTURE-PROOF SUSTAINABLE SECTOR

The COVID-19 crisis has been a harsh reminder of the need to preserve the resilience of many sectors of the economy in light of health emergencies and natural disasters. The pandemic has also exposed many systemic weaknesses in the agri-food sector, which, if not corrected, will be most likely compounded by climate change and associated phenomena in the years to come.

The economic recovery from the COVID-19 crisis is the opportunity to "build back

**EMERGING RESEARCH AREAS**

- Sustainable recovery
- Circular economy
- Diversified agroecological systems
- Climate-resilient, green infrastructure
- Protocols for agricultural extension and on-farm research
- Water management
- Precision agriculture

better" (OECD, 2020a), rather than returning to environmentally destructive practices. Moving towards a more resilient agri-food system entails building a more sustainable value chain that efficiently reduces risk and vulnerabilities to a broad range of threats, including diseases, climate change, water scarcity, biodiversity loss, land degradation, and pests. This view is shared not only by key players in the agri-food value chain but also by all Canadians. A recent Abacus Data's poll (2020) found that at least half of those surveyed believe that climate change should be integrated into recovery efforts.

Environmental sustainability concerns should remain at the forefront of both scientific and technological development in the agri-food sector. Recovery measures should include research projects that promote both environmental sustainability and resilience while improving the sector's capacity for increased productivity of all the links in the value chain.

Maintaining the balance between agricultural production and the environment is crucial to ensure the sector's long-term resilience. Sustainable recovery post-COVID-19 would be possible by aligning productivity developments with environmental goals in areas such as agronomics, alternative feeds and additives, bioenergy, environmental-friendly packaging, and circular economy, among many others.

**Sustainable production**

Efforts should also be oriented towards paving the way for research and innovation projects that focus on the production of resilient, input use-efficient crop varieties suited to prevailing agricultural systems, agroecological contexts, and end-user preferences. Sustainable productivity growth to meet food security goals in a changing climate, for instance, can be supported by circular economic and diversified agroecological systems. The adoption of circular economic systems—industrial systems that are restorative by design (World Economic Forum, 2014)—can contribute to UN Sustainable Development Goals (SDGs) by designing out waste. Diversified agroecological systems—farming practices that intentionally include functional biodiversity to maintain ecosystem services that provide critical inputs to agriculture (Kremen, Iles & Bacon, 2012)—also offer a unique opportunity to reconcile the economic, environmental, and social dimensions of sustainability.

Climate-resilient, green infrastructure will likely gain renewed priority, thus increasing employment and capital formation. In this context, the development and deployment of novel technologies and production models can contribute to decarbonizing the agri-food sector while enabling farmers' transition to sustainable production intensification and diversification.

### Agricultural extension and on-farm research

Containment measures impacting crop production systems have prevented extension service providers and other various actors in the food system from performing their tasks. As a result, important services supporting sustainable farming activities, including training, field visits, and pest monitoring, have also been disrupted during the pandemic. Likewise, research and development (R&D) activities were suspended with significant consequences, impacting research institutions' abilities to release new crop varieties or provide agricultural extension advice. Because targeted training for producers is essential to trigger the sector's transition to more sustainable agricultural practices, post-COVID-19 agri-food extension and on-farm research protocols need to be assessed to provide ongoing support to farmers and producers and to be better prepared to avoid delays in emergency situations.

### Water management

The COVID-19 pandemic is closely related to access to safe water and sanitation. Alongside physical distancing and other precautionary measures, frequent hand washing and surface cleaning enormously contribute to preventing the transmission of the virus. Agricultural production and food security rely on access to freshwater resources, which are gradually diminishing. In fact, agriculture accounts for 70% of freshwater withdrawals worldwide (FAO, 2020d). Thus, achieving sustainable water management to increase water productivity in food and agriculture remains a key challenge for the agri-food sector. In the post-COVID-19 world, knowledge-based precision technologies for irrigation and farming practices that support sustainable intensification will be needed in the sector to contribute to this area.

# 5. FOOD SAFETY: SAFELY HANDLING, PACKAGING AND SHIPPING AGRI-FOODS

**EMERGING RESEARCH AREAS**

- Food safety practices
- Physical distancing and biosecurity protocols
- Sustainable packaging
- Consumer confidence and traceability

Although specific information about the virus causing COVID-19 remains unknown, at the time of writing, there is no evidence that people can contract the disease from food or food packaging. Likewise, livestock, such as poultry, hogs, cattle, sheep, among many others, do not carry the virus responsible for the current pandemic.

Recent research, however, concluded that the COVID-19 virus can survive on different surfaces–including plastic, cardboard, stainless steel, and copper–for between 24 and 72 hours (FAO, 2020b, c). This evidence suggests that agri-foods can potentially be contaminated through

contaminated respiratory droplets or through contact with contaminated equipment, surfaces or environments.

The agri-food sector must reinforce new and established environmental sanitation measures and food safety practices to mitigate the spread of COVID-19. While the use of personal protective equipment (PPE)—gowns, gloves, masks, and facial protection—provides a physical barrier to help prevent potential exposure to the virus, physical distancing, strict hygiene and sanitation measures at each stage of food production processing, manufacture, storage, and distribution until the point of consumption are critical to surviving the current pandemic. Post-COVID-19, public health protocols aimed at reducing the likelihood that harmful pathogens threaten the safety of the food supply will likely be integrated into the day-to-day operations of producers, processors, distributors, retailers, and foodservice operators.

Ensuring compliance with measures to protect food workers and prevent food contamination calls for long-term, innovative, cost-effective, and sustainable approaches to strengthen food hygiene and sanitation practices.

The threat of COVID-19 calls on the need for additional hygiene and sanitation measures to be introduced to ensure protection for food workers. These measures include guidance for food handlers who directly touch agri-food products on a daily basis and workers who touch surfaces where food is handled.

From producers and processors to foodservice operators and retailers, the entire value chain would benefit from research on enhanced, cost-effective biosecurity protocols and specialized infrastructure to mitigate disease risk and maintain the integrity of the Canadian agri-food system. Establishing appropriate biosecurity measures for the sector supported by scientific evidence on food safety practices will become a key priority along the supply chain for the foreseeable future. Moreover, as we emerge from the COVID-19 crisis, an enhanced focus on biosecurity in livestock production to prevent transmission of zoonotic agents will be necessary to minimize food safety risks.

Likewise, the agri-food supply chain comprises multiple direct face-to-face interactions between on-field workers, suppliers, and distributors, which makes physical distancing particularly challenging. Yet, as physical distancing measures will likely need to continue for the foreseeable future, stakeholders in the sector may have to work together to come up with cost-effective solutions to ensure the ongoing practice of physical distancing. As outlined in the previous section, on-farm research and extension programs would have to find innovative ways to bring research results and new technologies to producers and processors while

sustaining widespread compliance of physical distancing guidelines. In this context, automated systems and digital platforms can enormously contribute to protecting workers' health and safety while reducing both costs and the demand for physical labour at different stages of the agri-food value chain.

In a post-COVID-19 world, handling, packaging, and shipping food will need to meet higher quality and safety standards. With the recent surge in demand for food delivery, smarter sustainable packaging solutions and practices that maintain food quality while assuring protection from contamination will become an important area of research.

On the consumer side, complying with these measures beyond the current crisis will certainly contribute to maintaining trust and confidence in agri-food products. Consumers now expect high-quality agri-food products that provide greater assurance of health risks being further minimized. Along the agri-food supply chain, industry players will be required to clearly communicate why their products and processes should be trusted. In fact, after COVID-19, consumers will likely base their in-store purchasing decisions on cleaning and safety measures undertaken by physical selling points.

Finally, strong communications strategies can also contribute to improving consumers' trust in the safety of agri-food products. Those may include the reviewing of existing transparency requirements to ensure the traceability of food and the implementation of food safety requirements to the rapidly growing field of food and beverage industry e-commerce.

# 6. LABOUR

Containment measures to mitigate the spread of coronavirus disease affected agri-food production on various fronts, including labour. While the capital-intensive commodities–wheat, maize, corn, soybeans, and oilseed–have been less impacted by labour shortages, labour-intensive commodities–fruits, vegetables, meat, dairy production, and fishery–have been substantially affected (Torero-Cullen, 2020).

**EMERGING RESEARCH AREAS**

- Automation and mechanization
- Domestic labour force in the agri-food sector
- High-skilled workers

COVID-19 spotlighted the strong dependence of primary agriculture and food manufacturing on foreign labour. As many producers and manufacturers have been unable to meet their labour needs with local workers, they have turned to hire seasonal foreign workers to fill the labour gap. Temporary foreign workers (TFW) are employed in various roles, from planting

and harvesting to operating agricultural machinery and obtaining raw animal products. Figure 2 shows the share of jobs in Canada's primary agriculture filled by TWF among jobs of all employees. In 2018, nearly 55,000 jobs were filled by TFW, who accounted for 20% of total employment in primary agriculture Statistic Canada (2020c). Fish, seafood, and meat processing plants are also reliant on international food workers. About 30% of the workforce in Canada's seafood industry is made up of foreign workers (FAO, 2020j).

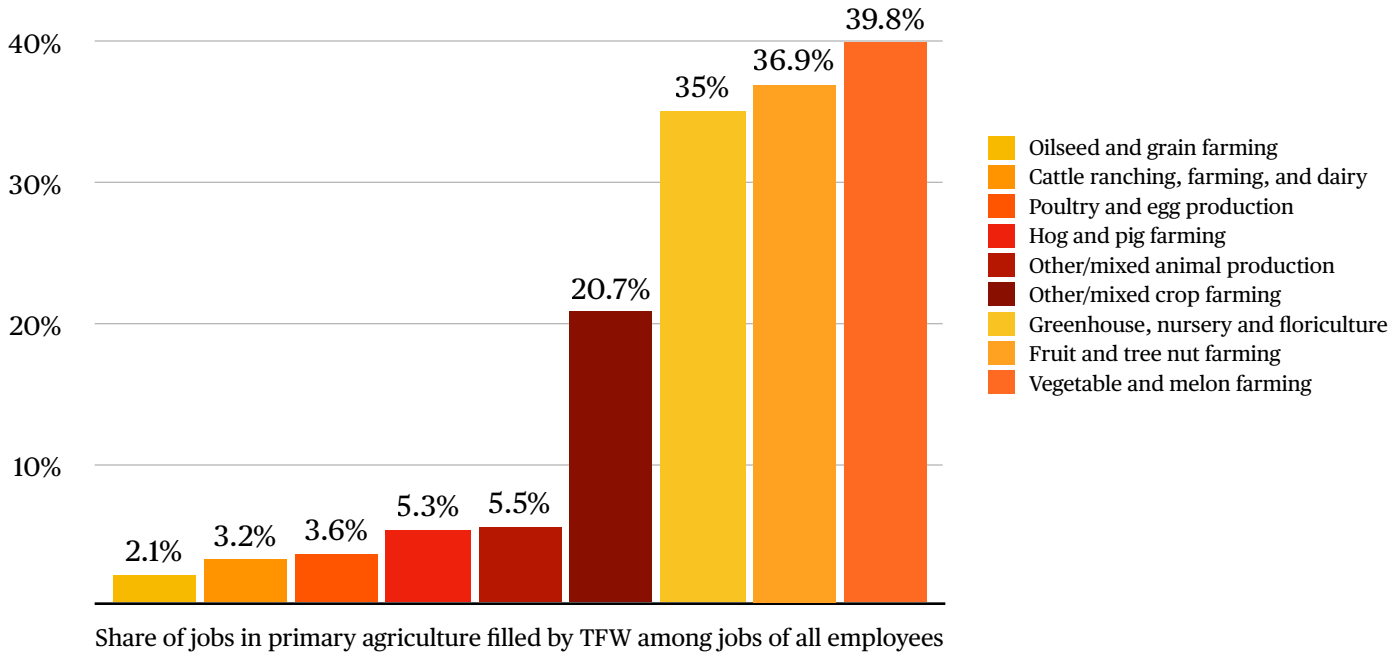



**Figure 2**. Share of jobs in primary agriculture filled by TFW among jobs of all employees.
***Source:*** Statistics Canada (2020). Temporary Foreign Workers File, 2018. Excludes Territories.

According to experts and various stakeholders, movement restrictions, travel delays, and added complexity to the arrival of seasonal foreign workers employed in primary agriculture have made access to qualified foreign workers one of the most important issues impacting crop and livestock production in Canada. Moreover, significant labour shortages can jeopardize the food processing industry's ability to supply agri-food products, leading to increasing prices for food staples post-COVID-19.

Implementing new screening processes, distributing personal protective equipment, ensuring physical distancing in common or shared spaces, such as fields, eating areas and bunkhouses, and complying with self-isolation requirements represent a significant added expense for employers. While ensuring occupational safety and health measures remains a crucial factor

in reducing the risk of infection, these actions will undoubtedly create a financial burden for agri-business.

Some Canadian producers have looked for opportunities to attract an alternative workforce, including workers laid off in other sectors and summer students. While attracting more domestic workers remains a critical need for the sector, increased automation and mechanization can also contribute to addressing labour shortages arising from the health crisis in the long run.

Before the pandemic, the global food automation market was projected to grow at a CAGR of 6.90% from USD 8.22 in 2017 to 12.26 billion by 2022 (Markets & Markets, 2017). With the increasing adoption levels from industry, this growth rate is now expected to increase to 7.5% to reach USD 14.3 billion by 2025 (Globe Newswire, 2020).

There is an opportunity for agri-tech companies to automate all links in the food value chain. From pruning, seeding, weeding, and harvesting to food processing, packaging and transporting, automation can optimize process flow, reducing turnaround times and preventing losses. In the foodservice industry, operators can benefit from technologies that facilitate online delivery options, providing greater value to producers, processors, and operators.

A highly automated sector entails less exposure to COVID-19 while ensuring the uninterrupted flow of agri-food products. Still, the technological changes required to increase efficiencies will inevitably raise the demand for high-skilled workers in the agri-food sector.

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