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# Imagine If....

## A Vision of a Near-Zero-Emission Farm and Food System for Canada

A report by the National Farmers Union

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## Preface

This report presents a hypothetical path to a future in which Canadian agriculture is more sustainable, food supplies are more dependable, farm incomes are higher, and greenhouse gas emissions are lower. Policy-makers, decision-makers, and farmers need to know that there are viable alternatives to the status quo—alternatives that can help us build a better society.

What follows is neither prediction nor projection, but rather a picture of what *could* be—one possible future among many. Important, however, is the realization that safe and positive paths exist, that they can be afforded, and that they offer many benefits beyond just curbing emissions of greenhouse gases.

## Visions of near-zero-emission farm and food systems

Imagine.... It's 2030. Canada has *exceeded* its 2015 Paris commitment to cut greenhouse gas (GHG) emissions by 30 percent relative to 2005 levels. And our country is on track to reach near-zero emissions well before 2050. All the provinces are onside and working together, and governments around the world are accelerating their actions and increasing their emission-reduction ambitions. Though huge amounts of work lie before us, holding global temperatures increases to below two degrees is now a high probability. We're on track to avert the worst impacts of climate change.

Canadian farmers are doing their part: taking lead roles to find ways to reduce input use and associated emissions; installing solar panels and other alternative energy systems; and embracing grazing and cropping systems that build soils, increase resilience, foster biodiversity, and minimize GHG output. Most inspiring, on some farms and in some communities in 2030, the outlines of a near-zero-emission food system are coming into focus. This report paints a picture of that food system—one with more farmers; improved net incomes; richer and better protected soils; more biodiversity; protection for water and trees; a focus on equity and inclusion; local and community control; a more nutritious, diverse, and delicious food supply; and near-zero emissions. Imagine....

We'll visit several farms in this exploration of what a near-zero-emission food system could look like. The first stop on our imagined tour is a farm near London, Ontario. There, a farm family is growing a diverse mix of crops including wheat, corn, soybeans, dry beans, barley, oats, rye, and perennial forage crops. As much as possible, when cash crops aren't planted, the ground is kept green with cover crops, helping build soil organic matter and feed the biological processes that are at the root, literally, of the holistic understanding of soil fertility now spreading to more and more Canadian farms.

This London-area farm is "conventional" in that it's not certified organic. The farmers use fertilizer, strategically, to get past certain fertility bottlenecks, but they minimize tonnage as much as possible—especially nitrogen, in order to reduce emissions of the powerful greenhouse gas nitrous oxide. Working with an expanding contingent of public-servant agrologists independent of farm-input sellers, these farmers have found ways to significantly increase fertilizer effectiveness and efficiency and to find *alternatives* to chemical fertilizers—getting more and more fertility from biological rather than industrial sources. Public-servant researchers, government-funded demonstration farms, extension classes, and independent soil testing—all funded by a modest 3 percent tax on fertilizers—together have fostered and spread a set of approaches that have enabled many farmers to reduce nitrogen fertilizer use by as much as a third and still maintain adequate yields. After more than eighty years of Canadian fertilizer tonnage doubling and redoubling and fertilizer-related emissions going up in tow, a farmer-government-academic partnership has inflected both trendlines downward. (A graph of Canadian nitrogen fertilizer tonnage from 1940 to 2030 is included in a subsequent chapter.)

Most important, because this research, extension support, education, soil sampling, and lab work enabled farmers to cut expenses more than output and revenue, margins have improved and net farm income has grown by billions per year—tens of dollars per acre. The on-again-off-again farm

income problems that have plagued many farmers for decades are easing, and Canadian taxpayers do not have to transfer billions of dollars annually to the agricultural sector, in the form of business risk management payments.

A farmer on that London-area operation spoke about the increase in margins. She told us: "My dad talked about how, in the 1970s and early '80s, the net on this farm averaged about a third of the gross. That means my parents could keep about 33 cents out of every dollar they generated. But in the 1990s, 2000s, and 2010s, before we started working with government agrologists to find ways to optimize input use, we'd be lucky to hold on to 10 cents out of a dollar; often much less. Now we're averaging 20 cents and that's going up. Sure, our output tonnage may be down slightly, but our net income is up significantly, and that's what's important. It feels good to get off the production treadmill. And we've reduced emissions too. That's huge!" The bottom line in Figure 1 highlights net farm income improvements between 2020 and 2030.

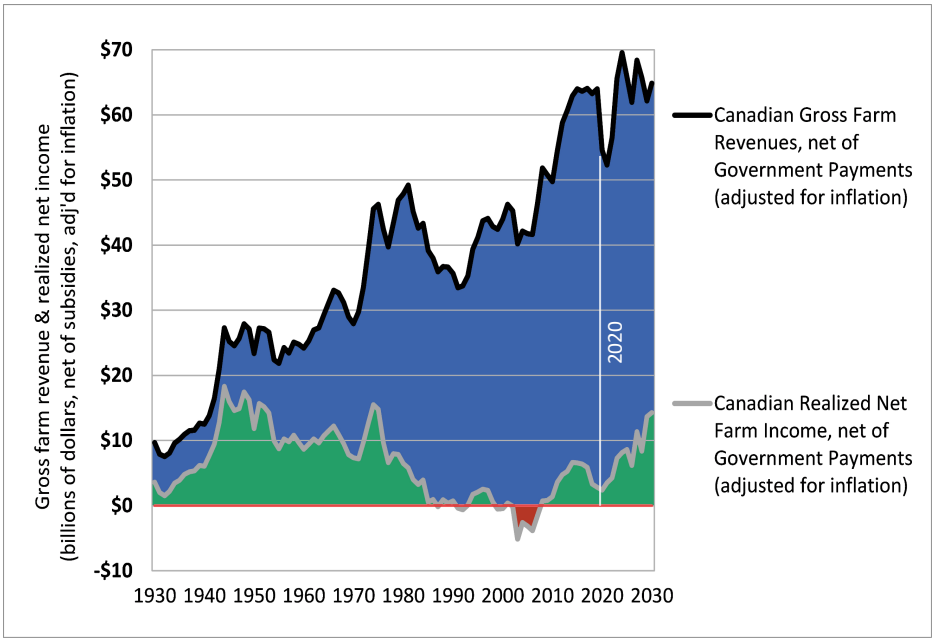


**Figure 1. Canadian gross farm revenue and net farm income, adjusted for inflation,[1] 1930 to 2030**
Sources: Stats. Can. tables 32-10-0045-01; 32-10-0052-01; and 32-10-0106-01. Numbers after 2019 are notional/fictional, and not projections.

Though organic acreage across the county is up 50 percent since 2020 and continues to increase steadily, most Canadian farms remain conventional. Nonetheless, a large and growing portion of conventional farmers have become interested in the methods organic producers use—practices they employ to reduce the need for purchased fertility. One conventional farmer put it this way: "We're not organic farmers, but I sure like talking to my organic neighbours. They've found ways to farm without writing huge cheques for fertilizer. The things I'm learning from organic farmers and from government extension agrologists—about soil biology, fungi, carbon, organic matter, cover crops, and diversified rotations—are helping me make my fertilizer cheques smaller each year. For us, we wouldn't want to farm without fertilizer and chemicals, but they're expensive, so it just makes sense to reduce input use as much as possible. And that reduces emissions. It's a double win."

1. For clarity, 2020 (not 2030) is used throughout as the base year for calculating inflation.

Starting in 2020, the federal government took decisive steps to reduce emissions from fertilizer use. In its 2020 *Climate Plan*, the government "set a national emissions reduction target of 30% below 2020 levels from fertilizers" and committed to "work with fertilizer manufacturers, farmers, provinces, and territories, to develop an approach to meet [that target]."[2] While some reductions in fertilizer emissions were achieved without cutting tonnage (by better timing and placement, for example), the 30 percent target required reductions in absolute tonnage—a big change after many decades of upward-trending fertilizer use.

Many farmers weren't enthusiastic in 2021 and 2022 when governments started saying that in order to reduce emissions farmers should cut input use. Farmers worried about lower yields and lower net returns. But federal and provincial governments collaborated to create a special insurance program: BMP insurance. If farmers agreed to adopt a designated set of beneficial management practices (BMPs) that reduced input use and emissions, then government programs would insure farmers' margins. Simply put, if reducing input use caused farmers' net incomes to fall significantly, then BMP insurance would make up most of the difference. In most cases, however, farmers—utilizing research and recommendations from government extension services and extensive soil testing—saw margins stay about the same or improve, so the insurance program's cost was modest for governments (and taxpayers). With financial risks reduced, farmers were empowered to experiment and find farm-specific alternatives to high-emission, high-cost purchased inputs. Most succeeded. And Canada took an important step toward a new guiding principle for its agricultural policies and practices. Maximum-production, high-input, high-emission agriculture was on the way out; sustainability, climate compatibility, and better margins were on the way in.

Lots of things are different in 2030, including many tractors. The London-area farm is part of a test program that financed and subsidized two new battery-electric tractors. Manufactured in Winnipeg, and using batteries from a huge new plant in Fort McMurray, Alberta, those tractors—one 75 horsepower and the other 200—can operate for six hours on a charge and recharge in 90 minutes, making twelve-hour workdays possible during busy seasons. The tractors—quiet, easy to maintain, cheaper to run—have become favourites. "There's no exhaust, little noise, and the power is amazing as you push the lever forward. It really feels like the future and makes our other tractors seem antique," commented a farm family member in her late 20s. In addition to electric tractors, the farm has two battery-electric pickup trucks. A neighbour is testing a hydrogen-fuelled combine as part of a similar program. Though low-emission machinery is still uncommon, a trend is emerging.

Throughout the 2020s, big changes happened *across* the country. Today, in 2030, on a ranch near Prince George, BC, farmers are employing a suite of techniques focused on soil building, grazing management, optimizing grass and forage quality, herd health, and genetics. The aim is to minimize emissions from cattle and beef while maximizing benefits to soils, grass, water, biodiversity, and grassland retention. One partner in the farming operation explained: "The higher the quality of grass and forage the easier it is to digest, and that lowers methane emissions from the cattle. We're rotationally grazing, and that means lusher grass, and we've included leafy legumes in the pasture mix, making it easier to digest. Better grazing, more plant diversity, and lusher growth mean that soil organic matter is going up, so that's a benefit, too."

The farmers work the cattle and move fence wires using an electric ATV; haying and feeding are done using electric tractors; and the cattle are taken to a local abattoir in a trailer pulled by an electric

2. Environment and Climate Change Canada, "A Healthy Environment and a Healthy Economy: Canada's Strengthened Climate Plan to Create Jobs and Support People, Communities and the Planet" (Ottawa: ECCC, December 2020), 45, https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf.

truck. "So long as the customer takes the beef home in an EV, it could be the case that *zero* fossil fuels were used in the production and delivery of this meat," said a young member of the farming operation, with obvious pride.

Cattle-price increases triggered by a combination of national, North American, and international events have made it easier to finance investments in enhanced management—investments such as cross-fencing, water-supply expansion, and improved grass and forage mixes. Funding and financing delivered through the Environmental Farm Plan 3.0 program have removed barriers for farms that want to move to enhanced grazing practices.

Before the latter 2020s, cattle often were seen as a climate problem—large sources of methane emissions. Indeed, even now in 2030, nearly a third of total Canadian agricultural emissions still comes from the mouths of cattle. But methane is a short-lived GHG and, unlike carbon dioxide, quickly broken down in the atmosphere. This means that the steps taken in the mid-2020s—in Canada and around the world—to ratchet down methane emissions from oil and gas production, coal mines, and landfills soon brought total "anthropogenic" (aka human-caused) emissions down below the rate of destruction. That has meant that now, in 2030, despite only a modest decrease in the size of the global cattle herd, atmospheric methane concentrations are *falling*: the warming effects from methane and cattle are *decreasing*. In the words of one farmer, "grazing animals have been on Earth for millions of years; oil 'n' gas companies haven't. To make room for continued grazing—*crucial* to healthy grassland ecosystems—countries had to cut methane emissions from oil 'n' gas. Once fossil fuel companies got the message they took the necessary steps, and the costs and impacts were manageable." Another farmer emphasized similar points: "Animals grazing for thousands of years didn't send the climate into meltdown; a hundred years of fossil-fuel production did that. The oil companies need to make way for grazing and grasslands, not the other way 'round. We're doing our part—working darn hard to reduce emissions from each animal—but the real change has to come from Exxon and Shell."

Near Red Deer, Alberta, on a large, multi-generation grain farm, farmers are using 4R nitrogen fertilizer efficiency techniques to reduce emissions while maintaining yields. "4R" stands for right product formulation, right rate, right placement, and right time of the year. Those Red-Deer-area farmers are putting down coated fertilizer with their seeds in the spring—fertilizer that releases more slowly, provides nutrients when plants need them, and avoids the large nitrous oxide emissions that might otherwise occur in the spring.[3] Two hours north, in Redwater, Alberta, the nitrogen fertilizer factory there is using carbon capture and storage to minimize $CO_2$ emissions from fertilizer production, a project initiated in the 2010s and now being adopted by other fertilizer plants as a result of government-legislated mandatory adoption by 2035.

In addition to 4R techniques, the Red Deer-area farm also is using precision agriculture technologies, field-mapping, and variable-rate fertilizer application to minimize emissions. A member of the family who recently returned to the farm after earning a degree from a technical college outlined the challenges and benefits: "The problem with precision agriculture used to be that, in most cases, the big input and machinery companies controlled the technology platforms and data—and they used that to control farmers. Six or seven years ago, around 2023, a government-university-farmer joint venture launched a data platform that keeps farmers' information private and keeps the farmer in the driver's seat. We call it data sovereignty. I don't want to give my input-use or production data to Deere, Bayer, Nutrien, or Cargill; now I don't have to. Instead, we can use these precision ag technologies to

3. In 2025, governments enacted regulations requiring all fertilizer coatings to be organic, wholly biodegradable materials, to avoid micro-plastic contamination of farmland soils.

do what we want to do: maintain yields while reducing inputs. Our drill is programmed with soil test data and yield data from previous harvests; it puts on less fertilizer where less is needed. The combination of 4R, coated granules, variable-rate application, regular soil testing using independent government labs, better rotations, better understanding of soil biology, and carbon capture over at the fertilizer factory means that our nitrogen-related emissions are *half* of what they were in 2020. That's progress."

In Prince Edward Island, many potato growers are adopting similar technologies: electric tractors and trucks, solar-panel arrays, fertilizer efficiency measures, enhanced rotations, and cover crops. Said one long-time grower at a meeting in Summerside: "Used to be that, in many years, PEI had some of Canada's highest per-acre fertilizer rates. Those rates are coming down." He continued, "We've got a ways to go, but with the right policies and with governments as partners, I'm confident that soon, Island-wide, our emissions will be down by a third, and production will be near to what it was before."

In addition to farming each acre with fewer inputs, farmers are farming fewer acres. Federal and provincial governments created set-aside programs that now have taken 6 percent of cropland out of production and returned it to grassland, wetlands, riparian areas, tree rows and bluffs, and forests. Set-aside programs create several benefits. First, the programs pay farmers to voluntarily retire their least-productive land—acres that formerly absorbed inputs but seldom made positive contributions to the farm's net income. Second, by reducing cropland area, set-aside programs reduce the use of fuel, fertilizer, other inputs, and, thus, emissions. Third, by ceasing efforts to send another record-setting harvest to market every year, set-aside programs can help put upward pressure on prices. "I'm not cropping my low-margin acres anymore," said a woman from her farm near Regina. "The government is paying me a fair price to idle those. Wildlife has more habitat. And I think that these set-aside programs—here, in the US and EU, and in other countries—are part of the reason grain prices are rising. We've stopped going all-out to over-produce, and it seems like the grain companies are having to pay more. There's more to prices than supply and demand, but it's never wise to oversupply."

Beyond reducing production-related emissions, farms and rural communities have become centres of clean-energy generation. Across Canada, incentive payments and financing mechanisms are enabling farms to install solar-panel arrays.[4,5] Many operations are installing arrays large enough to power trucks, tractors, and other machinery in addition to providing electricity for buildings. "A big solar installation isn't cheap; ours cost more than $60,000. But Ottawa financed it over 30 years, and that electricity is replacing maybe a third of the fuel we used to buy. In effect, we pre-bought much of our energy for the next two or three decades. It's early days, but it looks like there'll be big savings, long term," reported a farmer at a Moncton, New Brunswick, conference on agricultural decarbonization. Many farmers are excited about the challenge that some have labelled F4: fossil-fuel-free farming.

Incentives and financing programs are helping farmers retrofit homes and buildings, thereby reducing emissions from heating systems. Better insulation means that many buildings now can be heated affordably with electricity, often from on-farm solar panels. "Our house and shop are now tight and energy efficient. This has allowed us to switch over to a heat pump that we power ourselves from our solar setup. We've unhooked from the gas line and that saves us a lot," reported one BC farmer.

4. And, on a more limited basis, manure methane collectors that can provide heating fuel or electricity.
5. The problems created by the Ontario *Green Energy Act* (GEA) (2009-2019) must be acknowledged. Improperly set (and then retroactively changed) electricity tariff rates, domestic content requirements that were later overturned by the WTO, and incursions into municipalities planning jurisdictions are just some of the problems with the GEA. That said, problems with this one *Act* in no way reduce the urgency of decarbonizing our electrical grids and our larger energy system. Future efforts to add solar and wind power must be implemented differently, but they must be implemented.

Coordinating much of the agricultural emission-reduction and climate-adaptation work is the federal government's new Canadian Farm Resilience Administration (CFRA). At a meeting near Camrose, Alberta, a farmer explained: "The CFRA is a *huge* help. Across Canada, they've set up dozens of demonstration farms that hold monthly field days where farmers come to gather ideas on how to use inputs efficiently. CFRA agrologists visit our farm regularly to help us implement input- and emission-reduction techniques and do soil sampling for nutrients and soil carbon. We're also working with CFRA field staff to restore 60 acres of wetlands. And their tree nurseries—partnerships with Indigenous communities—provided the free trees we used to plant 40 acres of shelterbelts and bluffs." She concluded, "A decade ago, governments were sending farmers mixed signals regarding emissions. But when Ottawa created the CFRA, we knew they were serious. Now, it's 'all hands on deck.' With the CFRA, farmers got the support and expertise we needed. It was a game changer."

With regard to emissions reduction in the food system, while farms are at the core, work is underway upstream and downstream as well. To cite one inspiring example, Edmonton, Alberta, has embarked on an ambitious plan to supply zero-emission foods for the city. A city councillor explained: "*Watershed* means the land around a river that contributes water to that river. Edmonton is creating a *foodshed*—surrounding land that will supply this city with more and more of the food we need. For the past six years, the City of Edmonton has been buying up much of the land put up for sale within a 50-kilometre radius. So far, we've assembled about sixteen thousand acres. We've been leasing that out in small and medium-sized parcels on low-cost terms to anyone who wants to farm it in sustainable, low-emission ways. We're providing land to new Canadians, young farmers, co-operatives, First Nations, organic growers, permaculturists, agroecologists, small-flock poultry farmers, free-range hog producers, organic vegetable growers, mental health and addictions-treatment programs, youth clubs, religious groups, and others. In 2027 we launched a food pick-up system wherein electric transport trucks follow efficient routes and pick up food from producers at regular intervals then bring it to local-food markets and food hubs throughout city neighbourhoods. Some of the foodshed farmers have electric tractors that they recharge from solar panels, and many have reduced or eliminated the use of chemical fertilizers and other inputs. So, with the electric trucks bringing the food into the city and residents walking and biking to pick it up, that's as close to zero-emission food as you can get. This is the future. We're doing it now. Zero-emission food!"

After decades of policies that maximized food exports (and imports), that led to the closing of processing plants and the centralization of capacity, and that led to ever-longer transport distances, Canada is now taking a pragmatic approach to relocalizing production and processing. For example, across the country, governments have catalogued waste-heat sources and encouraged growers to use those to heat greenhouses to produce local vegetables and fruits. Thermal powerplants, compressor stations, co-generation plants, district heating systems, industrial and manufacturing plants, fertilizer plants, and a range of other facilities are being paired with greenhouses that can utilize the heat. "We can truck in cucumbers from Mexico or, by using heat that would otherwise be wasted, we can grow those cucumbers right in the city with zero added emissions," said a greenhouse owner in Brandon, Manitoba, who is utilizing heat from the Koch Brothers nitrogen fertilizer factory.

Reducing emissions from greenhouses, farms and ranches, and other centres of food production is critical, but the project of optimization and rationalization has extended up and down the food chain. For example, food waste—a huge contributor to whole-system emissions—was slashed through a number of initiatives including legislation that made it illegal for retailers to dispose of food without first offering it for other uses. In another example, to curb denutritionalization (turning high-quality, nutritious ingredients into health-damaging, obesogenic junk food and empty calories), the

government imposed excise taxes on sugary and fatty snacks and drinks. Governments also educated consumers about how food choices can affect a household's emissions footprint (e.g., air-freighted green beans vs. local lentils). "Coming out of the 20th century there was inefficiency, irrationality, and *waste* in the system, the result of its architecture being set during times of cheap, abundant fossil fuels. In the 2020s, governments began to push food processors and retailers to deliver more nutrition with less energy and fewer emissions. That's now paying off," said the Canada Research Chair in Food-System Efficiency and Sustainability from her office in Whitehorse, Yukon.

Governments made other important, even revolutionary, changes to accelerate emissions reduction. In Canada as elsewhere, oil companies were the big opponents of effective climate action. So government bought them. The federal government paid $220 billion for the shares of the ten biggest Canadian oil and gas companies.[6] Once citizens owned the resources, we could decide how much to produce and how much to leave in the ground. But that wasn't the most important part: those companies came with skilled workforces. Energy companies are financing, logistics, engineering, and construction *powerhouses*. Energy companies have experience operating in remote and rural environments and building megaprojects—exactly what Canada's clean-energy revolution needed. In 2024, the government began gradually transitioning these companies from fossil fuel projects to renewables. Today, in 2030, Canadian oil production is down 24 percent but employment in these companies is up by 9 percent.[7] An energy-sector employee explained: "I worked for years building refineries and pipelines. Now I'm building huge solar installations. The pay is similar but the work is better and safer and I'm part of a fast-growing sector, not a declining one."

Canada's Minister of Finance applauded the move: "Buying the energy companies was a brilliant turn-key solution. In a single move, it ended much of the organized, well-funded opposition to doing the right thing regarding fossil fuels and emissions, and it delivered a skilled and powerful workforce to install the millions of solar panels and thousands of wind turbines and other infrastructure we need. It's the single most important and transformative public policy move in Canada in the past fifty years. In audacity and effect, it's comparable to Medicare."

Energy-sector workers are now installing solar arrays on farms, building wind turbine parks that are co-operatively owned by rural communities, building hydrogen production and distribution infrastructure, and adding electrical-grid capacity so that we can heat buildings, charge vehicles, power transit and trains, and run factories using clean electricity.

The 2020s were a Canadian food-system reboot—the beginning of a renaissance. By the decade's end, net farm income from the markets was 60 percent higher than the average for the preceding 40 years. A portion of those additional billions in net income is now making its way through rural communities, spurring economic rebirth for many towns and small cities. Farm debt, having increased every single year since 1993, began falling in 2022 and in 2030 is down by a full third (graph provided in following chapter). The area farmed using organic, holistic, regenerative, and

6. A national government owning oil companies seemed radical initially, but only until people were reminded that most oil companies are owned by national governments. The list is long and includes Saudi Aramco (Saudi Arabia); Sinopec Group (China); China National Petroleum Corporation (China); Kuwait Petroleum Corporation (Kuwait); Petroleos de Venezuela (Venezuela); Pemex (Mexico); National Iranian Oil Company (Iran); Petronas (Malaysia); Equinor/Statoil (Norway); Abu Dhabi National Oil Company (United Arab Emirates); Indian Oil Corporation (India); British Petroleum (UK) (wholly or partly state-owned 1914-1987). OPEC members hold approximately 80 percent of global oil reserves. Most of the oil production in those countries is done by state-owned enterprises. Private-sector energy companies control only a minor portion of global reserves. State ownership is not a radical proposal: it is the global-market norm.

7. While some were ideologically opposed to the public purchase of fossil fuel companies, a growing majority of citizens came to understand that the alternative was the withering of the energy corporations, as nations around the world found ways to use less fossil fuel. The result of this wholly predicable contraction in demand and production would have been rising Canadian unemployment, falling wages, and (possibly permanent) economic decline for many regions.

agroecological methods *doubled* between 2020 and 2030. The rapid loss of young farmers ended, with the 2026 Census of Agriculture recording the first significant increase in young farmers since record-keeping began in 1991. And it's likely that the number of farms in Canada will be higher in the 2031 Census than in 2026, marking the first time since 1941 that the number of farms has *increased!* "Instead of increasing input use and emissions and reducing the number of farmers, we've decided to try the reverse," quipped Ontario's Minister of Agriculture. "It's working rather well," she added.

The reboot and renaissance extended throughout the food system, with local processing expanding and flourishing, a tripling in sales through farmers' markets compared to those of a decade ago, and a surge in production of local cheeses, preserves, and prepared meats. "The food system is more nutritious and delicious, and much more *interesting*. And it's a viable career option for young people again. When you begin solving one problem you find ways to solve many problems. The climate crisis is forcing us to make changes, but the changes we're forced to make open the door for the changes we *want* to make. As we started to push back against high energy use, high emissions, corporate control, centralization and concentration, export mania, and a range of other food-system pathologies we began to find and install alternatives. And we learned that one solution often clears the way for others. The climate crisis was the trigger, but it unleashed a *wave* of creativity and action and activism that is now remaking Canada's food system. And it is *so* ... *much* ... *better!*" said the President of the National Farmers Union, in an address to the NFU's 2030 National Convention.

The following chapters detail the lower-emission, higher-net-income, more nutritious, re-booted food system coming into focus in 2030.

**A turning point in 2020**

How did we get to this positive 2030? Things could easily have gone the other way. A decade ago, Canadian fossil fuel use was high and public awareness and concern was not. A critical inflection point was the COVID-19 pandemic of the early 2020s. That pandemic revealed the brittleness of the food system, reinforced the need to heed scientists' warnings and prepare for looming threats, highlighted the limits of the market forces and just-in-time delivery systems, and demonstrated the need to work together to safeguard our loved ones and the future. A decade ago, even before the full impacts of the pandemic were clear, the National Farmers Union published these wise words:

> A sustainable and just food system ... will ... prevent multiple cascading crises and provide the foundations for a good life.... Our post-pandemic food system will stand upon the three pillars of sustainability: ecological health, social justice and economic viability. Using climate-friendly, low-emission production, it will deliver a healthy and secure food supply to Canadians and provide sustainable livelihoods to a larger, younger, and more diverse population of farmers while engaging in fair international trade relationships.... A strategy of on-farm diversification and geographically dispersed food processing, storage and distribution will improve resilience, whether future disruptions are from the next pandemic, climate change, or other crises.[8]

8. Cathy Holtslander, "Envisioning a Post-Pandemic Agriculture and Food System," National Farmers Union, June 23, 2020, https://www.nfu.ca/policy/envisioning-a-post-pandemic-agriculture-and-food-system/.

## 1. Emissions. Falling, not rising, in 2030

After rising for 100 years, in the early 2020s Canadian agricultural emissions began to fall. Emissions in 2030 are 18 percent lower than those of the 2020 peak. The decrease is a result of emissions reductions in almost all categories. The largest decrease was in the production and use of nitrogen fertilizer, shown in the bottom two bands in Figure 2. Emissions related to nitrogen were down 26 percent Canada-wide (though fertilizer tonnage was down only 19 percent; see Figure 3). Emissions in other categories (including fuel use, enteric methane from livestock, manure management, etc.) were down by lesser though still significant amounts—10 to 15 percent.

The following chapters provide details on how some of these reductions were achieved and the many co-benefits from the adoption of efficiency measures and beneficial-management practices (BMPs).

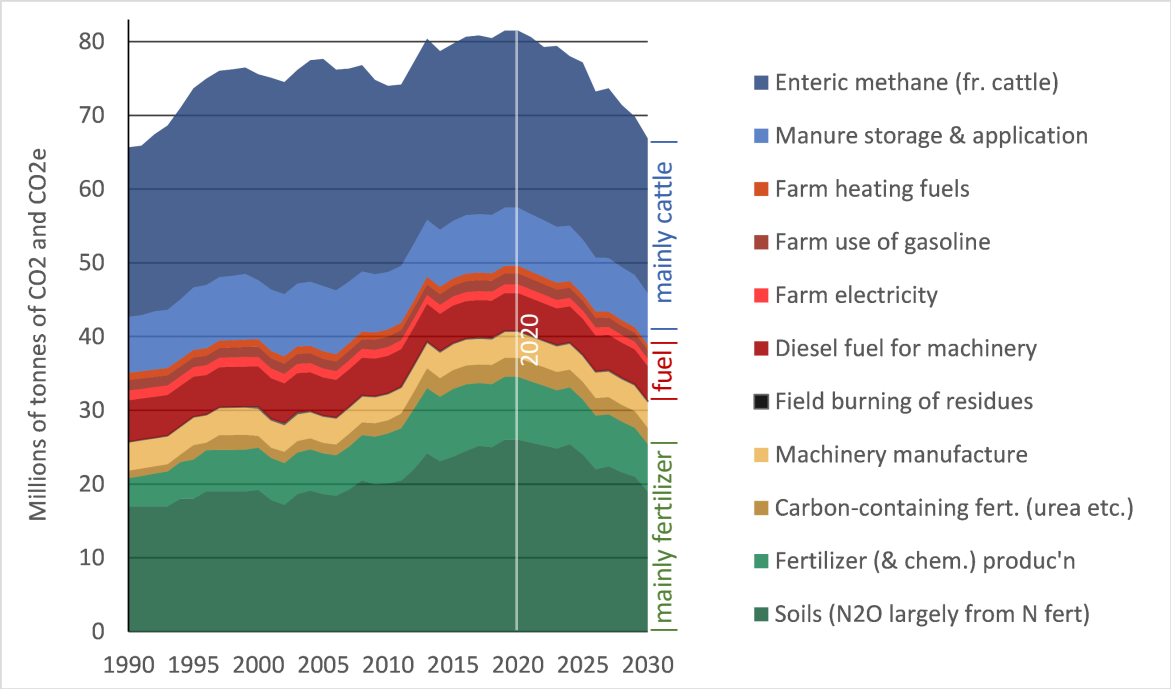


**Figure 2. Emissions from agriculture and the production of agricultural inputs, Canada, 1990 to 2030**
Sources: Environment and Climate Change Canada, "Canada's Official Greenhouse Gas Inventory"; and calculations of emissions from fuel use, electricity production, and machinery and fertilizer manufacture based on reports by Dyer et al.[9] Numbers after 2018 are notional, not projections.

Canada's success in cutting agricultural emissions was matched in other countries, with comparable or larger reductions in most EU countries, the US, Australia, and New Zealand. Brazil did not cut agricultural emissions, but made huge steps in cutting emissions from land-use changes as it stopped the conversion of savannahs and rainforests into farmland. Similar moves in Asia to halt land-use changes have led to dramatic global reductions in emissions related to food production and land use.

9. J. Dyer et al., "Integration of Farm Fossil Fuel Use with Local Scale Assessments of Biofuel Feedstock Production in Canada," in *Efficiency and Sustainability in Biofuel Production*, Ed. Barnabas Gikonyo (New York: Apple Academic Press, 2015); J. Dyer et al., "The Fossil Energy Use and CO2 Emissions Budget for Canadian Agriculture," in *Sustainable Energy Solutions in Agriculture* (Boca Raton: CRC Press, 2014); and J. Dyer and R. Desjardins, "Carbon Dioxide Emissions Associated with the Manufacturing of Tractors and Farm Machinery in Canada," *Biosystems Engineering* 93, no. 1 (2006).

## 2. Fieldwork energy. Solar, not fossil

For 99 percent of the time that humans have practiced agriculture it has been solar powered. Sunlight upon leaves—photosynthesis—powered farms, creating the food that energized the farmers and creating the grass, fodder, and grain that energized the draft animals. The processing mills that existed also were powered by solar energy, delivered in the forms of wind and flowing water.

For just 1 percent of the time that humans have practiced agriculture it has been fossil fuelled. The 2020s were a time to begin reconnecting agriculture with its normal, long-term power source: the sun. In 2030, farms and food systems are increasingly powered by solar power: photovoltaic panels, wind turbines, and hydro dams, with a contribution from other sources such as methane from manure biodigesters and limited use of biomass.

The brief experiment of powering food systems with fossil carbon (implemented fully in only a few countries and for only a handful of decades) has been revealed as unfeasible moving forward, and a reversion to the solar norm is now underway.

Difficulties remain, of course. Electricity from low-emission sources can be easily delivered to stationary uses—to houses and other buildings. But getting electricity to moving vehicles—to trucks, tractors, combines, sprayers, and other equipment—is much harder. For that task, energy carriers are needed: chemical or mechanical means to transfer energy to enable it to be used in remote locations or in moving vehicles. The most developed energy carriers in 2020 were batteries and hydrogen.[10] Unclear in 2020, however, was which technology would be best to power farm equipment. Governments took the position that the question would likely be resolved in the long-haul trucking sector. So governments partnered with machinery companies to ensure that the energy carriers and low-emission drive trains that came to dominate trucking could be quickly integrated into tractors, combines, and other machinery. Farmers and governments were fortunate that an agency specializing in machinery technology already existed: the Prairie Agricultural Machinery Institute (PAMI). Federal and provincial governments came together to expand PAMI to all provinces and create the Canadian Agricultural Machinery Institute (CAMI) in 2024. In 2030, that stage-setting has paid off. In parallel with the profusion of near-zero-emission long-haul trucks now on Canadian highways, battery-electric and hydrogen-powered farm equipment is beginning to roll off assembly lines and into fields.

To support and accelerate the adoption of low-emission farm equipment, governments brought forward several programs and policies in the 2020s, including:

a. Cost-sharing with machinery companies on ten-year warranties for battery-electric and hydrogen drivetrains;
b. Cost-sharing on one-year, no-questions-asked return policies on low-emission machinery;[11]
c. Right-to-repair legislation that enabled farmers and third parties to access information, diagnostic software, tools, and parts needed to repair and modify machinery;
d. Matching funds for R&D on how to integrate low-emission drive trains into farm machinery;
e. Sales mandates for the major machinery companies wherein a rising percentage of machines must be zero-emission by certain dates; and

10. There are many possible energy carriers/stores, incl. compressed air, flywheels, wound springs, ammonia, methanol, etc.
11. The cost to the farmer would not exceed that of a one-year lease.

f. Incentives for farmers to purchase low-emission machinery, including low-rate financing and accelerated depreciation.

Governments partnered with industry and farmers to ensure both the supply of, and the demand for, low-emission machinery.

**Case study: The western Canadian low-emission machinery technology cluster**

An important success story that emerged in the early 2020s is the technology cluster that developed in western Canada to design and build battery-electric and hydrogen-powered farm machinery.

Spurred by government R&D funding, several companies and agencies banded together. The initial seed of the cluster germinated in Manitoba, when New Flyer Industries, builder of electric and hydrogen-powered transit buses,[12] began talking with Buhler-Versatile, maker of medium-sized and large tractors (175 to 600 HP). Both companies are headquartered in Winnipeg. Additional R&D investments came initially from the Manitoba government and Manitoba Hydro. Buhler and New Flyer produced five prototype tractors in 2023 and 2024.

Soon, the Manitoba cluster expanded to include Ballard Power Systems, a world-leading hydrogen fuel cell company based in Vancouver, BC. A final and key addition came when federal and provincial governments convinced Ford and GM to site a joint-venture battery mega-factory in Fort McMurray, Alberta.

In addition to these research and production facilities in the west, there is also a large factory producing low-emission tractors in Oshawa, Ontario, employing unionized workers who formerly made internal combustion engine cars, as well as an R&D lab in Kentville, Nova Scotia.

To ensure low-emission operation, electric tractors purchased in provinces where electrical-grid power still creates significant emissions[13] come with a solar-array package made up of parts and panels from Canadian Solar, a top-five global solar-panel maker headquartered in Guelph, Ontario.[14]

These decade-long efforts by government and industry have led to the fortunate situation wherein in 2030 Canada produced *nearly half the battery-electric tractors made in North America*, leading some analysts to refer to the Canadian technology cluster as "Agri-Tesla."

For much of the 20th century, Canada was a leading player in global farm machinery manufacturing. But since the 1980s and the loss of Massey Ferguson, that has not been the case. This new farm machinery technology and manufacturing cluster is restoring Canada to a global leadership role in agricultural manufacturing. Recently, the Canadian consortium of manufacturers and technology developers turned down a purchase offer of $11 billion from UK/Italian-based CNH Industrial.

Surveys of farmers using low-emissions tractors indicate extremely high customer satisfaction and reduced operating costs—paralleling the experiences of electric car and light truck purchasers.

12. For details on these buses, see: https://www.newflyer.com/buses/xcelsior-charge/ ; https://www.newflyer.com/site-content/uploads/2019/03/Xcelsior-CHARGE-H2-web-1.pdf
13. E.g., even in 2030, Saskatchewan has not yet eliminated fossil fuels from its electricity production mix.
14. All the companies listed in this section are real and as described, though this technology cluster is fiction, for now.

## 3. Fertility. Biological, not industrial.

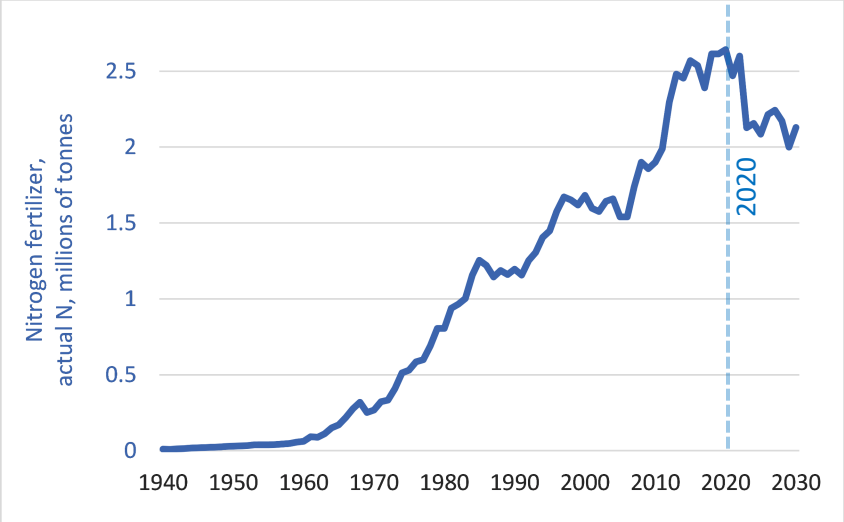


**Figure 3. Canadian nitrogen fertilizer use, actual N nutrient, 1940 to 2030**
Sources: Stats. Can. tables 32-10-0039-01 and 32-10-0274-01; Dominion Bureau of Statistics, *The Fertilizer Trade*, various years, http://publications.gc.ca/site/eng/9.853796/publication.html; Maurice Korol and Gina Rattray and Agriculture and Agri-Food Canada (AAFC), Canadian Fertilizer Consumption, Shipments and Trade 1997/1998 (Ottawa: AAFC, April 1999), https://docplayer.net/29628267-Canadian-fertilizer-consumption-shipments-and-trade-1997-1998.html; Numbers after 2020 are notional, not projections.

Between 1993 and 2020, Canadian nitrogen fertilizer tonnage doubled. But nitrogen fertilizer use peaked in 2020 and is now down by more than 19 percent. In 2030, there's a growing commitment among farmers to reinstall biological processes (alongside industrial) as important sources of the nutrients needed for agricultural production. A new focus on soil health, above- and below-ground biodiversity, closing nutrient cycles, and biological nitrogen fixation coupled with proven methods of improving fertilizer-use efficiency means that crop yields have not fallen despite significant reductions in fertilizer production and use (and attendant reductions in fertilizer-related emissions).

As noted above, governments brought forward several programs and policies in the 2020s to support reductions in nitrogen use, including:

a. Creation of the Canadian Farm Resilience Administration, which administers:
    - More than a thousand independent extension agrologists focused on helping farmers maintain yields while reducing input use and finding alternatives to purchased inputs;
    - Independent labs that provide regular testing of soil nutrients and carbon levels;
    - Thirty demonstration farms where low-emission practices are refined and showcased;
    - Staff and programs to assist farmers in developing soil-health strategies, nutrient-management plans, and environmental farm plans;
    - Programs to proliferate enhanced grazing practices;
    - Tree nurseries that produce free trees for shelterbelts and bluffs (in partnership with First Nations); and
    - Set-aside, wetlands protection, and wetlands restoration programs.
b. Education on input-reduction and -efficiency practices, such as 4R nitrogen management;

c. Creation of independent farmer-controlled data platforms to enable farmers to adopt precision agriculture methods without sharing data with agribusiness corporations;
d. Mandating carbon capture and storage at nitrogen factories;
e. Research, awareness, and support programs focused on soil health, cover crops, intercropping, diversified rotations, biological nitrogen fixation, closing nutrient loops, and biological sources of fertility such as compost and manure;
f. Imposing a 3 percent tax on fertilizer sales to fund much of this emission- and input-reduction research, support, education, and testing; and
g. Increased government support for alternative production methods with the aim of diversifying approaches and multiplying the acreage farmed using organic, holistic, regenerative, low-input, and agroecological methods.

The starting point for all this work was the 2020 announcement by the federal government of a goal to reduce emissions from fertilizer by 30 percent below 2020 levels by 2030.

## 4. Water. Green, not blue

In 2020 came another push to build canals and expand irrigation on the Prairies. Huge sums were earmarked for such projects.[15] Spurious concepts such as "drought proofing" gained currency again. In effect, the proposal was that millions of taxpayers would provide billions of dollars to a few hundred farmers so that they could irrigate one or two percent of Prairie farmland.[16] And with that very costly yet wholly inadequate effort, we would supposedly secure future harvests against the ravages of climate change.

Academics who think about water and food have come up with the concept of distinguishing between "green water" and "blue water." The former is the rainwater in soils and plants; the latter is surface water taken from rivers or groundwater taken from aquifers and pumped onto the land to irrigate crops. The irrigation megaprojects touted in the early 2020s were an attempt to massively increase the supply of blue water. Farmers, however—as they found ways to increase the soil organic matter and, thus, moisture-holding capacities of their soils—increased their capacity to intercept, hold, and utilize green water. Farmers demonstrated that the solution to the problem of inadequate soil moisture was not engineering megaprojects but, instead, the restoration of our soils.

As farmers and farm organizations learned more about the billions planned for canal building and the relatively small portion of Prairie farmland and farms that would benefit, individuals and groups began to call for that money to instead be spent on soil health programs so the benefits could be shared much more widely. Bowing to pressure, the federal government announced that its share—nearly $2 billion—would instead be directed to the then-newly-created CFRA. CFRA agrologists worked with farmers on many thousands of farms and across tens-of-millions of acres to develop soil-health plans—long-term strategies to increase organic matter and permeability so that soils could intercept and store more water (important as rainfall events became both more intense and less reliable). As with so many of the positive moves in the 2020s, the shift in the focus from canals and pumps to soils and plants was part of a larger shift wherein farmers got more of what they needed from biological sources and less from industrial—more from their own farms and less from distant corporations.

Though enhanced soil health alone cannot guarantee a Prairie-wide crop in a drought year, neither can irrigation. The former, however, has the advantage of being much more broadly distributed, more sustainable, lower-energy-use, and a source of myriad co-benefits.

15 Arthur White-Crummey, "Sask. Announces $4 Billion Project to Irrigate up to 500,000 Acres," *Regina Leader-Post*, July 2, 2020, https://leaderpost.com/news/saskatchewan/sask-announces-4-billion-project-to-irrigate-500000-acres.

16 Darrin Qualman, "Sask. Irrigation Expansion Questioned," *The Western Producer*, August 27, 2020, sec. Opinion, https://www.producer.com/opinion/sask-irrigation-expansion-questioned/.

## 5. Technology. Tools for farmers, not farmers as tools

In 2030, farmers remain at the centre of a struggle. Who will control agriculture? Who will profit most? Intersecting with these questions are others: How will we solve agriculture's sustainability and emissions problems? Are solutions largely techno-industrial? Or are they ecological and biological? If pre-20th-century, near-zero-input agriculture was near-zero-emission, and if emissions rose as input use rose, can farm-input corporations now reverse this situation and supply new products that reduce rather than increase emissions? Can the sources of the problem deliver needed solutions?

Seen from a high level, two broad solutions to agricultural emissions problems were on offer in the 2020s and remain on offer in 2030: one in which a reintegration with ecosystem patterns and cycles is the solution, and another in which data platforms, sensors, digital genetic manipulation, high-tech materials and chemistry, automation, and artificial intelligence are the solutions. Agroecology or agri-technology? Global agribusiness input corporations—worth, collectively, hundreds of billions of dollars—have staked huge sums on the latter. Many pundits and policy-makers have fallen in line.

The following quotes from farm-input makers, industry groups, and governments, published around 2020, outline plans to solve sustainability and emissions problems via farm inputs and technologies:

Fertilizer Canada in 2018:

> The agriculture sector is on the cusp of a digital data revolution that will further enhance crop performance, productivity, and enable the sector to advance evidence-based systems of performance metrics, while reducing GHG emissions. ... Earlier this year, Dominic Barton, chair of the Minister of Finance's Advisory Council on Economic Growth, released a report titled "Unleashing the Growth of Potential Key Sectors." ... The report identifies the need for increased investment in ... farm data and information collection systems; high tech GPS-guided machinery on-farm; sensors and data-driven analytics; quantification platforms and the formation of technology hubs....[17]

Deloitte in 2017:

> Smart livestock farming aims to achieve more productive, efficient, and sustainable farm operations based on the effective use of digital technologies. The largest potential lies in individual animal monitoring and analysis, which is referred to as precision livestock farming (PLF). In PLF, tools and sensors are used to continuously and automatically monitor key performance indicators of livestock in the areas of animal health, productivity, and environmental load. ... Operations can be improved further when farmers also share the information collected across the supply chain with relevant stakeholders, such as veterinarians, slaughterhouses, meat processors, and animal feed producers.[18]

17. Viresco Solutions and Fertilizer Canada, "Towards a National NERP Carbon Management Strategy" (Ottawa: Fertilizer Canada, 2018), https://fertilizercanada.ca/wp-content/uploads/2018/07/National-NERP-Carbon-Strategy-2018_vf-1.pdf.
18. Deloitte, "Smart Livestock Farming: Potential of Digitalization for Global Meat Supply," Discussion Paper, 2017, https://www2.deloitte.com/content/dam/Deloitte/de/Documents/operations/Smart-livestock-farming_Deloitte.pdf.

IBM in 2016:

> Data generated by sensors or agricultural drones collected at farms ... offer a wealth of information about soil, seeds, livestock, crops, costs, farm equipment or the use of water and fertilizer. Internet of Things [IoT] technologies and advanced analytics help farmers analyze real time data like weather, temperature, moisture, prices or GPS signals and provide insights on how to optimize and increase yield, improve farm planning, make smarter decisions about the level of resources needed, when and where to distribute them in order to prevent waste. Efficiency and productivity will increase in the next years as 'precision agriculture' grows bigger and farms become smarter and more connected. It is estimated that by 2020, over 75 million agricultural IoT devices will be in use, while the average farm is expected to generate an average of 4.1 million data points every day in 2050, up from 190,000 in 2014 [a 20x increase]. ...
>
> While digital transformation is disrupting the agricultural world and more data comes [to] feed the systems, solutions like the Watson IoT platform enhance value by applying machine learning abilities to sensor or drone data, transforming management systems in real artificial intelligence systems. ...
>
> Growing urbanization will lead to a decrease of workforce in the rural areas. Innovative technologies using cognitive systems will help address this challenge by easing farmers' work, *removing the need for large numbers of people to work the land* [italics added].[19]

The following quote is from a 2019 government of Canada announcement of a nearly-$50-million investment in the Canadian Agri-Food Automation and Intelligence Network which aims to "accelerate automation and digitization in Canada's agricultural sector":

> The future of farming will require farmers to adopt new technologies and processes in order to stay competitive. ... The Canadian Agri-Food Automation and Intelligence Network's work to build on Canada's strengths in artificial intelligence, robotics and precision agriculture to develop exportable farming solutions will be critical to ensuring this vital sector continues to grow for years to come.
>
> –Hon. Navdeep Bains, Minister of Innovation, Science and Economic Development[20]

In a series of reports, technology-assessment NGO ETC Group summed up the plan and the risks:

> All of the actors at the input end of the industrial food chain, from seeds to fertilizers to machines, are developing Big Data sensors and working with robotics. Agribusinesses [are] using high-flying satellites, low-flying drones or ground-level tractors to identify crop species, predict yields, analyze chemical usage, and even determine the patents or licenses associated with the plant varieties or chemicals. This data can be gathered either openly or surreptitiously.... In such an arena, victory usually goes to the companies with the deepest pockets. For field crops, this would

19. Madalina Irimia, "Five Ways Agriculture Could Benefit from Artificial Intelligence," *IBM Watson Blog* (blog), December 14, 2016, https://www.ibm.com/blogs/watson/2016/12/five-ways-agriculture-benefit-artificial-intelligence/.
20. Innovation, Science and Economic Development Canada, "Minister Sohi Announces Investment in the Future of Farming," news release, July 22, 2019, https://www.canada.ca/en/innovation-science-economic-development/news/2019/07/minister-sohi-announces-investment-in-the-future-of-farming.html.

> give the upper hand to the world's largest farm machinery companies that have both the money and the platforms into which everybody else has to place their products.[21]

In the 2020s, for many of the most powerful agribusiness corporations and aligned governments, the solutions to agriculture's emissions and sustainability problems were clear. The future would be a world of cloud computing and artificial intelligence, planting prescriptions and fertility plans downloaded to smart seeders, the Internet of (Farm) Things, digitization and automation, drones and 'bots—driverless tractors and farmerless fields.

But we didn't go that way—at least not yet. Throughout the 2020s, operators of small and medium-sized farms (and many large ones), enlightened governments, international agencies, some academics, some farm organizations, and others resisted techno-industrial colonization—the transformation from a food system based on sun, soil, water, plants, and people to one based on sensors, Big Data, 'bots, and corporate AI. A growing number of farmers rejected the plan for ever-deeper corporate entanglement, technological lock-in, and dependency, and began instead looking for solutions on their own farms—among plants and other organisms. Many producers seem to have decided—though in 2030 the direction still remains tentative and reversible—to connect not with computing clouds and Big Data platforms, but rather with ecosystems, nutrient cycles, and soil micro-organisms. A growing portion of farmers are choosing a partial decoupling from agri-business and a renewed integration into nature.

The struggle for the control of (and profits from) farming will continue. But the 2020s saw, if not a reversal of the trend toward techno-industrialization, then at least a slowing, a pause, and an ever-wider rethinking. Many came to see the promises of agri-tech (control, efficiency, simplicity[22]) as false. Increasingly discredited, the techno-domination of nature and agro-ecosystems is being replaced, on a growing number of farms and research stations, with a new ecosystem-based approach that seeks to re-entangle agriculture with ecology and biology—with *life*. In 2030, emissions are down, soil health is up, net incomes are up, and debt levels are down. Farmers' renewed partnership with nature seems to be providing what agribusiness never did.

A decade ago, an NFU member from near Lucknow, Ontario, offered a revealing sketch of agricultural history. He said, "Thousands of years ago, with the plough, we enlisted physics into food production. Then a hundred years ago, with fertilizers and pesticides, we added chemistry. Now, after a long hiatus, we're rediscovering biology."

21. Pat Mooney and ETC Group, "Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms and Food Sovereignty Solutions" (Berlin: ETC Group, 2018), 16, https://www.etcgroup.org/sites/www.etcgroup.org/files/files/blockingthechain_english_web.pdf.
22. Monsanto promised: Seed, Spray, Harvest, Simplify.

**Avoiding naive techno-optimism**

Many books and articles have been written examining technology-as-a-system and its impacts on societies. These explorations of the real-world effects of technologies include ideas such as technological lock-in, the ways that technology can drive inequality, impacts on the quality of work and worker control, and the effects on patterns of thought and democratic functioning. Moreover, the intensifying ecological problems we face—the fastest extinction event in 65 million years, potentially civilization-withering levels of global heating, oceans full of plastic, deforestation, etc.—should make us open to the ideas contained within these critiques of technology. The contention that technologies bring solutions more than they bring problems is observably false.

Leaving aside most of the ideas found in critiques of technology, one *is* worth highlighting: Gerry Mander's contention that technologies usually are introduced via *best-case scenarios*—often by proponents, company employees, pundits, or legislators connected to the techno-solution in question.[23] Moreover, it is usually impossible to perceive, at the launch of a technology, the problems that will develop later. Imagine Henry Ford in 1913 touting his assembly line and the inexpensive automobiles it could produce. Ford might have highlighted the benefits of affordable cars: bringing families together, ridding cities of horse manure, and democratizing transport. In 1913, no one would have interrupted to ask: But Mr. Ford, what about smog, climate change, urban sprawl, traffic jams, and foreign wars for oil? To the public and legislators, news of a technology's benefits is delivered first, often in glowing terms, while awareness of problems trails decades behind.

Because most technologies create increasing problems over time, and because it is hard to see those problems when those innovations are introduced, and because new technologies are usually presented initially by proponents and salespeople via best-case scenarios, adopting a sceptical stance is prudent.

23. Jerry Mander, *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations* (Sierra Club Books, 1992).

## 6. Livestock. Fair prices help reduce emissions

Livestock can be a climate problem, but grazing and grasslands can be climate solutions. Methane from cattle and other ruminants contributes to warming, but enhanced grazing builds soils, increases soil organic matter and carbon levels, fosters biodiversity, increases grassland ecosystem health, and prevents conversion of grasslands to cropland and the release of soil carbon as $CO_2$. How we manage cattle, grazing, grass, and soil determines whether the net effects of livestock are positive or negative.

In previous decades, when governments and academics talked to farmers about cattle production—about feed quality, rotational grazing, and other factors—many farmers turned the conversation to production costs and what changes were affordable given existing prices. In those years, the implication was that cattle could be fed, grazed, and managed better and that emissions could be lower if margins were larger and pressures to cut costs not so intense. Predictably, lowest-cost production systems often don't align with lowest-emission systems. The message from the 2000s and 2010s was that if farmers earned more, production systems could emit less. That message was taken seriously as Canada worked to restructure its food system in the 2020s. A series of national, continental, and international policies and events[24] had the effect of doubling cattle prices in the 2020s (Figure 4, below). Higher prices and larger margins made possible enhanced production systems that maximized benefits from grazing while minimizing emissions. During the 2020s, farmers worked hard to lower emissions per animal and per kg of meat or milk—building on work begun decades earlier and that had succeeded in reducing per-unit emissions.[25] (Figure 2, above, shows reductions in emissions from livestock.)

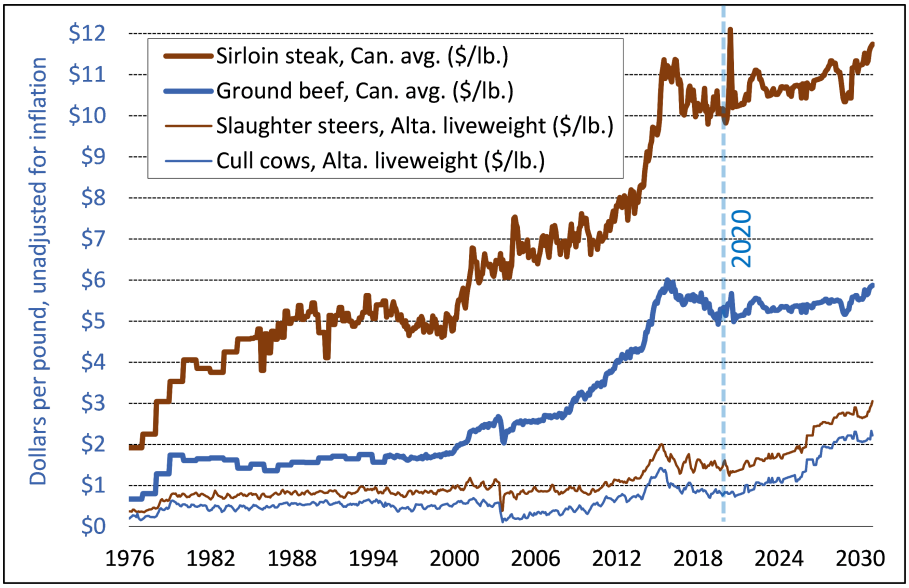


**Figure 4. Prices for farmgate cattle and retail-store beef, 1976-2030**
Sources: Available upon request. Numbers after 2020 are notional, not projections.

24. Including: 1. governments worldwide pitched in to pay Brazil and other nations to stop destroying rainforests, effectively closing the global frontier and ending millennia of farmland expansion; 2. Several countries imposed border taxes on imports of products with outsized emission footprints, increasing prices for some imported meats; 3. Canadian and US legislators threatened to force packers and retailers to open their books, and to break up oligopolies if necessary.

25. G. Legesse et al., "Greenhouse Gas Emissions of Canadian Beef Production in 1981 as Compared with 2011," *Animal Production Science*, 2015, http://dx.doi.org/10.1071/AN15386; Susantha Jayasundara and Claudia Wagner-Riddle, "Greenhouse Gas Emissions Intensity of Ontario Milk Production in 2011 Compared with 1991," *Canadian Journal of Animal Science* 94, no. 1 (December 7, 2013): 155–73, https://doi.org/10.4141/cjas2013-127.

However, getting global atmospheric methane levels under control also required work in other sectors. In the lead-up to the 2030 reckoning of their Paris commitments, Canada, the US, and other nations finally took action to staunch the flow of methane from the fossil fuel sector—from oil and gas wells and coal mines. Actions to enforce restrictions on this senseless venting of powerful greenhouse gases repeatedly had been delayed, but by mid-decade several countries took effective measures. A small reduction in global emissions from livestock coupled with moderate reductions from the global fossil fuel sector caused atmospheric levels to begin falling—creating (atmospheric) space for sustainable, soil-building grassland farming, mixed farms, and grazing animals.

## 7. Net income. Restoring farmers' rightful share.

Three financial indicators tell the story of the changes in the 2020s. The first is net farm income. In the years leading up to 2030, realized net income from the markets rebounded to levels normal throughout much of the 20th century but rare since 1985 (see Figure 1). That rebound occurred because farmers' expenses declined relative to their revenues—their *margins* increased. See next.

The second indicator is margins. Figure 5 shows farmers' margins from 1930 to 2030. Here, margins are defined as realized net income from the markets divided by gross revenues from the markets. For example, if net income is $3 billion and gross revenue is $60 billion then margins are 5 percent, and 95 percent goes to pay expenses—to fuel, fertilizer, and machinery companies, banks, etc. Note the steady decline in farmers' margins since WWII. A big factor is increasing reliance on purchased inputs. Farmers' portion was falling because the portion captured by others was increasing. See next.

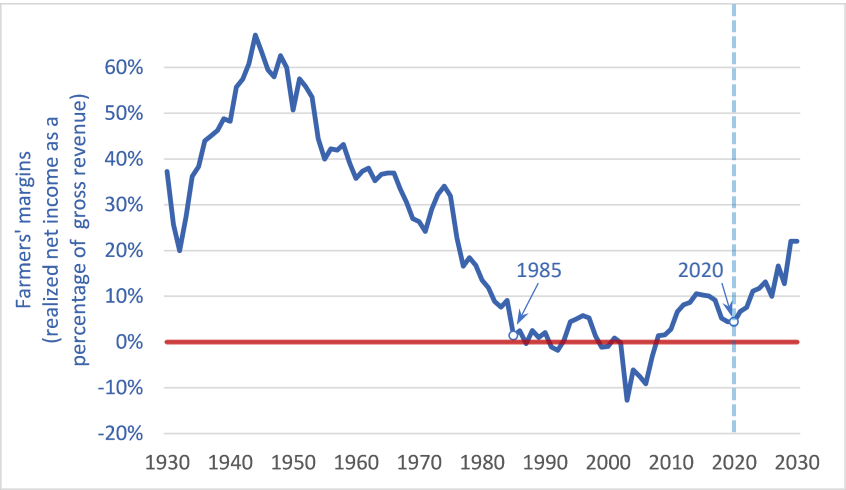


**Figure 5. Farmers' margins, Canada, 1930-2030**
Sources: Stats. Can. tables 32-10-0045-01; 32-10-0052-01; and 32-10-0106-01. Numbers after 2019 are notional, not projections.

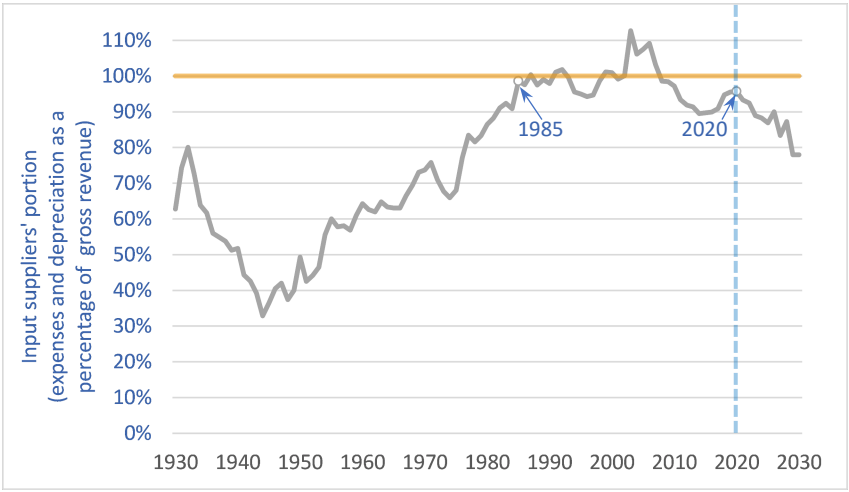


**Figure 6. Input suppliers' share of Canadian gross farm revenues from the markets, 1930-2030**

If farmers are keeping less, others must be taking more. Figure 6 shows the portion captured by input makers and service providers. Note the 40-year progression from 1945 to '85. Input makers

and sellers took about 40 percent in the 1940s, about 50 percent in the 1950s, about 65 percent in the 1960s, about 75 percent in the 1970s, about 95 percent in the 1980s, nearly 100 percent in the 1990s, and about 105 percent in the 2000s.

As farmers became more dependent on a wider array of farm inputs and services, the share of farm revenues captured by non-farmers increased. Given the expanding range of farm inputs on offer, this isn't surprising and wouldn't have been damaging had it levelled off at some tolerable level—say, corporations capturing 75 or even 85 percent. But inadequately restrained by competition and bristling with market power,[26] global input corporations such as Bayer, Deere, Nutrien, and others captured more and more of farmers' revenues until, through much of the 1990s and 2000s, they captured more than 100 percent—leaving taxpayers to make up farmers' shortfalls.

But the collision with planetary limits triggered a rethink. In the 2020s, the project of maximizing yield, output, and exports was curtailed and replaced with new goals wherein input use would be moderated to reduce emissions. As input use fell, the portion of farm revenue captured by input suppliers fell too (Figure 6), and the portion retained by farmers rose (Figure 5).

The third indicator of the 2020s turn-around is debt. Figure 7 shows inflation-adjusted Canadian farm debt levels from 1970 to 2030. Debt nearly tripled in 27 years, rising from $40 billion in 1993 to $115 billion in 2020. Then, with the turn-around, it began falling. Farm debt is now a third lower than at its 2021 peak—down nearly $40 billion. As a result, farmers are saving a billion dollars per year in interest charges. That billion dollars is staying on farms and circulating in rural economies.

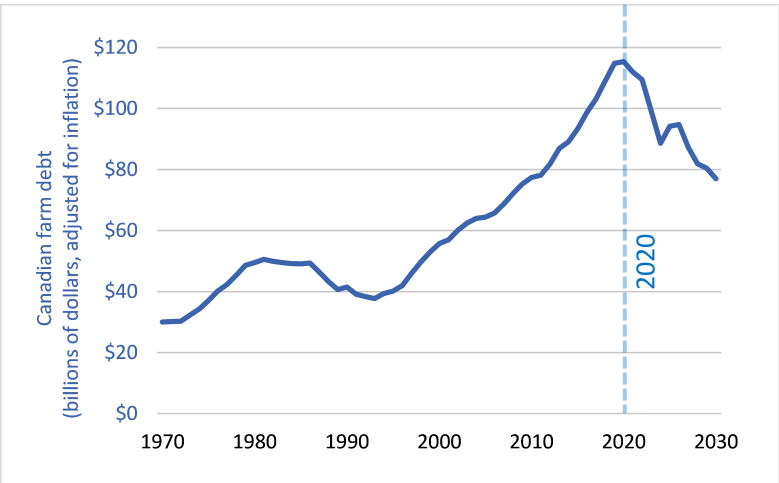


**Figure 7. Farm debt, Canada, adjusted for inflation, 1970 to 2030**
Sources: Stats. Can. Tables 32-10-0051-01. Numbers after 2019 are notional, not projections.

All these economic turnarounds occurred because farmers began getting more of what they needed from biology and less from industry. And this transition from an industry-based to an ecology-based food system—what many farmers call "agroecological farming"—was also key to lowering emissions. As the NFU declared eleven years ago, in 2019: "Two things happen when farmers become over-dependent on petro-industrial inputs: emissions go up, and incomes go down. Easing the climate crisis by lowering input use and emissions can also go a long way toward easing the farm income crisis."[27]

26. National Farmers Union (NFU), "The Farm Crisis & Corporate Profits" (Saskatoon: NFU, December 1, 2005), https://www.nfu.ca/policy/the-farm-crisis-corporate-profits/.
27. Darrin Qualman and National Farmers Union, "Tackling the Farm Crisis and the Climate Crisis: A Transformative Strategy for Canadian Farms and Food Systems" (Saskatoon: NFU, 2019).

## 8. Local food, local processing, foodsheds, and the end of export mania

Local food does not always equal low-emission food. As some point out, big trucks filled to capacity have low emissions per tonne-kilometer compared to a car or light truck carrying just a few boxes to a local sales point. Thus, the following proposition: not all local food systems are low-emission, *but most low-emission food systems will be local*. Localizing and regionalizing food, done with care and forethought, is key to reducing whole-system GHG emissions.

In the 2020s, many organizations, governments, food councils, and companies worked to combine the necessary components for low-emission food systems:

a. Local, low-emission food production;
b. Local and regional *processing*, to minimize transport distances;
c. Rational, low-emission transport methods throughout those local and regional food networks;
d. Consumer education about lower-emission foods (local carrots vs air-freighted asparagus);
e. Energy efficiency beyond the retail door: minimizing emissions from car trips to grocery stores; from in-home refrigeration, preparation, water use, and clean-up; etc.; and
f. Minimizing food waste and landfilling: diverting food to other residents, to other uses (such as livestock feed), or, at minimum, to composting.

Though a straightforward recipe, there are challenges. One is processing capacity. In the 1980s, 1990s, 2000s, and 2010s, as processing companies consolidated, plants closed, and processing became centralized, more and more cities lost the beef, poultry, pork, dairy, egg, flour, vegetable, fruit, and other processing plants once common in most cities or regions. A 2013 report on the food system in Regina, Saskatchewan, details processor loss in that city—a situation repeated across Canada:

> Regina is surrounded by crops and livestock. We might expect that much of that food would flow toward the city, however, that is not the case. ... Even if a cow or pig or bushel of wheat is raised a dozen kilometres from downtown, in order to get to a Regina table, those agricultural products are usually trucked away from the city.... A key reason is that food processing plants, once numerous in and around Regina, have been shut down, with production concentrated in a few very large plants, mostly in other provinces [or cities].... These ... plant closures have re-patterned food flows and severed Regina from its surrounding foodshed....[28]

Low-emission local and regional food systems require local and regional food processing plants. Luckily, in the years preceding 2030, there has been accelerating action to build and expand small and medium-sized processing facilities—places where, for example, local produce growers can pickle two thousand jars of cucumbers, abattoirs where 20 goats can be slaughtered and processed, or mills where heirloom-variety wheat producers can grind and bag three tonnes of flour. Accessible, appropriate-scale processing facilities are needed to ensure a wide variety of local foods on store shelves. Key to the creation and expansion of those facilities in the 2020s were new food-safety regulations appropriate for small processors as well as long-term financing for local businesses to set up or expand facilities. Even more important was a 2026 federal mandate requiring large food retailers in cities with more than 100,000 residents to source an increasing percentage of their food

28. Darrin Qualman et al., "Environmental Scan: Conventional and Indigenous Food Systems and Gaps in the Regina Area, SK" (Regina: Regina Community Food Systems Steering Committee, 2013).

from supplies grown and processed within 150 kilometres of those cities. 2025 was set as a baseline and the portion of locally sourced food had to increase by 1 percentage point per year. For example, retailers where 10 percent of food was sourced locally in 2025 had to source 11 percent locally in 2026 and 35 percent in 2050. Initially, lack of supplies and processing capacity near many cities caused problems. That was foreseen. Governments allowed flexibility and worked with companies. What was clear, however, was that local processing would be a paying proposition and food companies, co-ops, and other businesses responded accordingly. For half a century, market forces had delocalized food, shuttered plants, eroded competition, destroyed local provisioning capacities, and increased food-transport emissions. Reversing these destructive trends required strong government actions.

## Foodsheds

Cities have existed for about 5,000 years. For 99 percent of that time, most cities sourced most of their food from surrounding farmland—from their foodsheds. Only in the past 50 or 60 years have an increasing number of cities severed their foodshed connections and started provisioning themselves from hundreds and thousands of kilometres away. Creating low-energy-use, low-emission food systems required reconnecting cities to foodsheds. Redeveloping local processing was one key part; redeveloping local *production* was another. To restart and re-diversify local production, several cities have embarked on plans like this one, from Winnipeg:

A. Aided by financing from other levels of government, Winnipeg is buying land offered for sale around the city. A doughnut extending 30 kilometres from city limits encompasses about 5,000 square kilometers. The City is working to acquire 10 percent of that land: 50,000 hectares (just over 100,000 acres)—an area roughly equal to that of the city itself.

B. The City is providing that land on generous terms, in small parcels, to young would-be farmers, retired people, new Canadians, greenhouse growers, co-operatives, organic producers, agroecologists, small-flock livestock producers, herb growers, orchardists, vegetable producers, etc. Land is provided to anyone with a reasonable business plan who is willing to produce sustainable food for Winnipeg-and-area tables.

C. Battery-electric heavy trucks follow regular routes, picking up food and other products and bringing it to local processors, warehouses, markets, and distribution hubs within the city—facilitating emission-free access by bicycle, transit, and walking.

D. Using its procurement powers, the City and its food banks provide guaranteed markets and prices for the first two years of production from each new grower, enabling producers to launch their operations confident that they will have markets and sales.

Details vary from community to community. In some cities, farmer-owned co-ops have been created to buy and manage the land, with financing coming from governments. Other communities are relying on land trusts. One city is using tax abatements and other incentives to encourage private landowners to make food land available to would-be farmers and local producers. In other places, long-term, low-interest loans enable farmers themselves to buy the land (though restrictions on resale apply). Many different models and experiments are being tried. The overall effect of these various initiatives has been to restore the foodsheds around many Canadian cities.

The models being developed in Winnipeg, Edmonton, and other cities have created many benefits:

- Increasing the number of farmers and food producers;
- Supporting diverse production methods (diversity enables rapid adaptation to climate change);
- Building resilience and decreasing risk by radically relocalizing and diversifying food sources;

- Creating opportunities for children and youth to participate in food production;
- Restraining urban sprawl (a move that further helps control GHG emissions) and slowing the loss of prime farmland; and
- Creating a verdant, well-tended, beautiful countryside, reminiscent of European rural areas.

Beyond the processing, relocalization, foodshed, and waste-reduction measures listed above, other actions have helped lower food-transport emissions. These include regulations curbing food air freight (down 60 percent from 2020); encouraging citizens to eat "in season" to reduce transport emissions; and urban planning that seeks to provide food retail stores in all neighbourhoods, enabling residents to shop without driving.

## The end of export ag as a federal fixation

Movement toward local food provision required changes among processors, retailers, and producers. It also required a shift at the highest level: the federal government. Agriculture and Agri-Food Canada (AAFC) had to change the prime directive for Canadian agriculture, from "maximize exports" to a suite of goals that includes reducing emissions, reducing input use, increasing farmers' margins, building soils and resilience, and diversifying production approaches. The adoption of those new goals marked a huge change at the federal level. From the early 1990s to the early 2020s, the federal government had been fixated on export maximization. Aligning with the dominant food corporations, Ottawa repeatedly announced ever-higher agri-food export targets.[29] That export push succeeded. Between 1990 and 2020, Canada increased food exports three-and-a-half-fold (adjusted for inflation). Imports rose too. Canada's trade-maximization policies resulted in an increasingly far-flung food system that *maximized* food miles. Figure 8, below, shows agri-food exports, imports, and net exports (exports minus imports). Note the post-2020 reduction in imports.

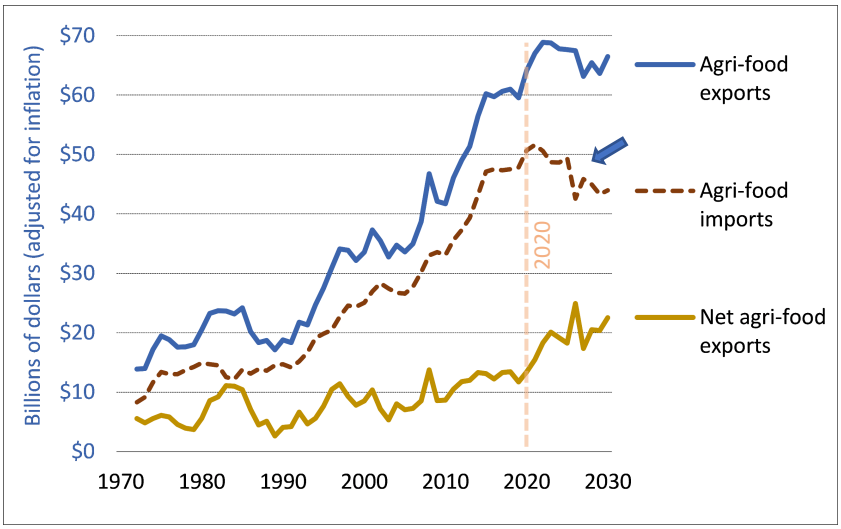


**Figure 8. Canadian agri-food exports, imports, and net exports, 1970-2030**
Sources: Agriculture and Agri-Food Canada, *Agri-Food export potential for the year 2000* (AAFC: Ottawa, 1996); recent-year data provided by AAFC, on request. Numbers after 2019 are notional, not projections.

29. In 1993, federal and provincial governments set a target to double agri-food exports to $20 billion by 2000. Having accomplished their goal by 1996, ahead of schedule, Ministers pledged to redouble exports to nearly $40 billion by 2005. Other targets followed. In Budget 2017, the federal government again pledged to increase exports, setting a target of $75 billion in 2025. (Export levels and targets here may not match the graph above, as the graph makes adjustments for inflation and figures in this note do not.)

## 9. Leadership. Citizens and governments, not corporations

In 2030, much has been accomplished regarding emissions reduction and food system resilience, and much more is underway or on the horizon. One big change is that after decades of lethargy and deference, governments have begun to act. In the US, Green New Deal retooling and rebuilding is roaring ahead—in Canada, too, though it goes by other names. The Canadian federal government's buy-up and repurposing of fossil fuel companies was a key step toward this new reality. Moves to restructure trade agreements also were key—moving from trade maximization to emissions reduction, food regionalization, resilience building, and a "Canadian Economy 3.0" based on clean, renewable energy, equity, stable employment, and sustainable communities.

In 2030, governments have rediscovered ideas that were long at the heart of economy- and nation-building. After years of being submissive to corporations and global trade bodies, governments are relearning approaches previously captured in terms such as "industrial strategy." They are studying the lessons of Canada's transcontinental railway era and the creation of Canada Post, the US New Deal and Tennessee Valley Authority, rural electrification and cross-country road building, the Apollo program, the massive World-War-II production and logistics push, and the many other examples of government-led investment, construction, renewal, and transformation. As our global civilization crashes into planetary limits, private profit motives are wholly inadequate to steer us where we need to go. Governments are increasingly directing and restructuring economies to ensure that needed things get done. Governments also are mobilizing resources, public opinion, political will, and Canadian capital and productive capacity. Long passive before global corporate capital and invisible-hand markets, governments are once again active agents in the formation of a new Canadian energy system, economy, trade policy, and food system. There are nearly 200 nations on Earth. In 2030, it is clear that "markets," the invisible hand, global capital, and increasingly stateless and footloose corporations will not deliver a thriving twenty-first-century, low-emission economy to each of those 200 nations. *We* have to do that. Climate change is forcing many things, but most of all it is forcing a new active role upon governments and citizens. It is forcing us to once again take up our sovereign power and take collective, democratic responsibility for our future and the health of the biosphere.

Bayer, Nutrien, Deere, Exxon, Cargill, JBS, Loblaws, Sobeys, the New York Stock Exchange, the Chicago Commodity Exchange, and World Trade Organization will not give Canada the low-emission food system we need. *We* must make it. Our leaders must lead. That's government's new role on our swiftly warming, swiftly changing Earth. In 2030, that's well understood. And citizens and governments are acting.

**The beginnings of reconcilia(c)tion**

Between settler and Indigenous peoples, reconciliation is not a destination or end point, but a path to be walked each day anew. From the standpoint of 2030, we can see some progress but also much to be done. Here, though, it's worth highlighting how much we *can* do, if we choose to.

The COVID-19 pandemic of 2020-2022 changed so much, and revealed so much. One thing it revealed was that when it comes to fighting viruses, tackling climate change, taking steps to support our citizens, or even taking action to redress structural injustices, we need not think ourselves limited by money. We can afford to do much more than we often assume.

Much of the land that now makes up Canada was acquired through theft. In many cases, the treaty-making process was coercive.[30] In many cases treaty obligations were not fulfilled; what was promised in exchange for land sharing was not given. And in many cases there were no treaties at all and land was not ceded, but rather seized. Much more can be said of the events of past centuries and of an ongoing process rightly labelled genocide.

Repairing relations and moving toward justice probably means transferring some additional and significant portion of Canadian land back to First Nations peoples. Many had assumed that to be impossibly costly—Canada could never afford it. But the pandemic of the early 2020s and the financial response to it revealed a different reality. In 2020, the federal deficit was nearly $400 billion. In 2021 it was nearly $250 billion. Consider that $650 billion. There are about 160 million acres of farmland in Canada. $650 billion would be more than enough to buy all that land (and nearly enough to include all the buildings, livestock, and machinery).[31] That said, no one is suggesting buying all Canadian farmland and transferring it to Indigenous peoples. But as a thought experiment, it's revealing: the power we have to redress wrongs is not money-limited. Here's another thought experiment: $650 billion works out to about $380,000 for each of the 1.7 million Indigenous people in Canada—about $1.5 million per theoretical family of four. All things are possible, or at least affordable.

Reconciliation goes far, far beyond land and money, but the preceding shows that there are no *economic* limits to what we can do. This point is important to raise here because the changes we make to the food system—the changes we make to solve climate and environmental problems—must be informed by, support, and move in parallel with the changes we make to reconcile settler and Indigenous peoples. Healing takes many forms, and must be pursued on many fronts. Everything is interconnected, and for that reason, it is simply impossible to do just one thing at a time. Reconnecting with nature and healing the planet must proceed entwined with work to reconnect peoples and heal relationships.

30. James Daschuk, *Clearing the Plains* (Regina: University of Regina Press, 2013).
31. The value of total farm assets was $655 billion in 2019. Stats. Can. table 32-10-0056-01.

## 10.Conclusion

Here is a solution:

The past 100 years: ↑ inputs → ↑ emissions + ↑ costs → ↓ margins + ↓ farmers

The future: ↓ inputs → ↓ emissions + ↓ costs → ↑ margins + ↑ farmers

We just have to turn agricultural policy on its head. And this is what planetary limits are now forcing us to do. As the 2020s progressed, a consensus emerged: To cut emissions we must cut energy and material use—cut farm input use; get more from biology and less from industry. The alternative was not just a damaged Canadian farm sector; it was a terminally injured civilization.

For most of the past 100 years, to feed the billions of people we've added to the planet we've pushed more and more energy into food-production systems. These energy inputs came in the forms of machinery and fuels, pumped irrigation water, iron and steel, high-tech seeds from complex technology firms, petro-chemicals, and, especially, energy-intensive fertilizers such as nitrogen. The result is a global food-production system unprecedented in human history—one that's massively dependent upon fossil fuels and that emits billions of tonnes of climate-destabilizing greenhouse gases.

The good news, however, is that from our vantage point in 2030, we can see the outlines of transformative change and solutions—the outlines of low-emission food systems and, in some cases, near-zero-emission systems. To reach this point we've embarked upon four key transitions:

1. from an agriculture that draws ever more from industry to one that emulates biology;
2. from food production energized by fossil fuels to systems powered by sunlight;
3. from export-maximizing, far-flung food chains to local and regional production and processing and a reconnection to surrounding foodsheds; and
4. from food systems shaped by corporations and stock market returns to ones shaped by governments and citizens and the imperatives of emission reduction, sustainability, long-term resilience, risk reduction, justice, and democratic and community control.

The steps Canada took in the 2020s, similar steps taken by other nations, and the steps we're committed to take in the 2030s and beyond literally *saved the world*. It could've gone either way. In 2018, Canada set a record for the highest fossil fuel use in its history. Agricultural emissions rose 23 percent between 1990 and 2018. It looked like we were on track for failure—on track to permanently destroy our future. It was a close thing. But we made the necessary changes. We acted boldly! We turned away from business as usual, ignored special-interest pleadings, and acted in the public interest. And now we can begin to breathe easier; we can take heart that we've averted the massive planetary perma-catastrophe that inaction, or slow action, would have created. As the 2020s unfolded we acted to save the planet rather than destroy it; that made all the difference.

Canadian farmers thank the governments that took courageous actions over the past decade; the citizens who put their shoulders to the wheel and their bodies on the line to speed action; and the organizations that educated, organized, and mobilized Canadians to fight for real change.

Just imagine....

**With respect and thanks to all Canadians, from the National Farmers Union.**

## Acknowledgements

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Founded in 1969, and with roots going back more than a century, Canada's NFU represents thousands of farm families and farming units from coast to coast and also enjoys the support of many non-farmer Associate Members. The NFU embodies the principle that all farmers share common problems and that farmers must come together to address those problems. We believe that agriculture should be economically, socially, and environmentally sustainable. Food production should lead to enriched soils, a more beautiful countryside, jobs for non-farmers, thriving rural communities, and healthy natural ecosystems. To learn more about the NFU, please go to our website: www.nfu.ca. **Please join the NFU, as a farm family, a farm youth member, or a non-farmer Associate Member.**


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Cover photo by Wheelbarrow Farm. It shows farmer Tony Neale and his electric tractor powered by solar energy.

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