

Farmer 4.0

How the coming skills revolution can transform agriculture

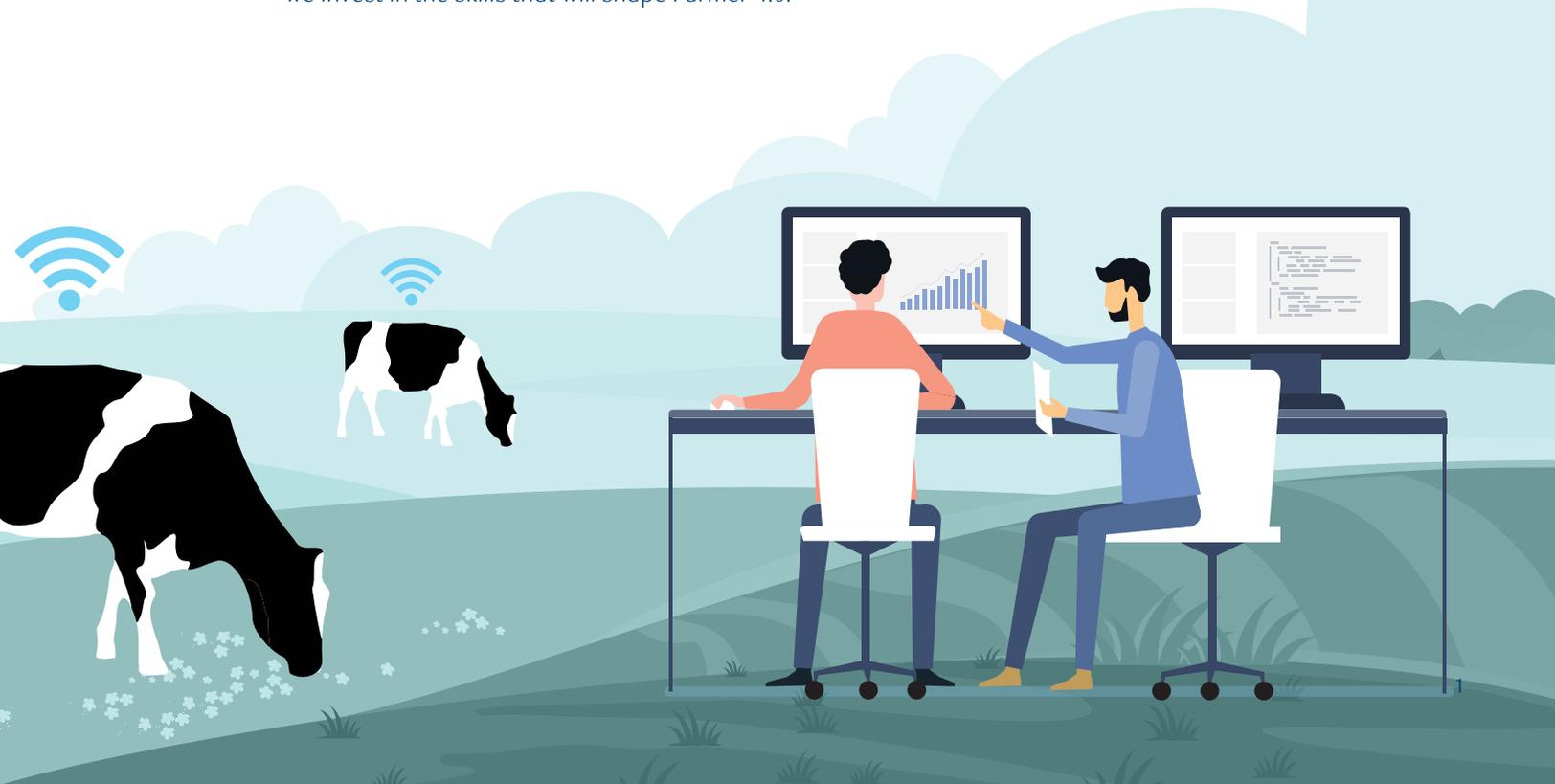




Taking the Field

A fourth agricultural revolution is underway, and Canada needs to seize it. The Internet of Farming, powered by advanced technologies like autonomous tractors and drone-mounted sensors, is already transforming the way we produce food. But this new generation of agriculture will take a new generation of skills, too. Canada is poised to meet that challenge. No other country has as much land, water or market access — or the education system to develop farmers and food producers who can thrive in a hyper-connected, data-driven economy. And yet our share of global exports is falling and productivity of our farms stalling. It could get worse, as a historic retirement wave begins and young Canadians show few signs of filling the gap. It's more than an economic imperative. Our food security is at stake, as is our chance to feed the world in more sustainable ways.

To help Canadians understand this critical moment, RBC's economics and thought leadership team analyzed labour-force data, sector trends and innovations in other countries. We also spoke to farmers, educators and agriculture authorities across Canada, to understand what a new skills agenda could look like. We concluded that with the right mix of skills, capital and technology, agriculture could add \$11 billion to Canada's GDP by 2030. To get there, we need to rethink our approach to education, both for agriculture and the growing range of sectors that affect it; do more to attract young people to farming; and invest in the skills needed to attract a growing immigrant population to the sector. Three previous agriculture revolutions — the domestication of plants and animals, the mechanization of work and the mass scaling of genetic and chemical science — led to profound changes. The fourth will be no less powerful, if we invest in the skills that will shape Farmer 4.0.

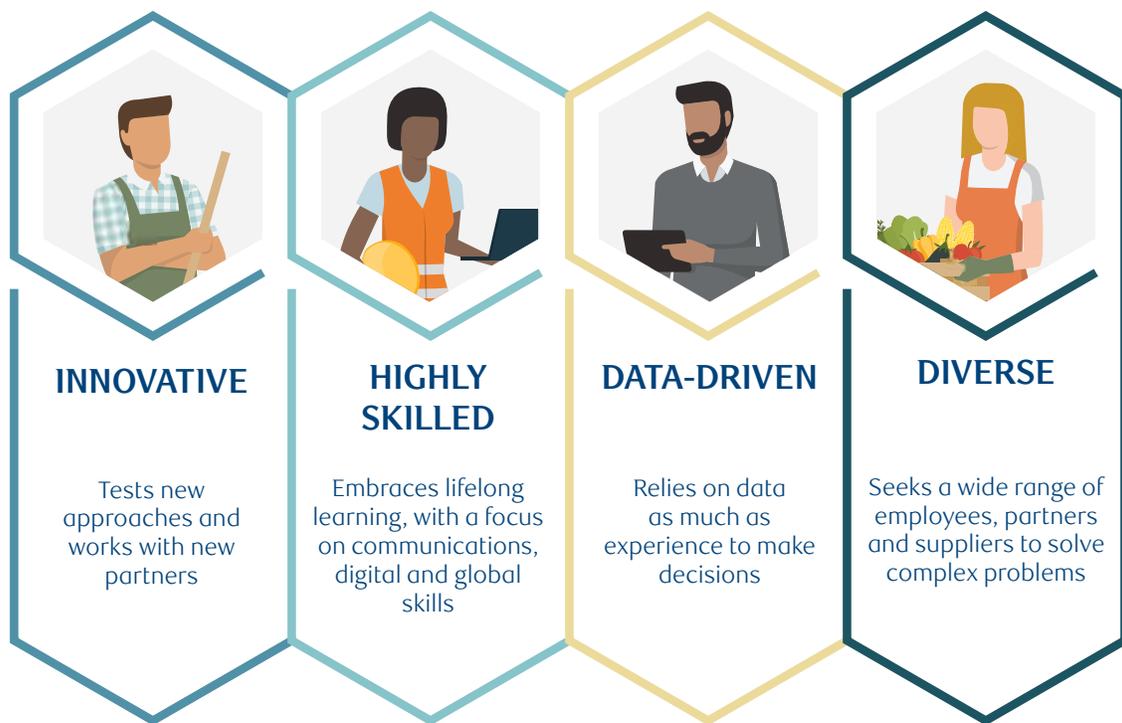


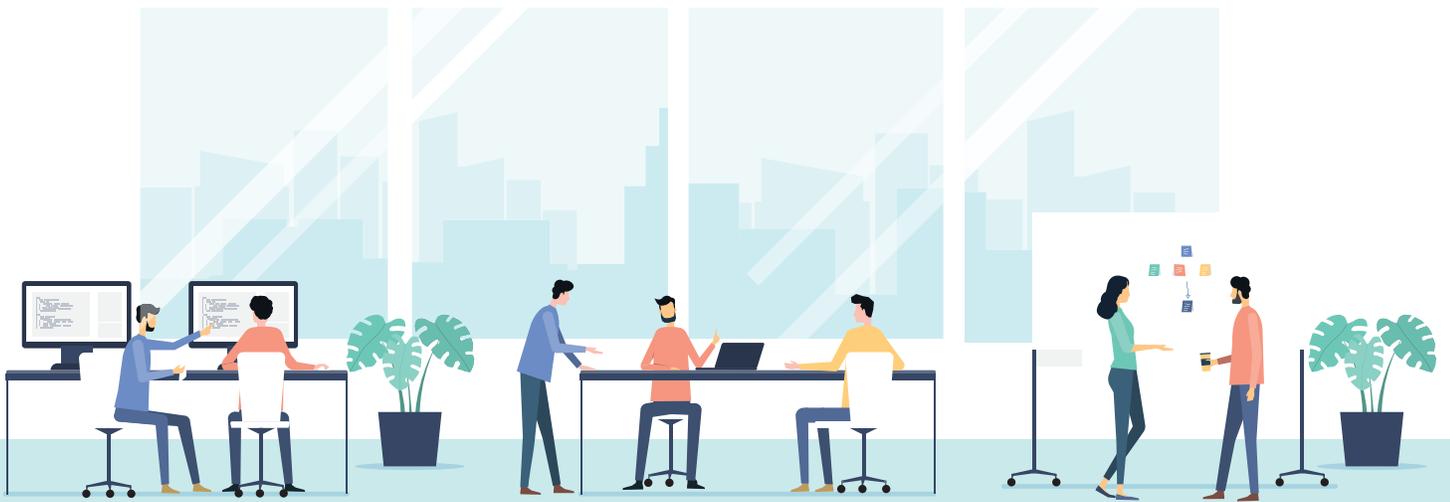
Key Findings

1. Canada faces a skills and labour crisis in agriculture, with a projected domestic shortage of 123,000 workers within a decade.
2. Canada could gain \$11 billion in annual GDP by 2030 by closing the agriculture labour gap and accelerating investment in technology. This would bring agricultural GDP to \$51 billion, making it bigger than automobile assembly and aeronautics combined.
3. Canada's share of global agriculture exports has fallen since 2000, as developing countries like China, India, Indonesia and Brazil produce and sell more to the world.
4. Canada imports more farm machinery than we make, while our share of global agtech investment is only 3.4%, behind that of India and Brazil.
5. Nearly half (47.2%) of agriculture workers under 40 have a post-secondary or CEGEP education, while those with only secondary schooling or apprenticeships are decreasing in number.
6. Enrolment in post-secondary agriculture programs jumped 29% in the past decade.
7. More than 80% of producers under the age of 40 report using technology; for those over 60, it's 57%.
8. One-quarter of Canada's farmers will be 65 or older by 2025.

Meet Farmer 4.0

Over the past century, Canadian agriculture has undergone three technology revolutions, and each has transformed farm and food production skills. In the early 1900s, a proliferation of seeds, fertilizers and machines began to allow subsistence farmers to specialize. By the middle of the 20th century, the spread of diesel- and gas-powered tractors changed things again, turning farmers into farm operators. In the 1970s and '80s, the advent of software and advances in crop genetics changed the role once more, into that of business manager and entrepreneur. Today, a fourth revolution in agricultural technology is underway and it's all about data. Farmer 4.0 will need to focus on strategy and systems, leaving past tasks to a new generation of smart machines.





A Growing Opportunity

Skills, technology and the future

Visit a canola farm in Saskatchewan these days, and you may spot a seeder moving up and down the fields without a person in sight. The autonomous DOT platform is the latest disruptive technology to hit farming, and it won't be the last. The machine (named by the inventor after his mother, Dorothy) drives itself, tells the farm owner about soil conditions and reports back, in real time, how it's performing in the field.

DOT, which is made in Saskatchewan, is hyper-efficient and may seem like a job-killer. It is anything but. Look more closely at one of the fields where it's working, and you'll spot a couple of software engineers, giving chase, to monitor, update and occasionally debug the \$500,000 contraption.

It's just one illustration of the fourth agricultural revolution, which is already demanding new technologies and skills, a fresh management mindset and a more global outlook than the previous generations of food production ever harnessed. And here's the surprise: even as automation replaces the hard physical tasks that once defined farming, the human quotient in food production appears to be greater than ever.

As we enter the 2020s, Agriculture 4.0 — powered by cognitive machines and a skills-savvy workforce — is starting to determine whether Canada can once again be an agriculture superpower, and do it in a way that feeds an ever-hungrier world, cuts greenhouse gas emissions, and supports thousands of communities that still help define our country.

Coding at the farm gate is just one illustration of the skills revolution underway. Across the Prairies, there are geneticists helping farmers meet the surge in demand for plant-based proteins. In the Okanagan Valley, horticulturalists are working with drones and earth sensors to better program their irrigation systems. In the greenhouses of Ontario, mechanics are tooling robots to pluck berries, while people are being redeployed to optimize growing conditions with market conditions. And farther east, off the coast of Atlantic Canada, lobster crews are working with sensors in underwater traps to gauge the environmental conditions of their catch, and ensure the data moves quickly into the systems of buyers around the world.

A strategic moment

There's no question, the world will need more food in the decades ahead; by 2030, there will be 835 million more people, and only 4 million of them will be Canadian.

Few countries are better positioned than Canada to provide that, and do it sustainably. Since 2011, Canada has consistently ranked as the world's 5th-largest global exporter of agricultural products. Our producers of oats and corn, as well as fish, pork and cranberries, are among the best, and have the market share to show it.

But equally, Canada could fall behind as the rest of the world moves rapidly into a new age of food production. Our share of global exports fell from 6.3% in 2000 to 4.9% in 2005 to 3.9% today, despite increased output. Yes, more farmers in more places, including China, India and Brazil, are growing more for the world. But Canada's agriculture productivity has also stalled.

Our access to the world should improve as a result of new trade agreements with Europe, Asia and the United States. The Comprehensive Economic and Trade Agreement, or CETA, eliminated most tariffs on Canada's agriculture and seafood exports to Europe and its 500 million people,

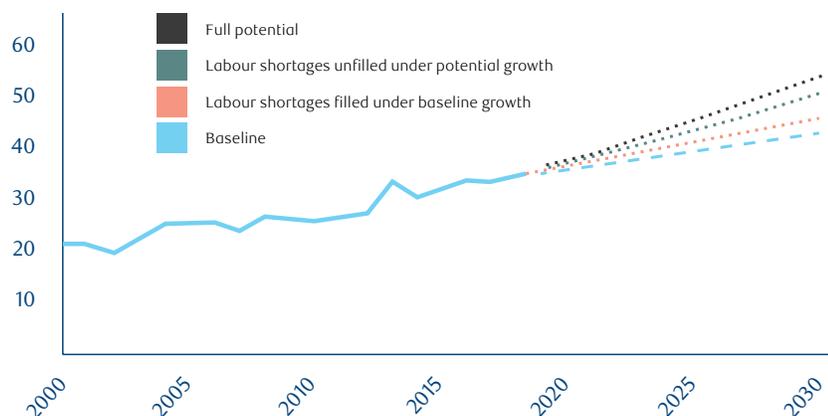
while the Comprehensive and Progressive Agreement for the Trans Pacific Partnership, or CPTPP, gives Canadian producers preferential access to 11 countries, including Japan, Vietnam and Australia, that represent another 500 million people and 13.5% of the world's economy. The U.S.-Mexico-Canada Agreement, or USMCA, may be the most important of all, securing continued access to the world's most advanced — and competitive — markets.

To seize on those opportunities, Canada needs to transform the way we produce food, and market it globally. If we don't, the sector will likely grow by only 1.8% annually on its current path of declining productivity, raising output to around \$40 billion in 2030 from \$32 billion today. But if we accelerate the adoption of innovative technologies and embrace an ambitious skills agenda, our research indicates Canada's agricultural productivity can get back in line with the recent 10-year average of 3%. The payoff: another \$11 billion of output, bringing agricultural GDP to \$51 billion in 2030.

We can add even more if we follow the lead of the Netherlands or Australia to develop world-class skills and embrace a culture of innovation across the sector.

Potential for Agricultural Sector Growth

Billions of 2018 \$



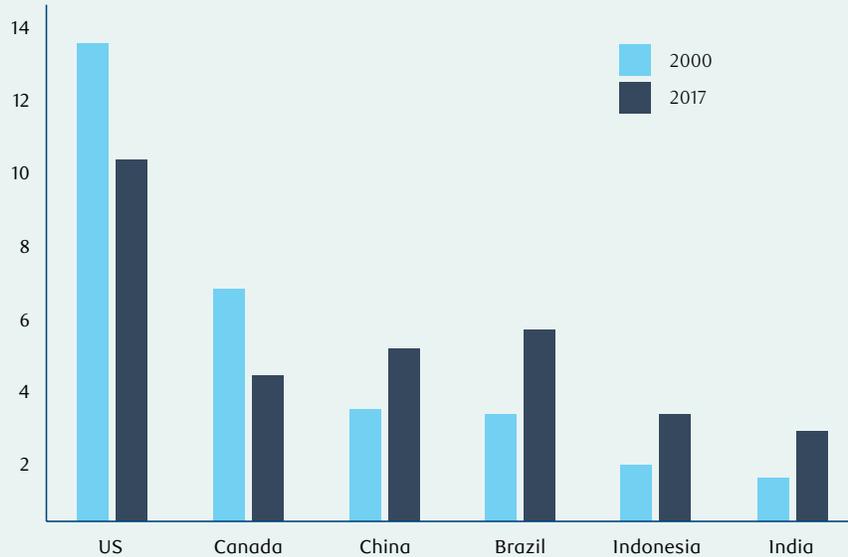
Source: RBC Economics, Statistics Canada, CAHRC

\$11 billion

Potential new agricultural output to be gained by 2030 by embracing an innovative skills agenda.

Change in Share of Global Agricultural Exports

Exports by Country, 2000 & 2017, by %



Source: RBC Economics, World Trade Organization

Agriculture's skills crisis

Mention labour-force challenges in any conversation about agriculture, and concerns are likely to turn to supply. We don't have enough people, and that's before the sector considers a decade-long demographic crisis that's about to begin. In a sector that shed 31% of its workforce over the last 20 years, there remain 16,500 vacancies, even after adding 60,000 foreign workers. Within a decade, the Canadian Agricultural Human Resources Council expects as many as 123,000 jobs to go unfilled by Canadians.

There's one simple reason: by 2025, one in four Canadian farmers will be aged 65 or older, and over the next decade 37% of the agricultural workforce will be set to retire. Moreover, Canadian youth are not looking to replace them, with 600 fewer young people entering the sector every year. Just look at any population map to see the challenge. Canada's cities have grown by more than 50% over the last three decades, to 25 million; our rural population has stayed flat at 6 million.

That's the quantity challenge. We'll need a shift in quality, too.

Some elements of Canada's approach to agriculture skills are already ground breaking — such as the scientific knowledge

OPPORTUNITIES FOR GROWTH

Only 0.08% of Canada's agricultural exports (almost exclusively wheat) go to Nigeria, where the population could double by 2050.

and practical experiential learning that 30,000 students in post-secondary agriculture programs are exposed to. Six Canadian universities rank in the top 100 agriculture and forestry programs globally, according to the widely respected QS World University Rankings. Another piece of good news: the number of students in ag programs has jumped 29% in the past decade — a faster pace than the 21% growth across all programs.

But in the decade ahead, we will need a lot more of that — as well as a better approach to lifelong learning for those already at work, and a continuous approach to new skills. It's not just digital skills. Across the country, we heard about the need for agriculture managers with experience in human resources and integrated systems management, and more exposure to programs focused on finance, engineering and environmental studies.

Farmer 4.0 will be working in office towers, data centres and engineering labs around the country, plugging into the people and machines that can turn our land and water into a hyper-efficient, and sustainable, food source for the planet.

The technology gap

All those new skills will need new technology, too, if they're to reach their potential. Unfortunately, Canada is lagging in the agtech race.

Canadian farmers rely heavily on government-supported funding for new technologies and processes. Even accounting for Canada's smaller size, private investment in R&D is a tiny fraction of what U.S. firms invest in the industry.

Meanwhile, global investment in agtech is booming. It hit a record of US\$16.9 billion last year, up 43% from 2017. Of that, about US\$6.9 billion was invested in technology specifically related to food production. While Canada ranked in the top five, our share of global agtech investment was 3.4%, or less than that of either India or Brazil, emerging economies that have significantly boosted their market share in agricultural exports in the last two decades.

PRIVATE SECTOR'S SHARE OF AGRICULTURE R&D SPENDING:



11%



73%

Source: AAFC, USDA

OPPORTUNITIES FOR GROWTH

Aquaculture is expected to surpass capture fisheries as the most important source of fish and seafood worldwide by 2022. Canada currently produces 0.2% of the world's aquaculture products.

The capital question

Canadian farming will also need more capital.

Agriculture is a capital-intensive business. It always has been. Which makes it tough to compete in a new economy that thrives on software and puts an ever-greater value on intangibles.

In 2016, the Canadian agriculture sector held \$510 billion in capital assets, with land and buildings comprising more than 80% of that value.

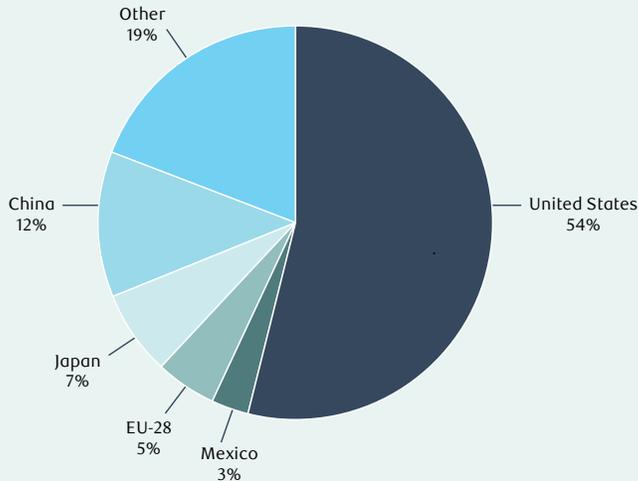
Farmers' access to credit is also surprisingly low: Canadian agriculture has a 1.9% share of national commercial lending. The global average is 2.9%; in New Zealand, it's 14.1%.

While Canadian farms hold substantial capital wealth, high operating and asset-servicing costs weigh on profitability — and make the challenge of drawing new talent even greater. Current expenses alone eat up some 83 cents of every dollar of sales, hampering producers' ability to invest in new technologies or skills.

The capital intensity is one of the reasons so many operations stay family-owned and operated, and stands as a barrier to young, Indigenous and new Canadians thinking about a career in agriculture.

Top Agricultural Export Destinations

Canadian Exports by Country, 2017 by %



Source: RBC Economics, The World Bank

OPPORTUNITIES FOR GROWTH

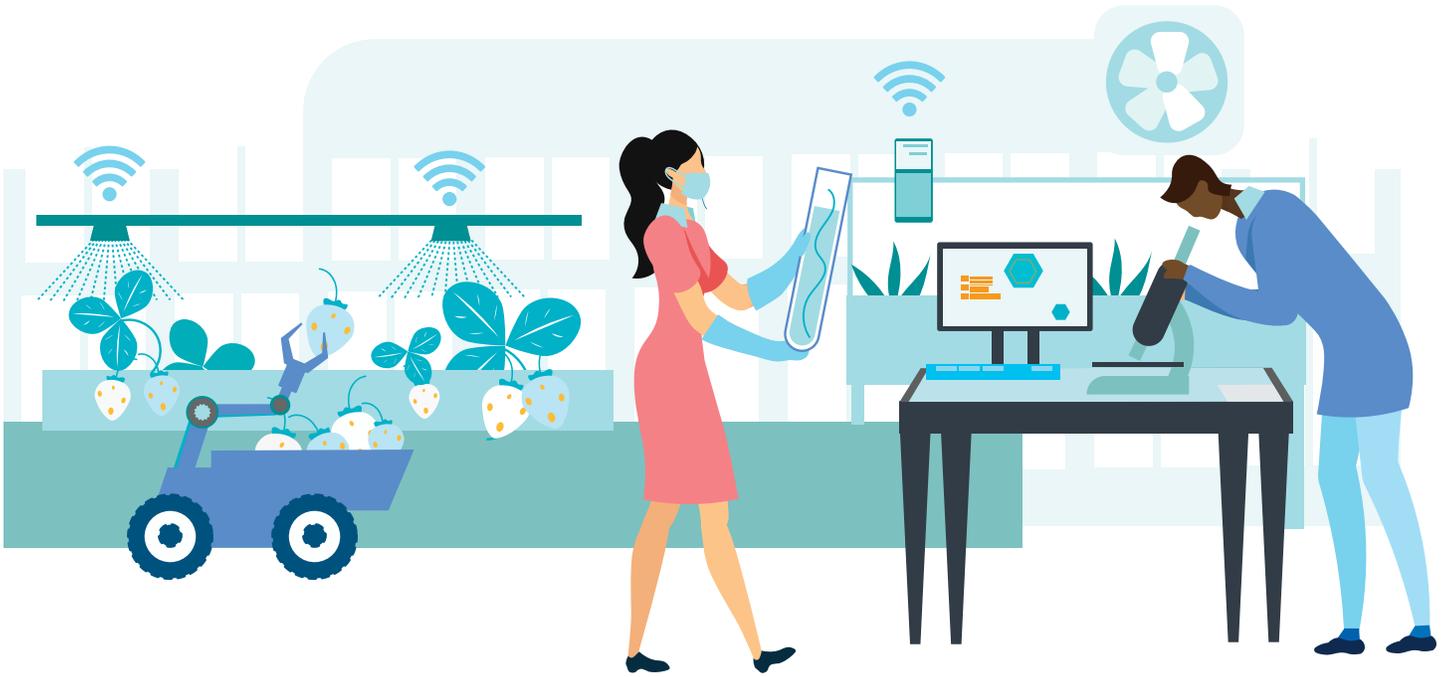
In India and Pakistan, where meat isn't a significant source of protein, consumption of dairy products is expected to rise substantially. Advances in technology and transportation could solve a key challenge: because they spoil easily, dairy products are difficult to trade internationally.

Thinking global

The good news is Canadian food producers are getting more competitive and more global. By one measure, 7.6% of Canadian farms achieved more than \$1 million in annual sales in 2016, compared with less than 2% two decades ago — and well above the 2.9% for U.S. farms.

The economic benefits of a more efficient sector are there. So, too, is the imperative of feeding close to 9 billion people by 2030 while not damaging the planet for the decades ahead. More technology, more skills and more people can help, if we get the ingredients right. But Canada will need to take a more focused approach to how we develop and support the agriculture workforce of tomorrow.





Food Producers of the Future

What the landscape could look like in 2030

We've looked at the constraints and opportunities facing food producers over the next decade and argued that an ambitious skills agenda could help reposition Canada as a more efficient, sustainable and competitive global leader in agriculture.

To see how, we used our *Humans Wanted* model of skills clusters to create five categories of agriculture workers and assess which ones will be in demand and what skills will be needed to meet that demand.

How will disruption transform these roles? What skills and experience will they need? And what education and training programs will help prepare these groups for a decade of transitions?

AGRICULTURAL JOBS UNFILLED BY CANADIANS

2017: 63,000

2029: 123,000

Source: CAHRC

The Decider

These are the entrepreneurs at the core of agriculture, the people who operate businesses ranging from single-family farms to large-scale vineyards. They make critical choices regarding hiring, capital investment and product allocation, and face little risk of automation. While they'll remain the backbone of the sector in 2030, deciders will need to manage ever-larger and more technologically complex operations, and will need the leadership skills and digital expertise that go along with that shift. Business skills, technology awareness and people management will be more in demand than ever. And the biggest need? More critical thinking. Recognizing this need, the Ontario Agricultural College at the University of Guelph has added communications and business skills development to a program that has been training farm operators and agriculture leaders since 1874. One key challenge: due to farm consolidation and an aging workforce, the number of deciders is shrinking faster than the demand for their entrepreneurial spirit and business acumen.

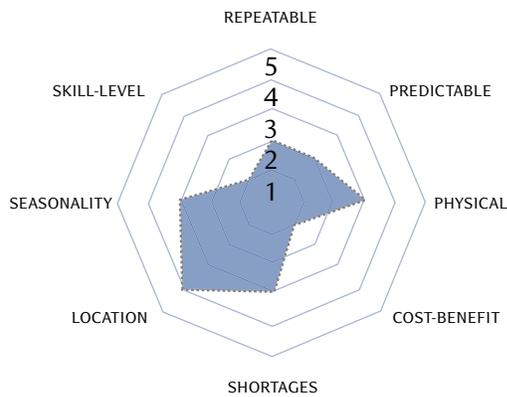
Labour Profile by 2030:

Demand: **135,570** Demand Growth: **-1.4%**

Shortage: **17.2%**

Automation Profile:

Probability: **5.4%**



Likelihood of automation, by select factors
1-very unlikely to 5-very likely



Phil Tregunno
Owner/operator

Tregunno Fruit Farms, Niagara-on-the-Lake, ON

“Automation is already here. It definitely won’t take 30 years before the industry is completely transformed.”

Phil has seized the opportunity provided by the retirement of local farmers to expand his family farm into an 850-acre tree fruit and wine-grape operation in Ontario’s Niagara region. He buys a new farm every year, and employs around 130 people during peak season — including 30 Mexican families who return year after year under Canada’s Temporary Foreign Worker program. Phil now has his sights set on displacing some of the imported fruit that’s found in abundance on Canadian grocery store shelves. Helping him compete against powerful rivals will be RFID (radio-frequency identification) tags to track produce from the tree or vine right to the container, and an automated box filler that uses imaging technology to grade each piece of fruit. While investing in the latter has enabled Phil to cut the number of workers needed to pack a trailer from 20 to 3, he’s opted to re-allocate that labour back into harvesting.



Tanton Archdekin
 Agriculture equipment technician
 Cervus Equipment, Saskatoon, SK

“Producers want the most efficient machines, and that means the most accurate data. If a sensor or implement is out of alignment, they can see it on their bottom line.”

On any given day Tanton is working at a different farm on tractors or combines, sprayers, seeders and bailers. These machines no longer serve single functions, as they are loaded with software and sensors collecting data and generating insights. To keep pace, Tanton — a journeyman welder and Saskatchewan Polytechnic grad — is in a constant state of learning, whether reviewing technical manuals or out in the field. He left the mining sector to pursue agricultural mechanics, seeing how technology was changing the industry at an incredible rate. Now he is on the front line of that change, making sure each farm’s machinery produces the efficiencies that his clients are striving for. Next up: hybrid drivetrains and autonomous tractors.

The Enabler

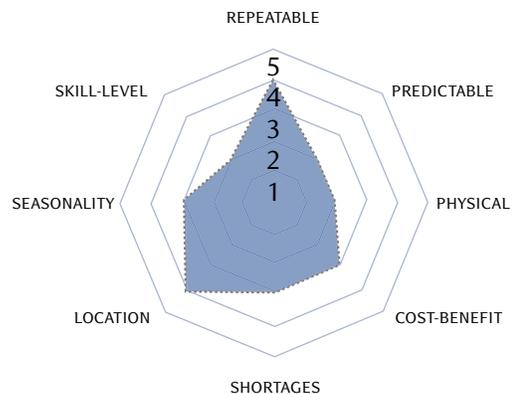
These are the skilled workers who supply, service and program the machinery and equipment that enable farms to function. They assess an operator’s equipment needs and install machines and technology that augment or supplant human labour. Enablers will play a critical role as agriculture becomes more automated, providing the technical know-how for digitally enabled farms. The skills growing in demand include software and user interface, leadership and business acumen, and the ability to install and repair equipment. Enablers will also need critical thinking skills and the ability to monitor complex technology and manage diverse groups of people. The University of the Fraser Valley is developing enablers with a two-year Agriculture Technology diploma program that provides specialization in either horticulture or livestock production, in conjunction with the university’s automation and robotics program. Supply constraints mean enablers will increasingly need to come from outside agriculture, from fields like engineering and computer science, raising the need for more education programs that cut across disciplines.

Labour Profile by 2030:

Demand: **24,762** Demand Growth: **8.7%**
 Shortage: **17.6%**

Automation Profile:

Probability: **51.9%**



*Likelihood of automation, by select factors
 1-very unlikely to 5-very likely*

The Specialist

While specialists form a smaller group, they're the piston in the sector's productivity engine. Specialists range from plant scientists and livestock managers to regulatory experts, whose technical know-how will be critical as operators try to keep pace with the world. Properly harnessed, they'll also be crucial to securing Canada's global brand for clean, sustainably produced food. The specialists of tomorrow will need more than subject-matter expertise, however. They'll have to be skilled in data analytics and precision agriculture, with an ability to communicate and collaborate with specialists from non-agricultural fields such as blockchain, artificial intelligence and intellectual property rights. The biggest general needs? Judgment and decision-making, followed by active listening. To develop more specialists, the Marine Institute of Memorial University in St. John's has developed a one-year post-graduate program in Sustainable Aquaculture, which mixes classroom instruction with three months of workplace training.

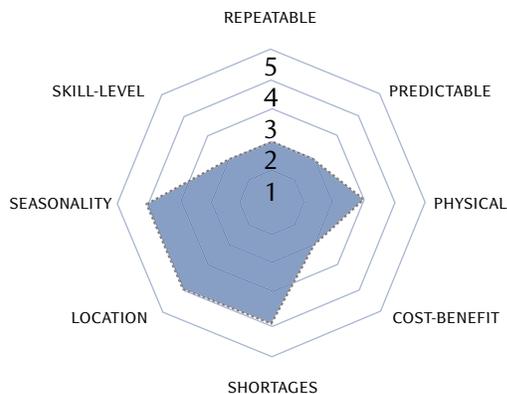
Labour Profile by 2030:

Demand: **18,393** Demand Growth: **6.7%**

Shortage: **25.7%**

Automation Profile:

Probability: **10.4%**



Likelihood of automation, by select factors
1-very unlikely to 5-very likely



Jessica Landry

Genomics and animal health specialist

Ferme Landrynoise, Saint-Albert, QC

“I got my training to see how things worked elsewhere and to bring that knowledge back to the farm, to improve what we do. Working with animals is never the same, so I need to keep up on the latest developments.”

Jessica had a significant incentive to earn a professional diploma in milk production and animal health from the CEGEP de Saint-Hyacinthe: her family owns Quebec's largest dairy operation, a 4,000-acre spread whose herd includes 1,200 milking cows and produces 39,000 litres of milk a day. Her father and uncles run the business end of the farm, which employs about a dozen staff and 28 robotic milking units. Jessica specializes in genetics for the herd, managing breeding and calving and other aspects of health for the farm's 2,500 animals. Data is becoming even more important to her role to track output and wellbeing of the cows and to develop care plans with veterinarians.



Israel Pillar-Perez

General labourer

Jost Vineyards, Malagash, NS

“The type of work I do hasn’t changed a lot over 12 years. I mainly work with my hands. It’s very physical work. I learn as I go, about different crops and ways of doing things, often with help from the other workers.”

Israel has provided general labour on a series of farms across Canada for the past dozen years, supplementing his Canadian-earned income with periods of construction work at home in southern Mexico. While he’s tended to a variety of crops from cucumbers to cauliflowers, his placements have all depended on manual skills. At Jost Vineyards, Israel’s work involves everything from planting and pruning to harvesting. He’s received on-the-job training and has learned to drive a tractor, though his limited command of English has been a barrier. Israel plans to continue to work seasonally in Canada’s agriculture sector as long as he can. He believes demand for skills like his will continue, based on what he’s observed in stints on farm operations in Western and Central Canada and now, Nova Scotia.

The Doer

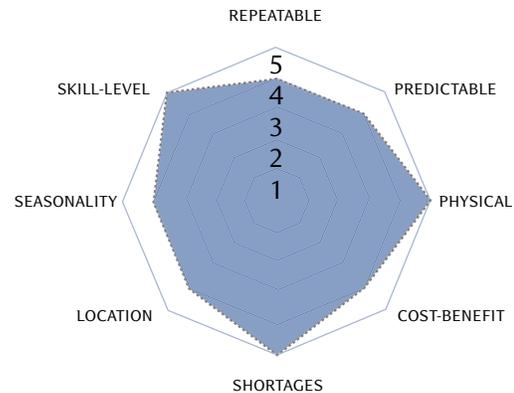
Doers provide the heavy lifting of agriculture, and for the most part represent general farm labour. While there are almost as many doers as deciders, they’re largely seasonal workers from other countries performing low-skill harvesting and packing work that many Canadians reject. The demand for them will increase in the short run — to as many as 115,000 foreign workers by 2030 — and decrease in the long term, presenting a critical transition challenge. Doers face significant disruption from automation, with a 94.2% probability that some of their skills will be replaced by machines in the future. That won’t happen overnight, however, because of the delicate nature of agricultural labour. Consider a fruit operation, where robots cannot yet pick small berries or identify ripe fruit. As technology advances, the biggest need for doers will be the things machines can’t yet provide: judgment, fine dexterity and digital interfacing skills. To manage this transition, Canada may need to provide retraining programs for labourers, even for those on temporary work permits, as they may be needed to fill the void left by retiring operators and supervisors.

Labour Profile by 2030:

Demand: **165,543** Demand Growth: **8.5%**
 Shortage: **51.2%**

Automation Profile:

Probability: **94.2%**



Likelihood of automation, by select factors
 1-very unlikely to 5-very likely

The Advisor

These are the highly educated and experienced consultants and strategic thinkers — think agronomists and financial advisors — who help farm operators make critical decisions on everything from capital allocation to business expansion and export strategies. As agricultural businesses become larger and more complex, the demand for outside consultants with deep, data-driven expertise will expand. To excel, advisors will need foundational skills that include critical thinking, communications and math. Specific skills in demand will include agronomy and data analysis (which is in short supply everywhere). To help develop advisors, Olds College in Southern Alberta created a post-diploma certificate as a pathway into the sector for non-agriculture graduates from, say, finance or global affairs programs. The college, in 2018, launched a Smart Farm to connect students with new technologies, like digital weather stations and wireless grain bin sensors, and help them develop their abilities to make evidence-based decisions to improve productivity, profitability and sustainability. Such “techronomy” training will prepare them to advise operators in any field.

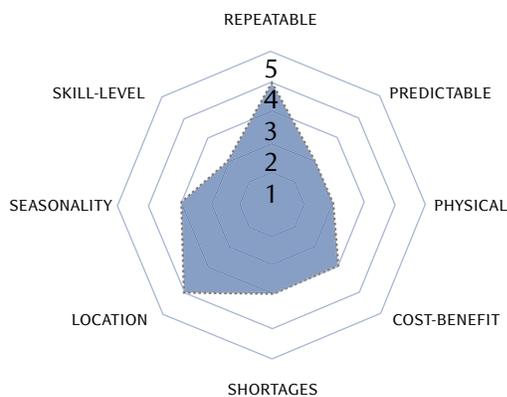
Labour Profile by 2030:

Demand: **18,146** Demand Growth: **7.5%**

Shortage: **22.3%**

Automation Profile:

Probability: **42.8%**



Likelihood of automation, by select factors
1-very unlikely to 5-very likely



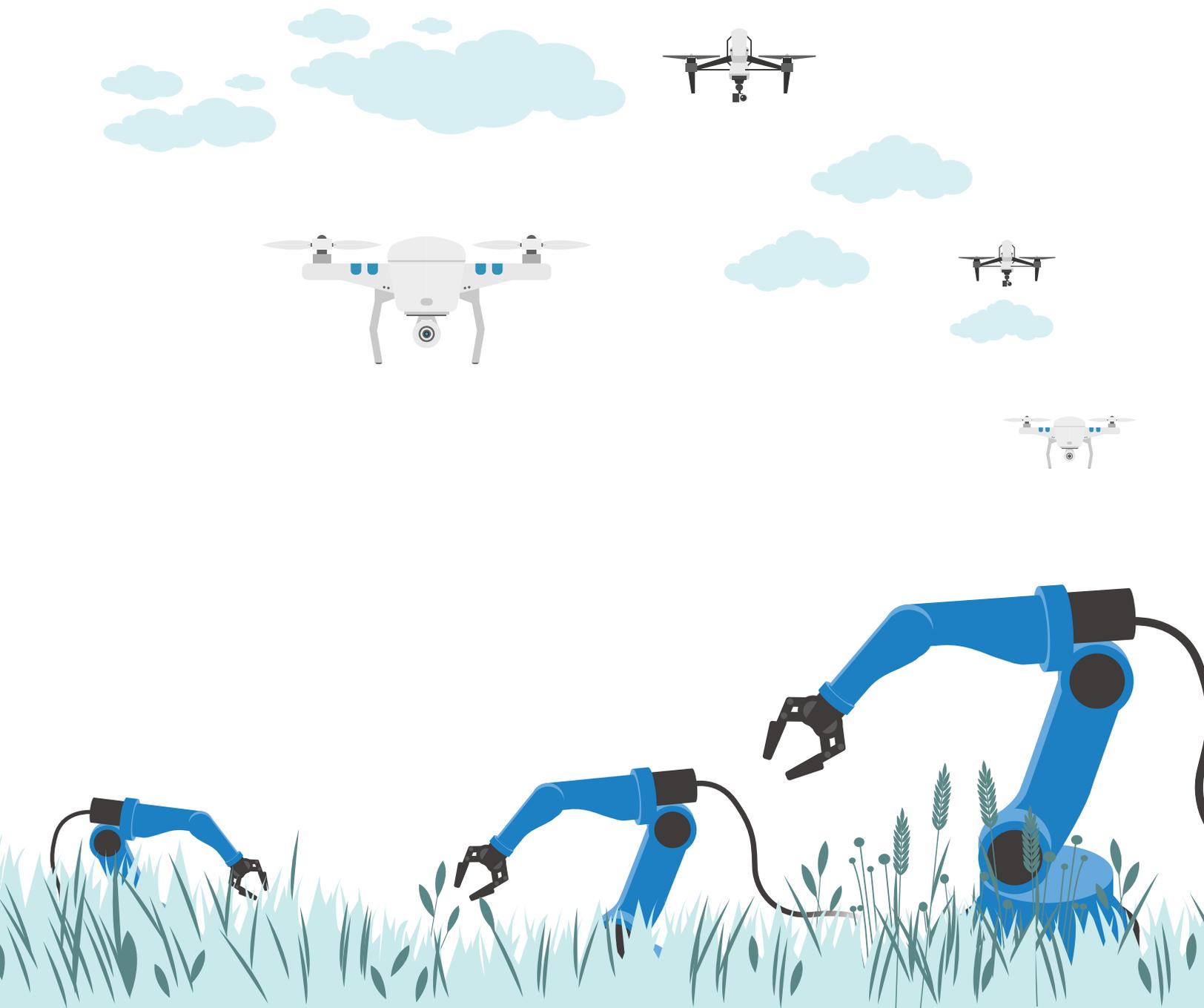
Dale Steele

Precision agriculture consultant

Steele Ag Insights, Lethbridge, AB

“We have a supply problem in precision agriculture. Colleges and universities need to prepare the next generation of ag workers with knowledge on software, agronomics, equipment and data tools.”

Dale’s two-year-old company provides expert agronomy advice to large grain and beef producers in Canada and the U.S. A University of Alberta-educated agricultural economist, Dale wears many hats: he’s a consultant, researcher, software specialist and author on innovative farm techniques. He wrote a 2017 report for the Canadian government on the adoption of precision farming techniques in Western Canada. He’s also an ag communicator and educator who’s served as a special lecturer and adviser on drafting university and college courses. Dale advises clients on productivity-enhancing technologies such as ground and satellite remote sensing and drones, using his expertise to help determine the right mix of data, equipment and processes for farm operators.



The Next Frontier

Where technology is taking the sector

Technology and innovation already play a central role in Canadian agriculture, and an increasingly educated workforce possesses many of the skills that will serve the sector in the future.

The challenge is this: overall adoption and usage of advanced technologies is uneven. Precision agriculture — which analyzes data at the granular level to maximize output — is the norm among Western Canadian crop producers, who've largely handed the physical work of farming to machines. Contrast that to the greenhouses and fruit farms of southern Ontario, which continue to rely on low-skilled, physical human labour.

Ease of implementation is one of the explanations. Some farm production, such as cow milking, is simply easier to automate. Fruit picking, which requires judgment and dexterity, has been more resistant. Capital is another barrier: advanced technologies may have the potential to cut operating costs in the long run, but they are expensive to acquire and implement.

While the extent of technological adoption varies, two things are clear: the bigger the farm, the more likely it is to use advanced technologies as part of its farm-management practices. And the younger the producer, the more likely he or she is to be using advanced technologies.

90% of crop producers across the Prairies use GPS to guide and track equipment.

52% of the biggest oilseed and grain farms are using advanced GIS (Geographic Information System) technology.

Source: Steele Ag Insights



Farms using advanced technologies in farm management



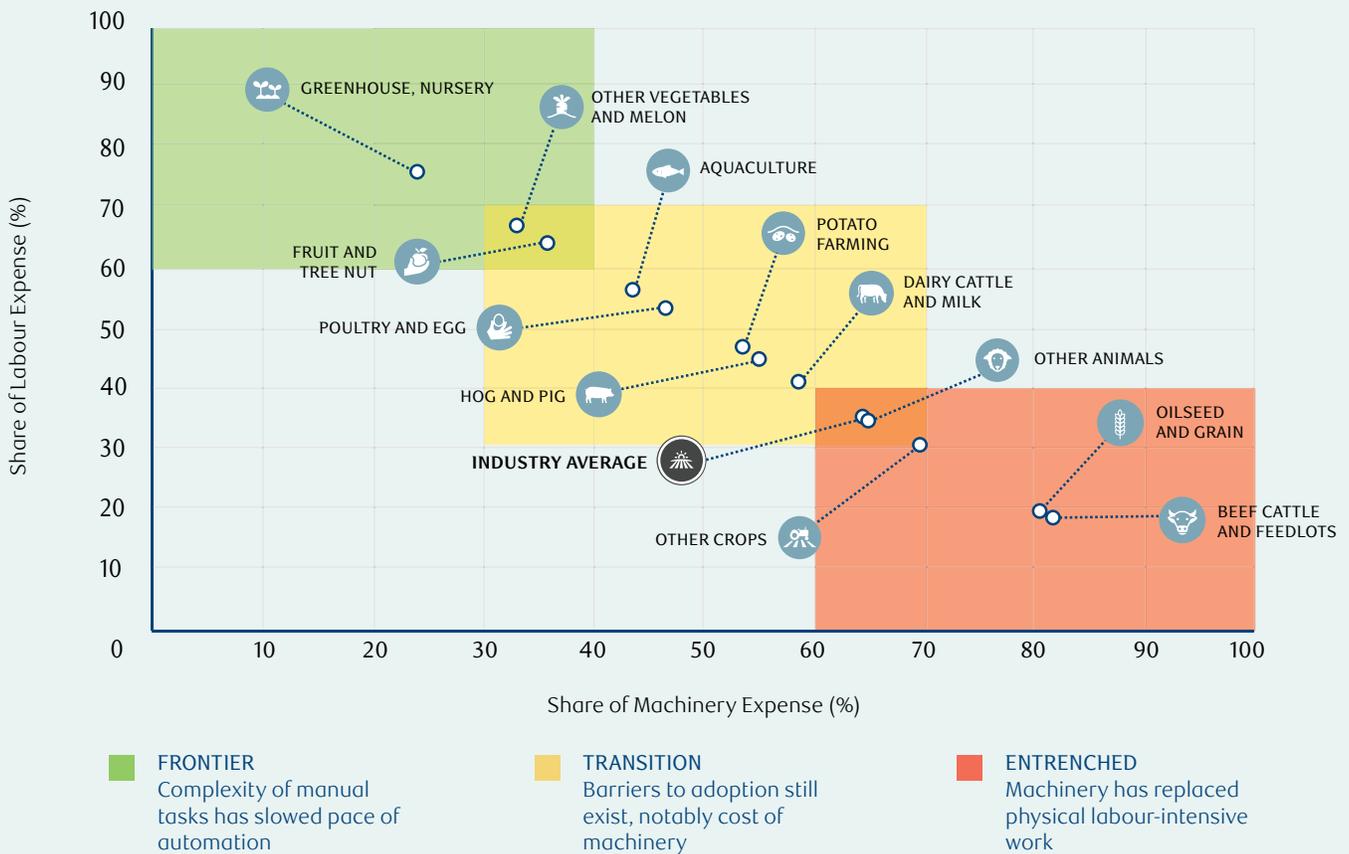
Source: Statistics Canada

Recent trends — bigger farms, more educated agricultural workers — suggest automation will gain ground in the 2020s, and the impact on farm operators could be significant. When faced with shortages, 20% of Canadian producers have resorted to overtime in the last year, while only 14% have adopted improved technologies. Another 8% opted to restructure or eliminate functions, losing out on sales and growth opportunities.

By analyzing data on farm operations' human capital and machinery-related expenses, we've created a framework to better understand which agricultural segments are furthest along in terms of technological adoption and what that means for the evolution of skills in the coming years.

Generations of Automation

Relative spending on labour and machinery by sub-sector, 2017



Source: Statistics Canada, RBC

In sectors where automation is already entrenched, including beef feedlots and grain farms, headcount is unlikely to fall further.

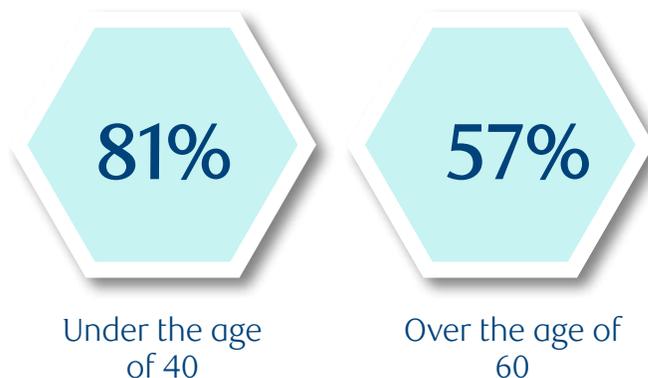
We're more likely to see labour adjustments in sectors still in transition with regards to automation, such as poultry production and aquaculture. For instance, over the last five years, human capital spending in aquaculture nearly halved relative to machinery spending as more technology is being used to meet global demand.

Why Deciders choose to automate

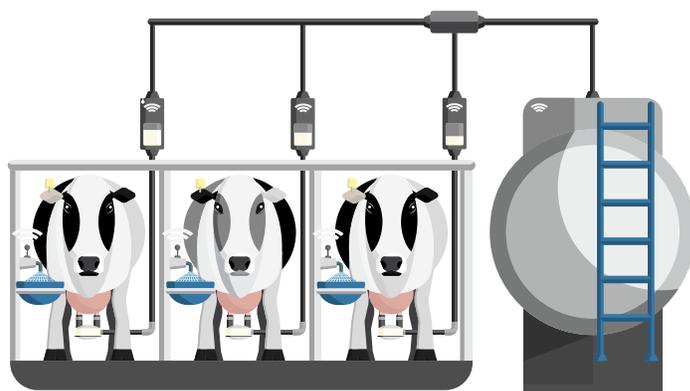
- 7% industry vacancy rate
- 67% face hiring pressures
- Rising minimum wage
- Foreign labour restrictions
- Changing food safety regulations
- Improving workplace safety

In sectors that are still human-intensive, such as greenhouses and field fruits, automation will cause more fundamental changes to headcount, primarily for general labourers, as well as to skills. With machines that can pick and pack produce, the new roles will require workers to interpret data not ripeness.

Producers using advanced technology



Source: Statistics Canada



The Game-Changers

How new technologies are changing old skills

ROBOTIC MILKING MACHINE <i>Lely Astronaut</i>	Cost: US\$200,000 Impact: reduces labour time by 75% Skills shift: from milker to data analyst
OPTICAL POTATO SORTER <i>Celox XT</i>	Cost: US\$225,000 Impact: doubles the capacity of a packing line Skills shift: from sorter to harvest manager

STRAWBERRY HARVESTER <i>Agrobot</i>	Cost: US\$100,000-\$250,000 Impact: picks five or more rows of produce at once Skills shift: from fruit picker to logistician
AUTONOMOUS SEEDER <i>DOT</i>	Cost: US\$500,000 Impact: cuts fuel consumption by 20% Skills shift: from driver to software engineer
VERTICAL FARMING <i>AeroFarms</i>	Cost: US\$39 million to build Impact: 30 times more produce per acre Skills shift: from operator to systems designer



Where the World is Going

Countries that are leading the way



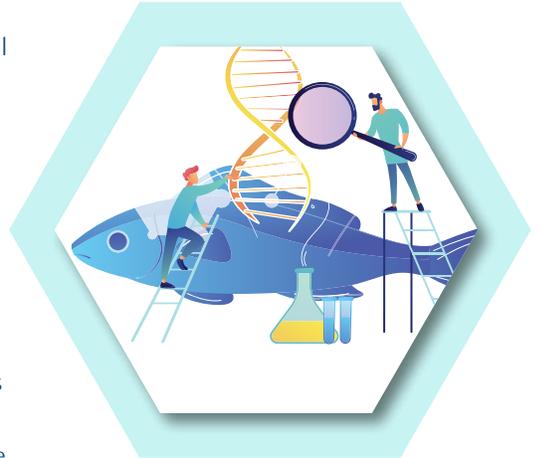
The Netherlands: Digitizing the greenhouse

The birthplace of the greenhouse is the world's second-largest food exporter (in dollar value) behind the U.S, exporting US\$101 billion of products. That's despite the Netherlands ranking 135th in the world in terms of land area. The Dutch remain leaders in glasshouse horticulture, but now they're operating fully digitized greenhouses where climate control is just the start: watering, fertilizer application and monitoring of CO² levels are also fully automated. Dutch greenhouses supply 50% of the world's floriculture exports, a third of the world's vegetable seeds and 20% of its tomatoes. The country boasts a world-class agricultural institute, Wageningen University, which continues to improve greenhouse technology and is leading agriculture's answer to the Internet of Things: the Internet of Food and Farm. The European initiative wants to make precision farming a reality by using sensors and data to create a more sustainable food system. Farming is an academic pursuit in Holland: three-quarters of its young farmers have a Bachelor's degree or higher, compared with 21% of Canada's under-40 farm operators.



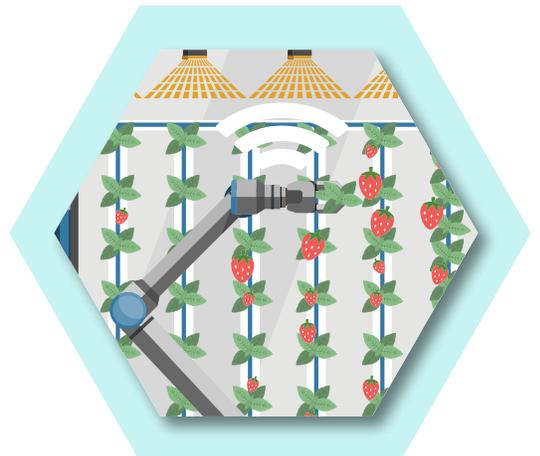
Norway: Turning salmon into science

Norway's most notable farming takes place underwater. The country is the world's largest exporter of freshwater salmon, providing 58% of global salmon exports. That's more than twice the exports of the next-largest global salmon exporter, Sweden. Protecting that commodity is serious business in Norway and is one of the reasons its Seafood Innovation Cluster partnered with IBM to develop AquaCloud. The platform uses AI to predict outbreaks of sea lice, one of the industry's most significant threats, costing it just over US\$500 million a year. Norway also exports aquaculture technologies to countries like Chile and Canada. The country's aquatech cluster expects agricultural technology exports to reach US\$7.8 billion by 2030. Preparing the next generation of fish farmers occurs at the Arctic University of Norway's Norwegian College of Fishery Science, where students and researchers are using blockchain to manage marine resources. The college is one of only a handful in the world that trains aquaculture specialists, and it uses an applied interdisciplinary model. Its SimFish Game challenges students to solve or cope with real-life challenges like loss of seafood quality or unregulated fishing.



California: Where robots tend to strawberries

Just an hour away from Silicon Valley lies Salinas Valley, which produces more than one-third of the vegetables and two-thirds of the fruit that ends up on U.S. grocery shelves. Salinas Valley has long been America's fruit basket; it's now also an agtech hub. Much of the impetus for that development has come from the region's insatiable need for pickers and packers. Indeed, for every job applicant in the California agricultural industry, there are four available positions, and labour shortages in the sector are twice the national average. As a result of those shortages and uncertainties around undocumented farm workers, the California industry has been heavily focused on automation, using it to perform tasks ranging from thinning out weeds in the field to harvesting lettuce to inspecting strawberries. Researchers at the University of California at Davis are working on solutions to the state's persistent labour problem. The university's top-ranked College of Agriculture and Environmental Sciences developed an innovative strawberry breeding program that patented two varieties of strawberries, which require less labour to maintain and harvest and are more resistant to disease.





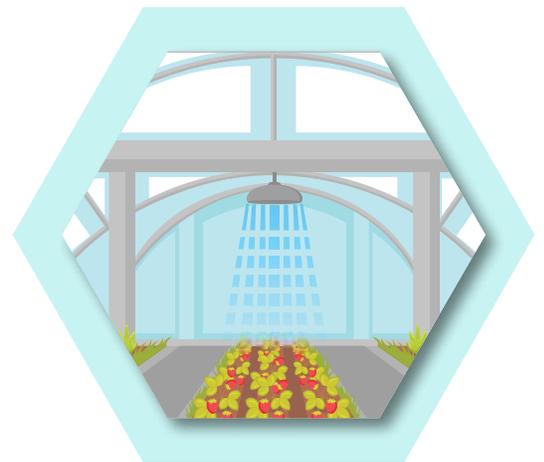
Australia: Crypto on the cattle ranch

Beef is big business in Australia, generating US\$2.5 billion in export sales last year. Australia produces 10.3% of the world's beef exports, and is the third-largest global producer behind the U.S. and the Netherlands. Managing that money-making herd has generated a lot of innovation. The country's national science agency, the Commonwealth Scientific and Industrial Research Organisation, has worked with partners to develop virtual fencing systems, smart livestock ear tags and a digital tool called eGrazor, which measures a cow's food consumption. CSIRO also funds graduate scholarships in digital agriculture at four Australian universities. One of those, the Queensland University of Technology, has developed a technology called BeefLedger that uses blockchain to track Australian beef at all stages of the production process. The goal: mitigating beef fraud and preserving Australia's reputation as a trusted supplier of healthy meat. The university also created a corresponding digital cryptocurrency called BEEF Token to serve as the foundation for BeefLedger.



Israel: Feeding a nation on drops of water

Decades ago, Israel came up with a novel way to harness scarce water for farming to solve two major problems: only one-fifth of the country's land is arable, and for political reasons it trades little with neighbouring countries. Its solution, drip irrigation, has transformed Israeli farming and been exported the world over. The country has since become the global leader in digital fertigation, which employs sensors and cloud-based analytics to determine the targeted release of water and fertilizer directly onto a plant's roots. One of Israel's success stories is citrus, even though the country accounts for only 1.3% of world citrus exports. Israel's strength is self-sufficiency. It imports just 9% of its food and agricultural products, mainly grains from the Black Sea region. Israel's somewhat unique geopolitical situation and social structure — collective farms and mandatory military service — have combined to produce generations of innovators. Some of Israel's agtech business leaders served in the country's Military Intelligence Directorate, where they acquired critical software-development skills as part of their training. The country's Ministry of Agriculture has also tapped private funding to set up 22 regional agricultural R&D centres to drive innovation; almost half of the country's total R&D spending has gone to these centres.





Toward a New Skills Agenda

Preparing for the next decade of disruption in agriculture

You can see the future of food production on open Prairie fields and remote fish farms. You can also find it in a bland industrial park in Burlington, Ontario. There, Scott Byers is developing an 11,500-square-foot indoor vertical farm he believes will transform Canada's production of chives, basil and other herbs. Back40Growers already ships more than 100,000 herb packets a month to local supermarkets; he thinks there's enough demand in southern Ontario alone to grow that to 250,000 packets. But to do that, Byers will need more mechanical engineers, electricians and horticulturists, and probably fewer labourers, to help scale up his packaging line.

The skills challenge at Back40Growers is playing out across the country, as food producers look to leverage (and pay for) new technologies with advanced skills — enablers and specialists — and fewer of the general labourers who have shaped agriculture for generations.

How can we help them? Policy makers, industry and educators are beginning to recognize their shared responsibility in getting this right. They'll need to do more, to attract youth to the sector, and ensure it's connected to the digital skills remaking every other sector. Here's some of what we can do:

1. Fill the talent pipeline

The average Canadian farm operator is 55 years old. By the mid-2020s, the industry will begin to descend a

retirement cliff. Attracting youth to careers across food production is critical. The same goes for women, new Canadians and Indigenous people. Big barriers remain, including awareness, access to capital and land, as well as the physical nature and remoteness of the work.

There's much room for improvement:

- 600 fewer young people are starting careers in agriculture each year, despite higher-than-average growth in post-secondary agriculture programs
- Women account for only 28% of farm operators
- Immigrants represent 1 in 14 of the agricultural population, compared with 1 in 5 of all Canadians
- Only 1.9% of farm operators are Indigenous, despite nearly 9 million acres of territorial land

Technology promises to open agriculture opportunities to non-traditional sources of talent. Automation will also help to make these jobs more accessible by reducing physical demands and creating a more "normal" work arrangement. But a tech-heavy farm sector will still have to compete with other sectors for this talent.

The nation is at a critical moment where the agricultural workforce can be restocked with future-focused, productivity-enhancing skills. Leadership from groups like the Canadian Agricultural Human Resources Council is essential to getting the demographic shift to work to our advantage, reconceiving farming in Canada — who, how and what — within a decade.

2. Innovate alongside skills

First movers on technology will have an advantage on knowledge acquisition. Canada needs to find new ways to commercialize technology, which goes hand in hand with the skills revolution. When tomorrow's technology is developed here, we can also cultivate the next generation of skills to go with it.

Currently, 67% of the machinery used on Canadian farms comes from other countries. To work with these technologies, we in essence import the skills and knowledge that come with them. Our training, research and even job descriptions are designed around imported technologies. Capturing cutting-edge skills demands that Canada also lead on innovation in agriculture, and in bringing these solutions to market.

The Canadian Agri-Food Automation and Intelligence Network is one avenue to achieving these gains. Led by Alberta Innovates and the Vineland Research and Innovation Centre, it aims to cluster funding and expertise to develop exportable farming solutions. What's promising too, is their inclusion of educators like Lakeland College and Olds College, to give students an early view into their innovations.

3. Agriculture as inter-disciplinary

Training Farmer 4.0 is an inter-disciplinary effort, blending food and land systems into non-agriculture teachings. We hear from employers in agriculture that they're looking for workers that are creative, adaptable and self-starters. Exposing those keen on entrepreneurship or education or engineering to the challenges present in modern agriculture could bring more highly skilled people to the sector.

This is a focus at the University of Saskatchewan, where food production is being built into the computer science program. At the University of Winnipeg, physics and computer science faculty lead a digital agriculture project that is bridging research on machine learning and agriculture. Another way to do this is through work-integrated learning, bringing different skills sets, say

from healthcare or data science, into an agricultural operation. The University of British Columbia offers a 4 to 6 month practicum to students and mature learners of all disciplines at the UBC Farm in Vancouver.

In part, this is needed to catch up with existing trends; nearly three-quarters of farm operators under 40 who attended college or university majored in business, health, education and technology. The earlier this integration of agriculture and non-agriculture learning can be done the better, starting in K-12, as 26% of young farm operators entered the industry directly from high school.



4. Plan for automation

Machine replacement has been routine in agriculture, with tractors, combines, graders and sorters dramatically reducing the number of tasks necessary for human intervention. The challenge ahead will be to equip the workforce with the necessary digital and human skills for the tasks that remain.

By the end of the 2020s, nearly two-thirds of job shortages in agriculture will require manually intensive, lower skilled tasks. The immediate solution will be to continue filling these roles through the Temporary Foreign Worker program, which could grow its share of the sector's workforce from 17% to 27% by 2030. The eventual solution for many of these roles will be automation.

To lead in the skills shift, we need to plan ahead of market forces. Unknowns remain, particularly around when these technologies will be scalable. Yet, our understanding of the future state of agriculture must inform how we train, hire and allocate resources today.

Call to Action

- The federal government should convene a national skills strategy for agriculture, together with employers, workers, educators and industry groups, to plan for future labour needs
- Industry groups should coordinate efforts on a bold campaign to attract and retain more youth, women, Indigenous people and new Canadians in agriculture
- The national work-integrated learning strategy should incorporate agriculture as a key sector, to increase exposure for non-agriculture students across the agri-food industry
- Ensure all major research and development initiatives, such as the Protein Supercluster, are linked to education and skills development
- The federal government should reduce barriers to high skilled immigration to agriculture, and consider a dedicated service channel under the Global Skills Strategy
- Accelerate the development of industry-wide data governance standards, in accordance with Canada's Digital Charter, to increase access to the best data and insights on food production
- Fulfill the federal commitment to provide high-speed Internet to the remaining 1.5 million rural and remote households within 10 years, giving them access to online learning and cloud computing
- Learn and apply lessons from countries like the Netherlands, Australia and Israel on approaches to agricultural human capital
- Recognize agriculture's centrality to Canada's future health and prosperity

Farmer 4.0 is the result of a four-month study by RBC researchers and economists on the changing skills demands in Canadian agriculture. This work was prompted by conversations with our clients, communities and partners in education on the sustainability of the agricultural workforce and the opportunities presented by new technologies.

It was informed by numerous interviews with agricultural experts across the country, including those in production, industry groups and academia. Consultations on the early findings were held with industry experts in Saskatoon and Guelph. Much of the analysis was possible thanks to the Canadian Agricultural Human Resources Council (CAHRC) and their AgriLMI data on labour trends in the sector.

This report is part of an RBC research series on the future of skills, complementing the findings of our 2018 *Humans*

Wanted report on the impact of automation on the future of work. The research supports Future Launch, RBC's decade-long commitment to helping Canadian youth prepare for the skills economy of the 2020s and beyond.

For more information about:

Farmer 4.0: rbc.com/farmer4

Future Launch: rbc.com/futurelaunch

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