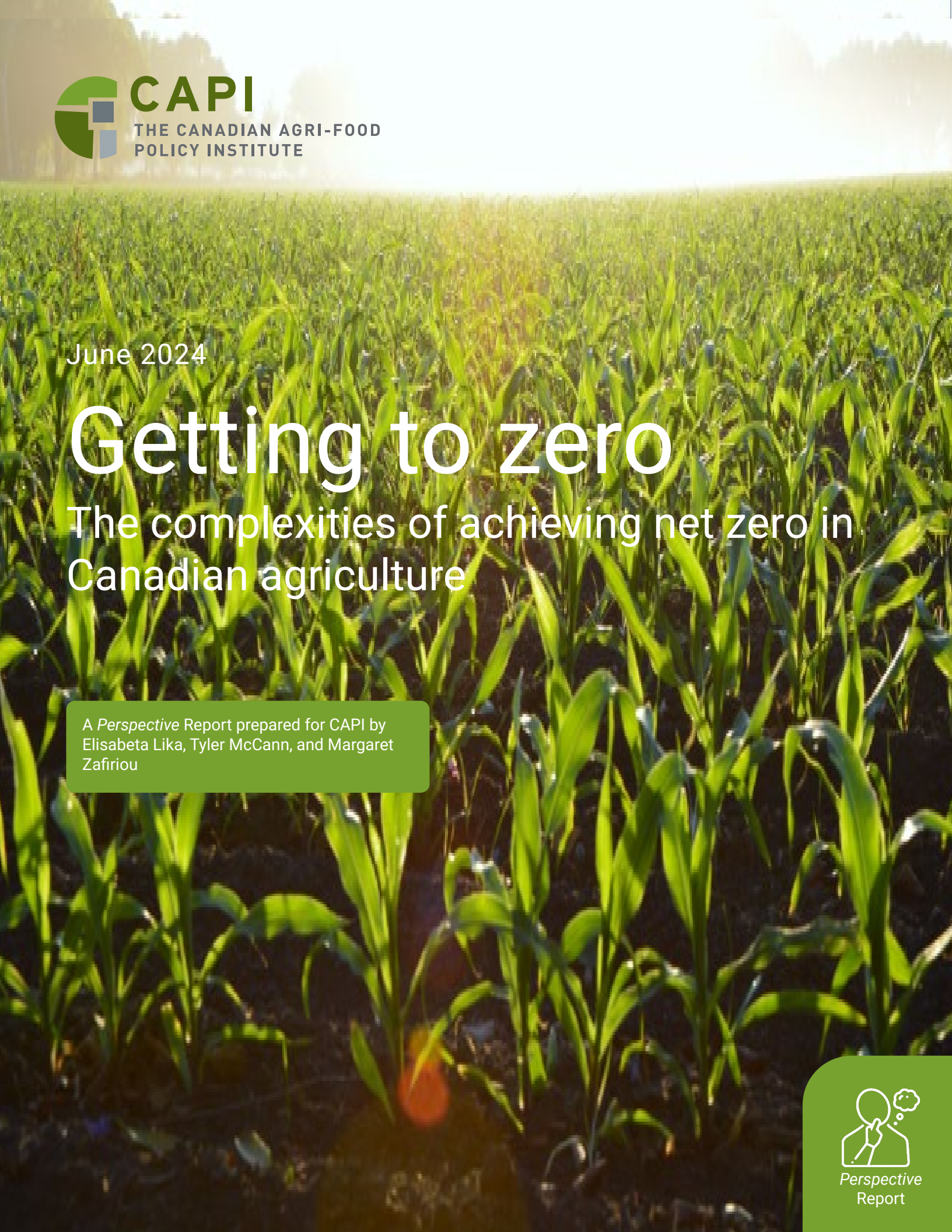

CAPI
THE CANADIAN AGRI-FOOD POLICY INSTITUTE

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Getting to zero

The complexities of achieving net zero in Canadian agriculture

A *Perspective* Report prepared for CAPI by Elisabeta Lika, Tyler McCann, and Margaret Zafiriou

Perspective Report

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The Canadian Agri-Food Policy Institute's mission is to lead policy development, collaborate with partners and advance policy solutions within agriculture and food.

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The findings, interpretations, and conclusions in this report are solely those of the authors.

To ensure the validity and quality of its work, CAPI requires all Perspective Reports to go through a peer review process.

CAPI thanks the peer reviewers for their comments on an earlier draft of this report.

Note from CAPI

As climate change accelerates, understanding the unique complexities of Canadian agriculture becomes increasingly important. This report builds upon two recent studies, one published by CAPI and the other by the Centre for Agri-Food Benchmarking, delving deeper into these complexities within the context of achieving net-zero emissions. It emphasizes the need for a broader understanding of net-zero, moving beyond the narrow focus on carbon emissions to consider the full spectrum of agricultural complexities. These include the economic, biological, and logistical challenges unique to the sector, which often go underdiscussed in mainstream net-zero strategies.

By exploring these complexities, the report highlights the value of evolving the current dialogue towards a more comprehensive approach that recognizes the diverse realities of agriculture. This is important for creating adaptable, practical policies that are not only effective in reducing emissions but also feasible across Canada's diverse agricultural environments.

The aim is to inform policy development to fully consider all aspects of agriculture and address the sector's complex challenges, ensuring that strategies are both realistic and grounded in the operational realities faced by farmers. This approach helps ensure that efforts to achieve net-zero emissions are thorough, equitable, and aligned with broader Canadian agricultural policy objectives.

Key Takeaways

- Current discussions and strategies around achieving net-zero in agriculture are focused on carbon emissions, often neglecting other crucial aspects. It is important to expand net-zero discussions to encompass the full spectrum of agricultural complexities, including economic, biological, and location-specific challenges, to ensure a comprehensive approach.
- Current on-farm GHG measurement tools often rely on generalized models that lack accuracy and regional specificity. It is recommended to develop and implement GHG measurements tools that are fit-for-purpose, accurately reflecting the specific conditions and needs of Canadian farmers.
- There is a gap in comprehensive aggregate GHG intensity data for the post-farm gate sector. Improving GHG intensity data collection and analysis for post-farm gate operations and developing consistent standards for measurement is crucial to support effective monitoring and strategy development for reducing emissions throughout the food value chain.
- Many net-zero strategies do not align well with the economic pressures and practical realities that individual farmers face daily. It is crucial to align net-zero strategies with the actual operational and economic realities of farmers, which will help promote sustainable practices and long-term sustainability outcomes and economic viability.
- Agricultural policies often struggle to adapt to the variable and dynamic conditions that characterize the farming sector. Implementing adaptive management strategies within policy frameworks is needed to better accommodate changing agricultural conditions and integrate new data and information on outcomes, enhancing both the long-term relevance and impact of net-zero strategies.

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1. Current state of net-zero discussions in agriculture

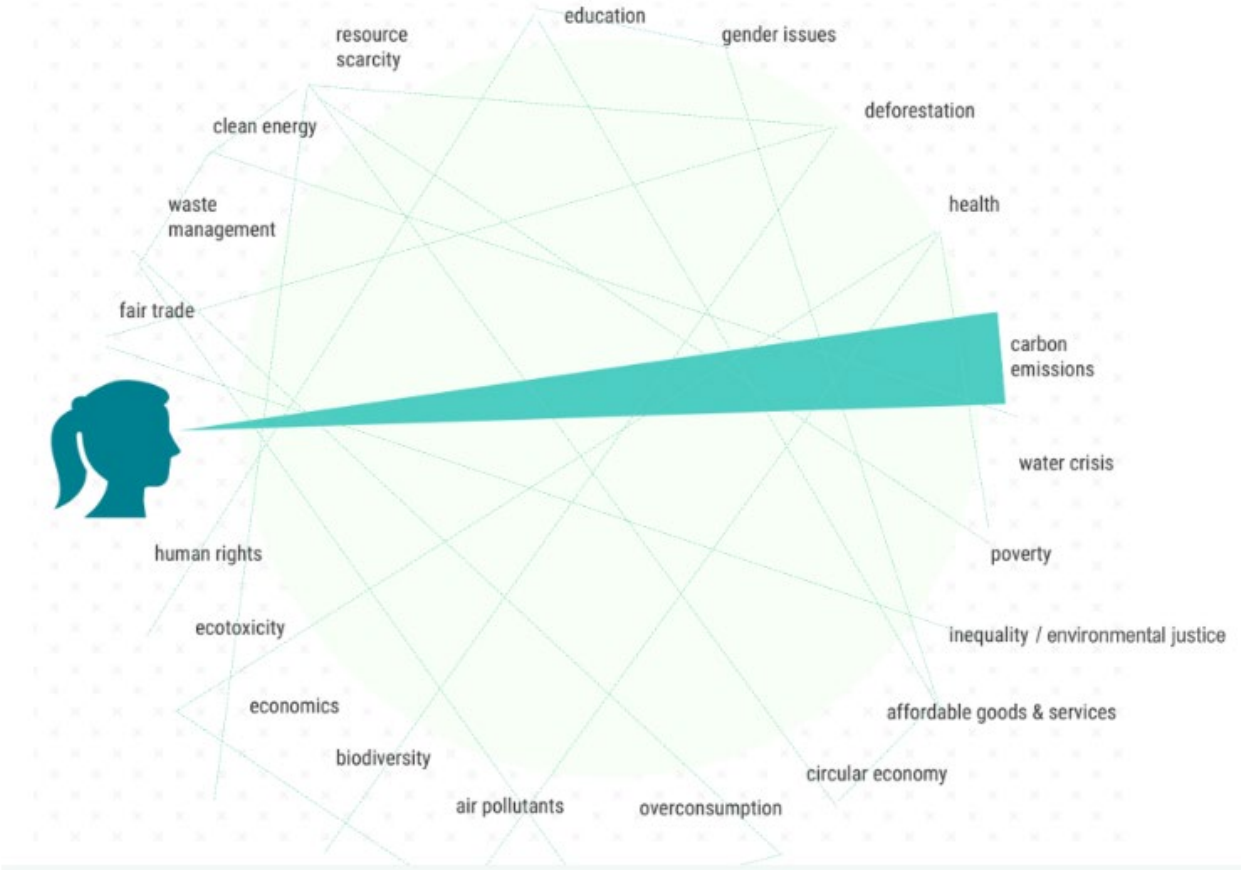
Discussions about achieving net-zero emissions in agriculture often focus on the details—measuring greenhouse gases, using the right tools and management practices, and managing emissions down to the last gram. But does this focus address the broader picture? Are the real costs of achieving net zero and essential questions being considered? Is there even a consensus on what "net-zero" actually means for agriculture?

The agricultural sector is marked by diverse voices and differing perspectives. What net-zero means for one farmer might differ significantly from another's view. Approaches must not only cherry-pick the easy parts; they need to tackle the full range of challenges and opportunities that come with farming.

Unlike other industries, agriculture cannot simply set a static target to be met annually. The sector is unpredictable. Strategies that are effective in one season might fail the next due to changing weather, new pests, or shifting market prices. Food security remains a non-negotiable priority, complicating the goal of achieving net-zero in agriculture and making it a complex and evolving challenge.

Currently, there's a lot of focus on merely slashing carbon emissions as if that's the sole goal. This "carbon tunnel vision" can overshadow other important issues like soil health, water use, biodiversity, and even social equity and food prices. A singular focus on carbon reduction risks ignoring these significant, interconnected issues.

Figure 1: Propensity for "carbon tunnel vision"[1]



Additionally, there's confusion between "net-zero" and "carbon neutrality." Although they sound similar, they entail different strategies. Net-zero involves reducing all types of greenhouse gases across the entire agricultural process, from farm to table. In contrast, carbon neutrality often means balancing out CO2 emissions with C

[1] https://www.bakerinstitute.org/research/schrodingers-cat-paradox-carbon-enemy-carbon-not-enemy

offsets like tree planting, not actually reducing the emissions from farming activities. This misunderstanding can skew strategies and decisions.

Another critical issue that often goes underdiscussed is the complex relationship between climate change and food insecurity. Climate change disrupts agriculture by altering weather patterns, reducing crop yields, and increasing the frequency and severity of extreme weather events, which in turn leads to reduced food availability. Farmers might respond by using more fertilizers or intensifying land use, which can degrade soil health and increase greenhouse gas emissions. It's a challenging vicious cycle where solutions to one problem might exacerbate another.

This report aims to add value to the conventional dialogue about net-zero in agriculture by confronting these complexities directly. It highlights for policymakers the real challenges in measuring and making progress towards net-zero and emphasizes the importance of considering farmers' diverse realities in designing and implementing adaptive, responsive policies. It informs industry leaders about the necessity for accurate data and tools that cater to the unique needs of different regions and value chain players (i.e. farmers vs processors). It also informs financial stakeholders about the state of greenhouse gas emissions measurement tools and the potential for developing aggregate GHG intensity estimates for the post-farm sector. This knowledge can aid in managing climate risks and supporting sustainable agricultural practices and outcomes.

By diving into these issues, the report emphasizes that while it is important to acknowledge that achieving net-zero emissions in agriculture is a crucial goal, it must be pursued in a way that fully respects and considers the complexities and realities of the sector.

2. Why net-zero should not be overlooked

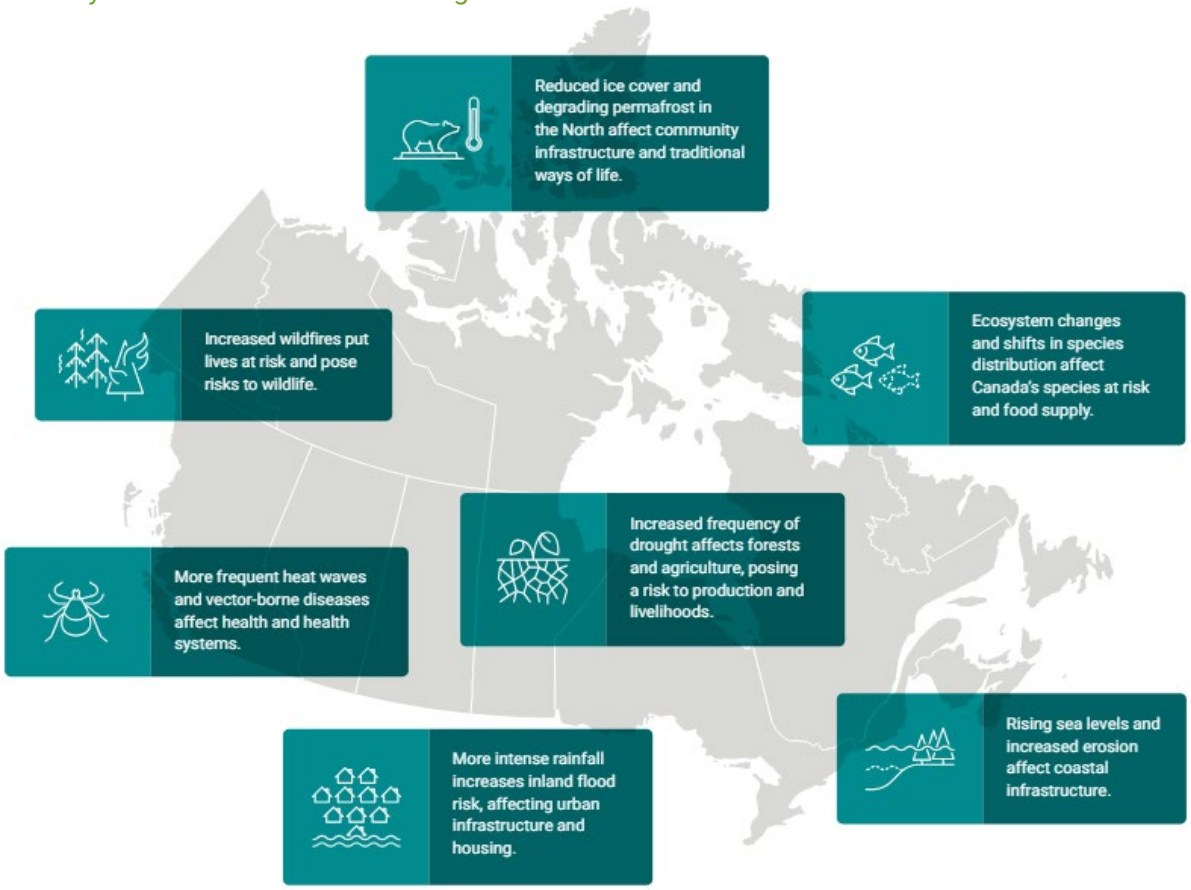
The exploration of current, often fragmented discussions around net-zero in agriculture reveals that these complexities cannot be ignored and must be thoroughly integrated into the policymaking and broader societal efforts. Despite the apparent messiness of the discourse and the inherent complexities of agriculture, the imperative to pursue net-zero emissions remains undiminished. Although opinions on the scale of climate change vary, there is a broad recognition of its significance as a global issue. However, presenting the quantitative consequences and economic impacts adds depth and value to this understanding, influencing perceptions and driving home the reality of what is at stake.

Under the Paris Agreement[2], Canada has pledged to limit global warming to well below 2°C, ideally to 1.5°C, relative to pre-industrial levels. Achieving this goal requires reaching net-zero CO2 emissions between 2050 and 2060[3]. Missing the 1.5°C target could result in severe consequences, such as extensive biodiversity loss, increased frequency of extreme weather events, and substantial economic costs from natural disasters[4].

The stakes are high. Without significant climate action, Canada could face up to $5.5 trillion in physical damage costs by 2100 under a high-warming scenario of 5°C[5]. Even a more moderate 2°C warming scenario could see costs reaching around $2.8 trillion.

[2] https://unfccc.int/process-and-meetings/the-paris-agreement
[3] https://climateinstitute.ca/wp-content/uploads/2023/12/ERP-assessment-2023-EN-FINAL.pdf#:~:text=URL%3A%20https%3A%2F%2Fclimateinstitute.ca%2Fwp
[4] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter3_Low_Res.pdf
[5] https://smith.queensu.ca/centres/isf/news/climate-change-damage.php

Figure 2: Physical effects of climate change for Canada[6]



Economic analyses indicate steep increases in costs to maintain agricultural outputs under changing climatic conditions. For instance, a 1°C increase in global temperature could persistently decrease global GDP by as much as 12%[7]. Similarly, changes in temperature and precipitation patterns are expected to raise agricultural production costs by 15-25% over the next few decades, affecting everything from irrigation needs to pest control and crop management.

On a societal level, the effects of climate change are felt through variations in agricultural productivity, which directly influence food prices and availability. Surveys show that 61% of Canadians believe climate change is harming the country's ability to produce food, with nearly half concerned about future food availability[8]. The impact of extreme weather in Western Canada in 2021, which resulted in 35% drop in wheat, 14% drop in canola production, death of 1.3 million farm animals, and a massive die-off of 80% of commercial shellfish stocks[9], underscore the dire consequences on food security and health.

Moreover, weather-related disasters in Canada have become more frequent and severe, with the average costs of these events rising dramatically – from $8.3 million per even in the 1970s to $112 million between 2010 and 2019. The 2016 Fort McMurray wildfires and the 2013 southern Alberta floods[10] are poignant examples of how these events can lead to massive economic and health costs, with associated financial damages at $11 billion and $601 million respectively.

[6] https://www.oag-bvg.gc.ca/internet/docs/parl_cesd_202111_05_e.pdf
[7] https://www.nber.org/system/files/working_papers/w32450/w32450.pdf
[8] https://globalnews.ca/news/9897049/food-security-climate-change-canada-survey/
[9] https://www.tandfonline.com/doi/full/10.1080/03066150.2022.2133602?scroll=top&needAccess=true
[10] https://climatechoices.ca/wp-content/uploads/2020/12/Tip-of-the-Iceberg-_-CoCC_-Institute_-Full.pdf

3. The complexities of achieving net-zero in agriculture

Achieving net-zero emissions in agriculture isn't just about adopting new technologies and shifting towards greener practices; it is about recognizing and addressing the unique challenges that make agriculture particularly complex. Exploring the economic, biological, and location-specific complexities that shape agricultural practices enhances understanding and injects a necessary dose of realism into discussions about net-zero in agriculture. This analysis substantiates the argument against a one-size-fits-all approach is ineffective, which is often asserted but not so often supported with concrete reasoning, and underscores the need for tailored, context-specific strategies.

3.1 Economic and practical realities

The quest for net-zero emissions in agriculture goes beyond pledges—it's about making these commitments work on the ground. Despite numerous pledges to cut emissions, there's often a lack of detail on how deep these cuts need to be[11], raising questions about the feasibility of achieving net-zero solely through agriculture. This uncertainty calls for possibly broadening our focus to include national objectives that account for agriculture's unique challenges and essential role in food security.

Tracking Canada's agricultural progress toward the 2030 net-zero pledges has revealed substantial challenges[12], amplifying concerns about meeting the 2050 targets. One major issue is the difficulty in showcasing the long-term benefits of emission reductions, which are only evident in the long term while the costs to farmers are tangible and immediate. These costs—financial, effort, and time—are significant[13] and felt daily, which can dampen motivation for pursuing ambitious environmental goals.

The narrow profit margins[14] typical in farming make it hard for farmers to invest in technologies or practices that reduce emissions. Policy interventions and incentives designed to support these changes must not add financial strain, ensuring the economic viability of farming operations. Moreover, the real challenge lies in making sustainable practices and their outcomes durable—farmers need to see the economic viability and environmental benefits to continue using them long-term.

For net-zero strategies in agriculture to be effective, they must align with the economic and operational realities farmers face. Policies should not only facilitate the initial adoption of sustainable practices but also support their ongoing application. Effective communication and meaningful engagement are crucial. Highlighting practical advantages like increased efficiency, potential cost savings, and improved soil health can make these practices more attractive to farmers[15].

Aligning farmer incentives with market demands and consumer expectations is also vital. Showing farmers how sustainable practices can enhance market positioning or provide access to premium markets can encourage adoption and maintenance of these methods[16].

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[11] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/healthy-environment-healthy-economy.html
[12] https://www.oag-bvg.gc.ca/internet/English/att__e_44477.html
[13] H. Charles J. Godfray et al. ,Food Security: The Challenge of Feeding 9 Billion People.Science327,812-818(2010).DOI:10.1126/science.1185383
[14] https://www.cfa-fca.ca/wp-content/uploads/2024/02/Farm-Financial-Health-Report-2023.pdf
[15] Jules Pretty ,Intensification for redesigned and sustainable agricultural systems.Science362,eaav0294(2018).DOI:10.1126/science.aav0294
[16] Anderson, K. (2010). "Globalization's Effects on World Agricultural Trade, 1960–2050." Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 3007-3021.

If the discussions and policies on net-zero in agriculture do not fully account for the economic and practical realities farmers face daily, there is a real risk that the strategies proposed will be disconnected from what is actually possible on the ground.

Policies need to align environmental objectives with the economic realities of farming, enhance incentives, ensure clear communication of benefits and consequences, and provide continuous support and adaptive policy management.

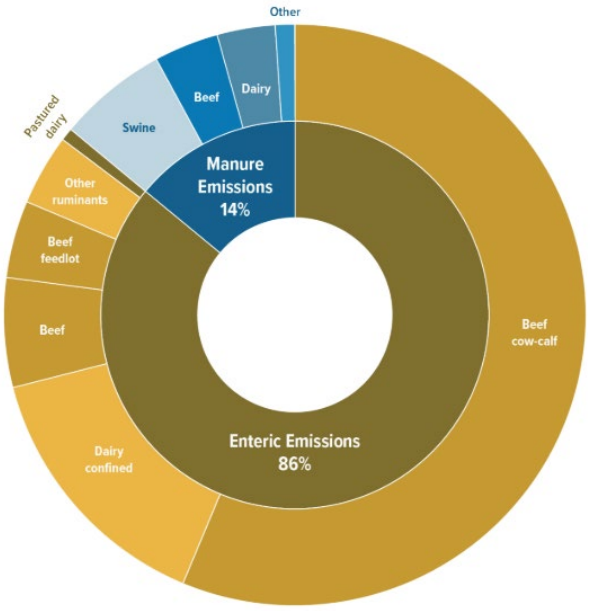
3.2 Biological realities and methane challenges

Agricultural emissions stem from both natural biological processes and managed agricultural practices. These emissions, especially from enteric fermentation in livestock and the management of manure, are intrinsic to daily operations of farming, posing significant challenges in mitigation efforts without impacting agricultural productivity and food security[17].

Methane, a potent greenhouse gas, is produced naturally in the digestive processes of ruminants (enteric fermentation) and through the management of manure. Together, these sources account for 30% of Canada's total methane emissions, with enteric fermentation alone contributing 86% of agricultural methane emissions and manure management contributing 14%.

Strategies such as improving livestock feed efficiency, better manure management techniques, and the use of methane inhibitors can significantly reduce these emissions. However, completely eliminating methane emissions from livestock maybe thermodynamically impractical as long as animals like cows remain integral to our agriculture. This highlights the need for a clear understanding of what net-zero means in the context of agriculture-acknowledging that is does imply absolute zero emissions but rather a balance between emissions produced and emissions removed or offset from the atmosphere.

Figure 3: Canada's agriculture sector methane emissions, 2020[18]



[17] https://openknowledge.fao.org/server/api/core/bitstreams/e1afd815-5a76-4b88-beac-fb9bc0e92001/content
[18] https://www.ccacoalition.org/sites/default/files/resources//Canada%20Methane%20Action%20Plan_0.pdf

It's important to place agricultural methane emissions in context. While Canada's broader methane reduction strategy primarily targets larger industrial sources like the oil and gas sector[19], the role of agriculture cannot be overlooked. Agricultural practices, despite their smaller relative contribution when compared to sectors like oil and gas, play a critical role in the national strategy to reduce methane emissions. This is particularly relevant as the sector represents a significant proportion of the country's methane emissions profile.

In developing policies and strategies to move towards net-zero emissions, it is important to consider both the unavoidable natural biological processes and the modifiable agricultural practices.

3.3 Efficiency paradoxes of technology role to achieve net-zero

Technological innovations are crucial for reducing emissions in agriculture, yet their effectiveness must be carefully managed to avoid the Jevons Paradox—where increased efficiency in resource use leads to higher overall consumption of resources, rather than reductions. This paradox emphasizes the complexity around the role of technology to achieve net-zero emissions in agriculture. Technologies such as precision agriculture, methane inhibitors, and advanced genetics and breeding techniques are transforming farming by enhancing efficiency and minimizing waste. However, to maximize their potential and minimize unintended consequences, a more nuanced view that balances the potential benefits with the realities of their application is important. For example,

- Methane inhibitors can reduce the carbon footprint of livestock and crop production by optimizing resource use and reducing methane emissions, directly tackling significant sources of greenhouse gases. However, if not managed carefully, the increased efficiency could lead to intensifying livestock production, potentially negating some of the benefits.

- Biochar, a stable form of carbon produced from organic materials like agricultural waste pyrolysis, not only sequesters carbon but also enhances soil fertility and water retention[20]. While biochar has transformative potential, its effectiveness can vary greatly depending on soil type, climate, and application methods, which could limit its impact in different regions.

- Biodigesters complement these initiatives by processing organic waste to produce biogas and nutrient-rich digestate[21]. Yet, the initial investment and maintenance costs can be prohibitive for some farmers, impacting widespread adoption.

- The "4 per 1000" initiative aims to increase soil carbon stocks[22], combining natural and technological methods. While aspirational, achieving such specific targets consistently across diverse agricultural landscapes presents significant challenges.

[19] https://www.ccacoalition.org/sites/default/files/resources//Canada%20Methane%20Action%20Plan_0.pdf
[20] https://www.sciencedirect.com/science/article/pii/S2772416622000900
[21] https://greenbusinessbureau.com/blog/what-is-a-biodigester/
[22] VandenBygaart, A. J., McConkey, B. G., Angers, D. A., Smith, W., de Gooijer, H., Bentham, M., Martin, T., & Gooijer, de. (2007). Soil carbon change factors for the Canadian agriculture national greenhouse gas inventory https://capi-icpa.ca/wp-content/uploads/2022/04/April-21-Carbon-Sequestration-Research-Report-Susan-Wood-Bohm-EN.pdf

While technology holds promise for reducing agricultural emissions, its role must be viewed within a framework that recognizes both the opportunities and the complexities.

To truly leverage technology for sustainable agriculture without risking unintended increases in overall emissions, strategies must include a mix of policy support, education, and a holistic approach to resource management.

3.4 Complex dynamics between food waste and net-zero goals

Agriculture's emission footprint goes beyond farm and food processing to encompass the entire food system.. Achieving a net-zero food system is complicated also because the significant role food loss and waste play in generating emissions. The role of food loss and waste is particularly significant, as it generates substantial emissions at every stage of the food value chain—from excess production and spoilage during storage and distribution to final disposal by consumers. In Canada, it's estimated that about 60% of food produced is lost or wasted, which equates to roughly 35.5 million metric tons annually. While the precision of these figures can be debated, they still provide a robust indication of the scope of food waste and its impact on emissions. This waste contributes major greenhouse gases at each stage—production, transportation, and disposal, with up to 20% of Canada's methane emissions potentially emanating from this wasted food disposed of in landfills[23].

Addressing food waste effectively requires integrating principles of the circular economy, which aims to design out waste and maintain the value of resources for as long as possible. By applying circular strategies such as composting, anaerobic digestion, and repurposing agricultural by-products, we can reduce the environmental impact of waste and close the loop in food production systems. These practices not only mitigate emissions but also enhance the sustainability of agricultural operations.

The challenge of accurately defining and measuring food waste complicates the formulation of effective strategies and realistic reduction targets[24]. Despite the existence of international frameworks like those from the OECD, inconsistencies in their application impede the full integration of food waste reduction into broader net-zero strategies.

Moreover, many Canadians are unaware of the implications of food waste, not only in terms of environmental impact but also the associated economic costs. While a significant portion of food waste occurs at the processing, retail, and restaurant stages, consumer behavior plays a crucial role. Educating consumers on proper food storage, understanding date labels, and encouraging the use of leftovers, along with enhancing waste management practices to prioritize recycling and reuse, are critical steps toward a more sustainable food system[25].

Incorporating food waste reduction and circular economy principles into the narrative of net-zero goals in agriculture emphasizes the need for a comprehensive approach that considers all aspects of the food system.

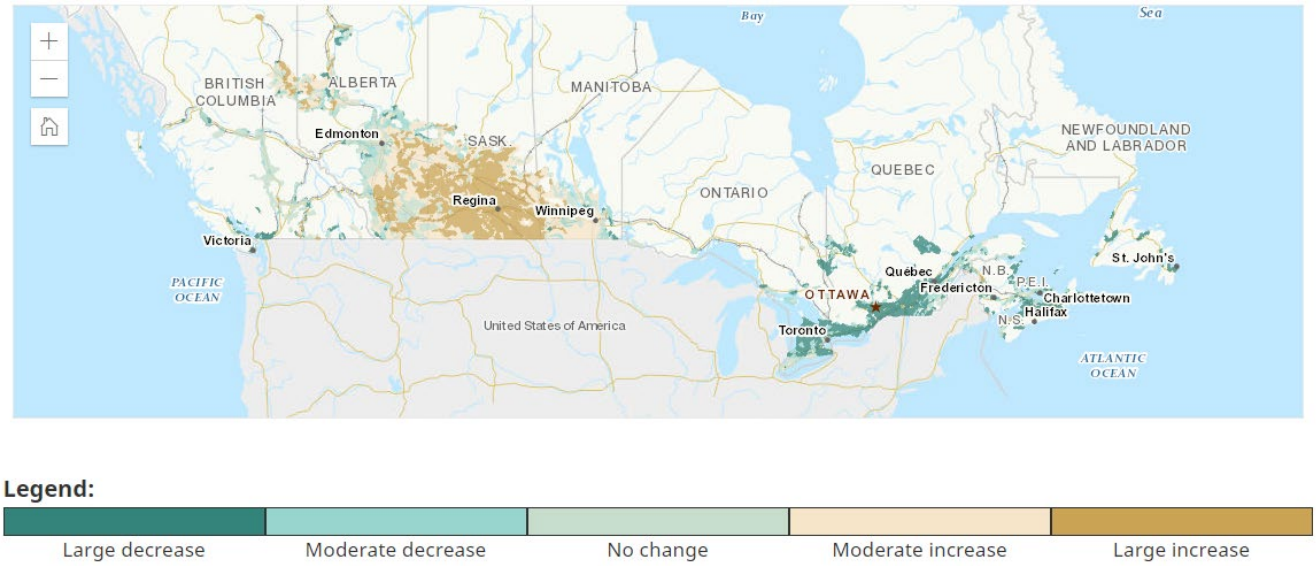
By understanding and tackling the complex dynamics of food waste, policies can be better designed to support the transition towards a net-zero compliant food system.

[23] https://www.nationalobserver.com/2021/04/20/news/private-bill-feds-food-waste-climate-change
[24] https://arrellfoodinstitute.ca/wp-content/uploads/2022/10/2022_FOOD-WASTE-REPORT_ARRELL_WEB.pdf
[25] https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics

3.5 The limits of soil carbon sequestration

Soil carbon sequestration is a crucial strategy for reducing net greenhouse gas emissions in agriculture, but it comes with inherent limits that must be realistically considered in the broader discourse on achieving net-zero goals. While it significantly contributes to emission reductions—recent data shows innovative farming practices have led to substantial sequestration of about 22 Mt CO2e in recent years[26]—it's not a limitless resource. In 2021 alone, agricultural soils stored 18 Mt CO2e, offsetting approximately 26% of Canada's total annual agricultural emissions[27]. This success is largely attributed to practices such as reduced tillage and the decline in summerfallow areas, which historically degraded the soil.

Figure 4: Soil organic carbon change (in kilogram per hectare, per year) in Canada in 2016[28]



Note: The Soil Organic Carbon Change indicator looks at the rate of change in carbon levels in agricultural soils. This indicator is used to see where soil organic carbon is increasing or declining, and at what rate it is doing so.

However, the capacity of soil to sequester carbon has its boundaries. Over time, soil reaches a saturation point beyond which it can no longer absorb carbon at the same rate, marking a natural limit to its sequestration potential. Additionally, the permanence of sequestered carbon is challenging; any reversal in sustainable farming practices can release stored carbon back into the atmosphere, negating previous gains. Also, voluntary programs that reward farmers for carbon sequestration through carbon credit markets still are undeveloped in Canada and have many issues that still need to be worked out.

Understanding that soil carbon sequestration can hit saturation highlights the need for continuous and adaptive management practices to maintain and enhance soil carbon levels.

Soil carbon management should not be viewed as a standalone solution to reach net-zero but as part of a broader, dynamic strategy that includes other sustainable practices and technological innovations.

[26] https://www.nfu.ca/agricultural-ghg-emissions-a-comprehensive-analysis-new-nfu-report/#:~:text=Emissions%20from%20on%2Dfarm%20diesel,from%20the%20atmosphere%20into%20soils.
[27] https://www.oag-bvg.gc.ca/internet/English/att__e_44477.html
[28] https://agriculture.canada.ca/en/agricultural-production/soil-and-land/soil-organic-matter-indicator

3.6 The impact of land use intensification

The decision on how to manage land use in agriculture, balancing between intensification and extensive practices, significantly influences the trajectory towards net-zero emissions. This complex choice involves evaluating different agricultural strategies, such as “land sparing” and intensive agriculture versus more extensive farming techniques, each with direct impacts on the net-zero narrative.

Land use intensification in agriculture is driven by the need to meet increasing demands for food, fuel, and fiber, but it comes with environmental costs. Intensifying agricultural practices often leads to soil degradation, depleting soil organic matter, reducing biodiversity, and impairing soil structure. These changes undermine the soil's ability to effectively capture and sequester carbon, posing long-term challenges to the agricultural sector’s contribution to net-zero emissions goals[29]. Both land sparing and extensive farming land use strategies offer different paths to sustainability, with varying impacts on the food production and environment.

Land sparing[30] approaches focus on maximizing agricultural yield in smaller areas to spare more land for conservation. By intensifying production in limited areas, it aims to reduce the overall agricultural footprint, potentially preserving more natural habitats which can act as significant carbon sinks and biodiversity reserves.

In contrast, extensive farming[31] spreads agricultural activities across a broader area but at a lower intensity. This approach may use more land but with less pressure on individual plots, aiming to minimize the ecological footprint per unit of land used. However, it risks consuming more land overall, which could otherwise be conserved for natural ecosystems.

In Canada, the dialogue around agricultural intensification and its impact on achieving net-zero emissions involves controversy and challenges. Critics argue that the push for higher yields often comes at the expense of soil health, which is fundamental to long-term sustainability and effective carbon sequestration. This debate is further intensified by the role of bioenergy production[32], which, while contributing to renewable energy goals, can divert land from food production or natural habitat, potentially leading to increased carbon emissions if not managed correctly[33]. Finally, Jevons paradox considerations add to the debate if more intensive agriculture in Canada and “land sparing” here only leads to more land being used elsewhere, contributing to “leakage” and higher overall global emissions (see our Competing pressures paper).

Addressing the complexities of land use intensification is about recognizing how the choice between high-yield intensive practices and extensive land use shapes the net-zero trajectory.

3.7 Food insecurity and the pursuit of net-zero emissions

Food insecurity in Canada resents a significant challenge with one in five Canadian households experiencing food insecurity in 2022[34]. This issue extends beyond national borders, as Canada's role in global food production is crucial for worldwide food security[35]. Therefore, Canadian agricultural policies aimed at reducing greenhouse gas emissions must carefully consider their impact on both domestic and international food supply and demand.

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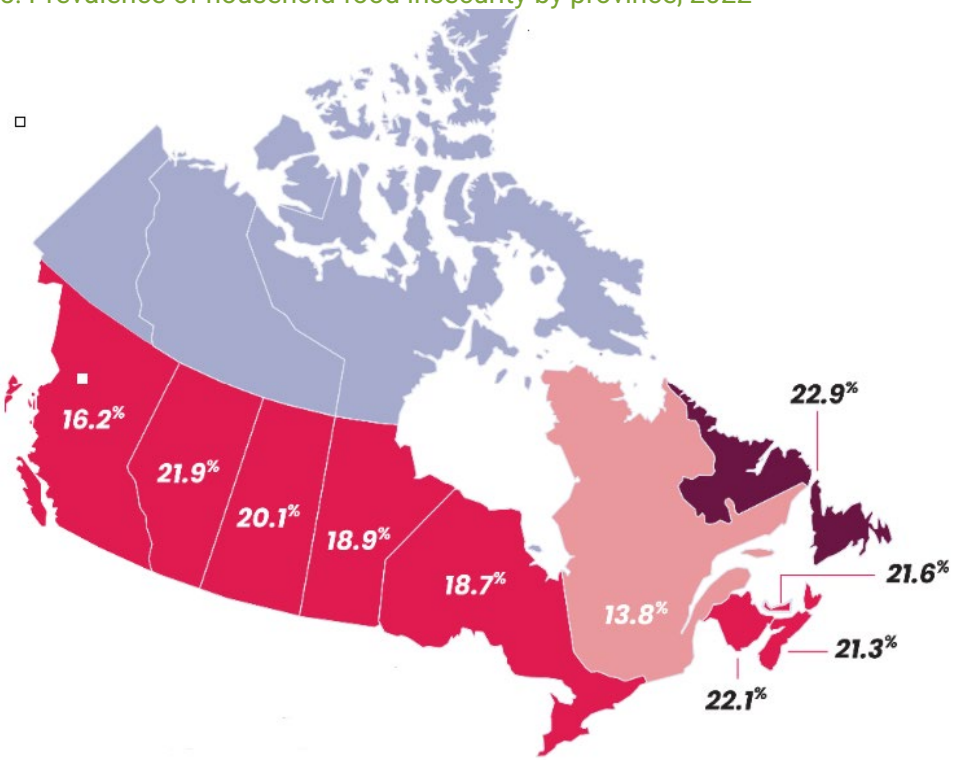
[29] Lal R. Restoring Soil Quality to Mitigate Soil Degradation. Sustainability. 2015; 7(5):5875-5895. https://doi.org/10.3390/su7055875
[30] https://thebreakthrough.org/issues/food-agriculture-environment/raising-agricultural-yields-spares-land#:~:text=In%20many%2C%20if%20not%20most,reduce%20pollution%20at%20larger%20scales
[31] https://capi-icpa.ca/wp-content/uploads/2023/06/2023-05-12-Competing-Pressures-on-Land-Use-Research-Report-EN-Final-230606.pdf
[32] https://www.sciencedirect.com/science/article/abs/pii/B9780128162293000107
[33] https://www.mdpi.com/2073-445X/12/1/213
[34] https://proof.utoronto.ca/wp-content/uploads/2023/11/Household-Food-Insecurity-in-Canada-2022-PROOF.pdf
[35] https://agriculture.canada.ca/en/department/initiatives/canadas-national-pathways/national-pathways-document

Figure 5: Prevalence of household food insecurity by province, 2022[36]



Domestically, Canadian agriculture is tasked with a dual challenge. It must transition towards more sustainable and less carbon-intensive practices while ensuring that nutritious and affordable food remains accessible, especially to the most vulnerable populations. This transition involves careful management of agricultural inputs like nitrogen fertilizers, which are necessary for crop yields but contribute significantly to emissions of nitrous oxide, a potent greenhouse gas.

Internationally, Canada's substantial influence in global food markets demands a strategic approach to policy development. Trade policies play a critical role, impacting both the economic viability of farming and the environmental footprint of agricultural practices. For example, crops like wheat and canola are major exports that generate significant revenue but also raise concerns about resource use and carbon emissions. Decisions about which crops to prioritize for export can directly affect food prices and availability in Canada, thus influencing food security.

The integration of trade considerations into the discourse on net-zero emissions is essential. It highlights the need to align trade policies with environmental objectives to prevent scenarios of carbon leakage—where emissions are shifted to countries with less stringent environmental regulations. Moreover, trade policies should support the adoption of sustainable agricultural technologies and practices that contribute to global food security while respecting environmental limits.

Discussions and strategies on net-zero emissions should consider both the need to reach net-zero and the growing issue of food security, to ensure that the pathway is both inclusive and equitable.

[36] https://proof.utoronto.ca/wp-content/uploads/2023/11/Household-Food-Insecurity-in-Canada-2022-PROOF.pdf

4. Policy considerations for achieving net-zero

The journey to net-zero emissions in agriculture is complex and multifaceted. While understanding the inherent complexities is crucial, it is equally important to consider additional factors that influence this transition. These policy considerations encompass economic impacts, environmental responsibilities, data accuracy, and the alignment of strategies with on-farm realities. This section outlines these key considerations, highlighting their importance in shaping the discourse around net-zero and ensuring that policies are responsive to the unique needs of the agricultural sector.

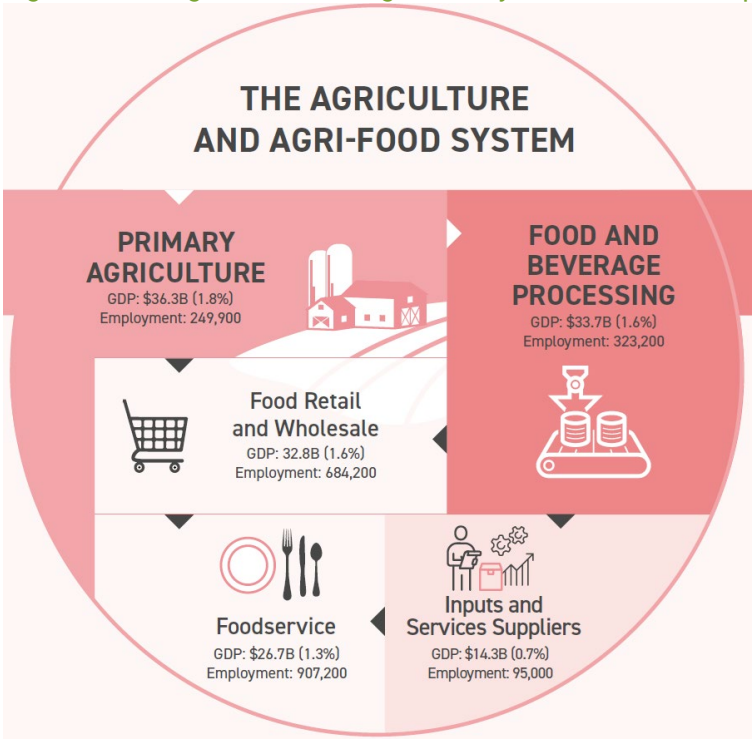
4.1 Balancing economic and environmental priorities of Canadian agriculture

An important part of ensuring effective discourse on net-zero targets and designing adaptive policies is recognizing the dual role of agriculture as both an economic and environmental contributor.

4.1.1 Economic contributions

Canadian agriculture significantly contributes to the national economy, accounting for 3.4% of Canada's GDP, including the primary agriculture and food beverage processing sectors. The sector provides essential employment, supporting one in every 34 jobs across the country. Wirth189,874 farms covering 62.2 million hectares, agriculture is a major presence across the Prairies, Quebec, and Southern Ontario. In 2022, farm market receipts soared to a record high of $87.7 billion, driven by robust growth in the production of grains, oilseeds, red meat, and dairy. This financial input highlights the sector's vital role not only in economic terms but also in maintaining food supply chains that feed both domestic and global populations[37].

Figure 6: The agriculture and agri-food system, GDP and employment, 2022[38]



[37] https://agriculture.canada.ca/en/sector/overview
[38] https://agriculture.canada.ca/en/department/transparency/briefing-documents/ministers-transition-books/book-2-overviews-department-and-sector

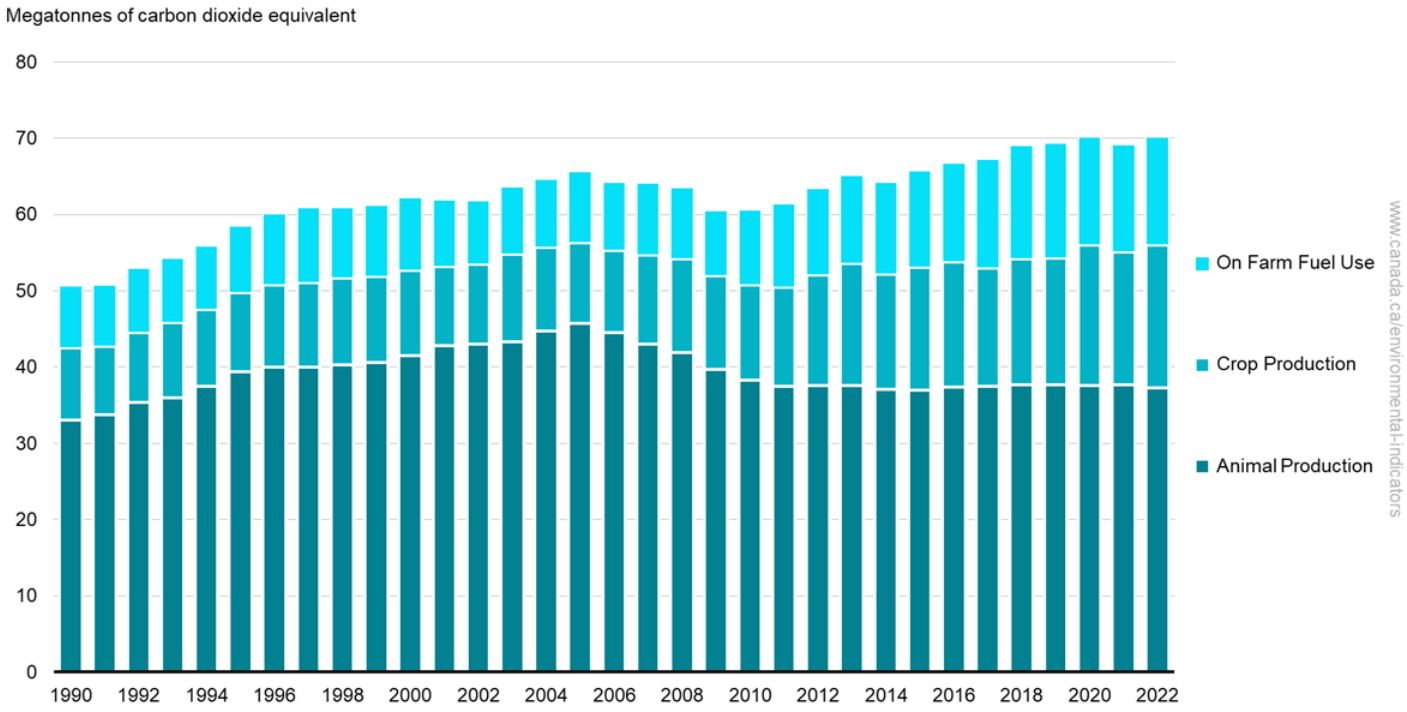
4.1.2 Environmental impacts

However, the environmental footprint of agriculture is also significant. In 2022, the sector contributed 7.9% to Canada's total greenhouse gas emissions, amounting to 56 Mt. Agriculture is a major source of methane (CH4) and nitrous oxide (N2O), accounting for 27% and 76% of national emissions for these gases, respectively. The environmental impact extends beyond these emissions, affecting air quality, soil health, water quality, and biodiversity. Agriculture and Agri-Food Canada tracks twelve agri-environmental indicators while the Organization for Economic Cooperation and Development provides a global comparison of agriculture's environmental footprint.

4.1.3 Emission trends

Agricultural emissions in Canada are not moving in the right direction. From 2019 to 2022, emissions increased by 1.6 Mt (3.0%), driven by higher inorganic nitrogen usage and soil carbon losses due to drought[39]. These conditions resulted in a 28% increase in emissions from soil carbon decomposition between 2021 and 2022. The agricultural emissions profile is influenced by fluctuations in livestock populations and fertilizer application rates. Since 2005, fertilizer use has surged by 79%, while major livestock populations peaked that year before declining until 2011. As of 2022, emissions have stabilized to levels similar to those in 2005, though the proportion of emissions from crop production has grown relative to those from livestock.

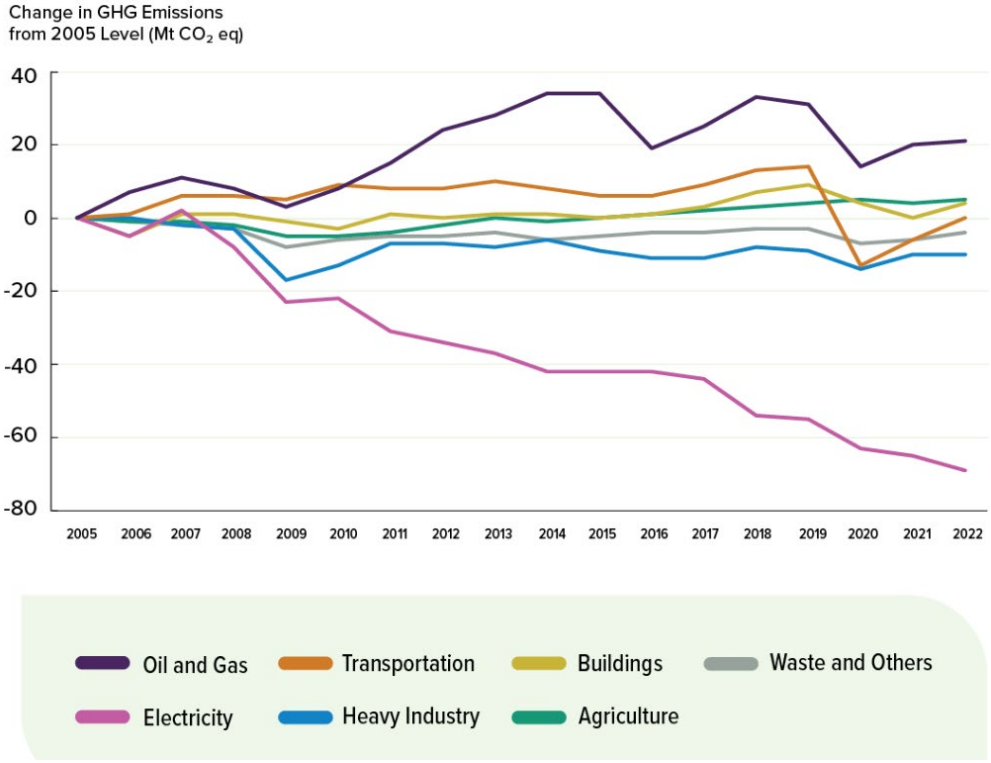
Figure 7: Agriculture sector greenhouse gas emissions, Canada, 1990 to 2022[40]



In comparing agricultural emissions with other sectors from 2005 to 2022, agriculture remains relatively unchanged, while other sectors, including energy production, have seen significant decreases. For example, the transport sector saw a 15% decrease in emissions from 2019 to 2020, largely due to the global reduction in activity during the COVID-19 pandemic, followed by a rebound increase from 2020 to 2022.

[39] https://www.canada.ca/en/environment-climate-change/news/2024/05/canadas-2024-national-inventory-report-shows-canada-is-successfully-reducing-emissions.html
[40] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html#agriculture

Figure 8: Change in Canadian agriculture's GHG emissions since 2005 compared to the other economic sectors[41]



While the agriculture sector's progress in reducing emissions may seem slow compared to other sectors, it remains a small share of Canada's total GHG emissions. In 2022, agriculture accounted for 7.9% of total national emissions, whereas sectors like oil and gas remain significantly larger contributors despite their reductions. Therefore, while agriculture must continue to seek improvements and innovations in practices to reduce its environmental impact, it is not the primary driver of national emissions.

The balance between economic contributions and environmental impacts is crucial.

Prioritizing economic stability and food security is essential, but so is mitigating environmental impacts to ensure long-term sustainability.

Policymakers need to weigh these priorities, recognizing that the importance of each can shift depending on various factors, such as market conditions, technological advancements, and environmental pressures.

4.2 Developing and scaling programs and projects

Private and public policy makers and influencers have struggled to implement effective programming to support pathways to net-zero agriculture. Despite good intentions and substantial funding, achieving meaningful progress has proven difficult. The 2023 Commissioner of the Environment and Sustainable Development's report underscores these struggles[42], highlighting various implementation barriers.

[41] https://publications.gc.ca/collections/collection_2024/eccc/En81-4-2022-1-eng.pdf
[42] https://www.oag-bvg.gc.ca/internet/English/att__e_44477.html

For instance, the On-Farm Climate Action Fund is an example where ambitious targets were scaled back due to implementation delays and logistical hurdles. Initially projected to achieve significant emission reductions, the fund fell short of its goals, illustrating the need for better planning and resource allocation. The Agricultural Clean Technology Program, aimed at promoting sustainable practices and technologies, has also faced challenges in achieving its emission reduction targets.

Private sector efforts, such as those by the Canadian Alliance for Net Zero Agrifood (CANZA), also face significant hurdles. Its two key initiatives include the Carbon Farming Initiative, which promotes soil carbon sequestration, and the National Biodigester Network Initiative, which converts farm waste into renewable energy[43]. However, transitioning these pilot projects to broader implementation across Canada's varied agricultural landscapes is hindered by financial and logistical obstacles. The Commissioner's report suggests that a collaborative approach between public and private sectors is essential for achieving net-zero goals.

While the commitment to achieving net-zero in agriculture is strong, the path is fraught with challenges.

Acknowledging these difficulties and learning from past efforts, as highlighted in the Commissioner's report, is crucial for developing more effective and scalable programs

4.3 Missing clear, consistent strategies

A crucial consideration in the discourse about net-zero agriculture is the need for clear and consistent strategies. Effective measurement of progress towards net-zero by 2050 requires a robust strategic framework that clearly outlines specific targets, timelines, and actions. This framework should provide benchmarks to assess advancements or shortfalls accurately. Integrating both public and private actors into this strategy ensures shared ownership and coordinated efforts.

The 2023 Auditor General's report[44] highlights the absence of detailed, quantifiable targets within Agriculture and Agri-Food Canada's (AAFC) planning, complicating evaluations of the sector's progress towards net-zero. While AAFC has initiated sustainability projects, these need to be part of a cohesive strategy aligned with Canada's broader climate goals. The delayed introduction of the Sustainable Agriculture Strategy, nearly a decade after AAFC's initial mandate, underscores the need for timely and integrated strategic planning.

4.4 Natural and external variables affecting GHG emissions

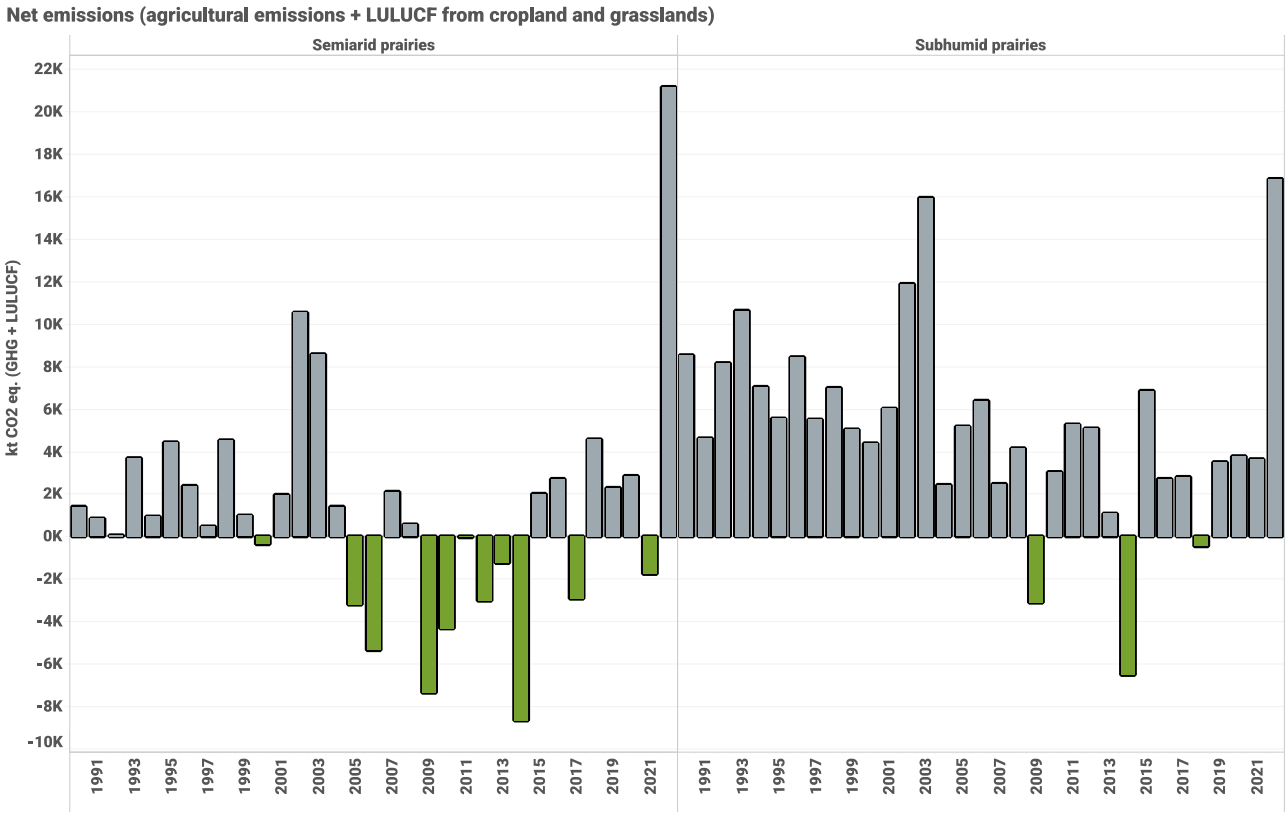
Net-emissions from the agricultural sector are significantly influenced by natural and external variables such as weather patterns, climate change, commodity market conditions and other economic and environmental factors. These variables can cause substantial fluctuations in agricultural production and hence emission levels, which should not be neglected in policy and discourse around net-zero goals.

For example, the swing in emissions from cropland sequestration between 2021 and 2022 highlights the impact of extreme weather conditions. Drought in 2021 led to reduced soil carbon sequestration, whereas improved weather conditions in 2022 resulted in partial recovery. Similarly, higher prices for canola and wheat in global markets in 2022 and import embargoes on pulse crops to India, one of Canada's primary pulse export markets, contributed to a change in commodity mix and hence GHG emissions. This variability underscores the importance of incorporating flexibility into net-zero strategies to account for such natural changes.

[43] https://thoughtleadership.rbc.com/championing-climate-smart-agriculture-building-a-road-map-for-low-emissions-agriculture/
[44] https://www.oag-bvg.gc.ca/internet/docs/parl_cesd_202404_05_e.pdf

Policymakers must recognize these external factors and integrate adaptive measures into their plans. By doing so, they can develop resilient policies that accommodate natural variability and support the agricultural sector in achieving sustainable, long-term emissions reductions.

Figure 9: Long-term trend of net agricultural emissions in agriculture[45]



4.5 Evolving data and methodology

Accurate and timely data are crucial for tracking progress and making informed policy decisions. The Canadian government has been improving its data collection and emissions tracking systems. CANZA is working to build a measurement, reporting and verification (MRV) system to help close the data gap. However, challenges remain in capturing all necessary data points to fully assess the impact of agricultural practices on greenhouse gas emissions.

The National Inventory Report 2024[46] highlights significant impacts from adjustments in methodologies. For instance, revised methods for calculating livestock methane emissions and updates in soil carbon accounting have resulted in more accurate emission figures, revealing previous overestimations by about 15%. Similarly, changes in estimating nitrous oxide (N2O) emissions have led to notable differences.

Improving data and methodology is essential to achieving net-zero. These refinements provide a clearer picture of the sector's emissions and its progress towards net-zero, but they also present challenges with an evolving dataset. Accepting that data and methodologies will change is essential for developing effective plans to achieve net-zero.

[45] https://data-donnees.az.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory/E-LULUCF/?lang=en
[46] https://publications.gc.ca/collections/collection_2024/eccc/En81-4-2022-1-eng.pdf

4.6 Data challenges and methodology gaps across on-farm and post farm sectors

Accurate and reliable data are essential for tracking progress towards net-zero emissions in agriculture. However, significant challenges exist in both on-farm and post-farm data collection and analysis. These challenges, highlighted in the two recent reports published by CAPI and the Centre for Agri-Food Benchmarking, underscore the need for improved and standardized methodologies and customized approaches to account for different levels of granularity and uptake needed. The following sections explore these challenges in detail, focusing on the effectiveness of on-farm GHG measurement tools and the gaps in post-farm sector data.

Miller, S., Groupe AGÉCO (2024). Greenhouse gas intensity measurement in transportation and food processing.

Wilton, B. et al (2024). From education to action: A review of greenhouse gas tools in pursuit of net-zero agriculture

4.6.1 On-farm GHG measurement tools

The pursuit of net-zero emissions in Canadian agriculture faces critical challenges around data accuracy and tool effectiveness.

Tools like HOLOS and AgriSuite, while science-based and designed to estimate GHG emissions at farm level, often rely on generalized aggregate data that fails to capture the diverse, farm-specific conditions across Canada. This gap diminishes the accuracy of these tools and their applicability to the nuanced realities of Canadian agriculture.

Moreover, the complexity and diversity of GHG tools available necessitate specific training, education and the infrastructure needed to integrate with other farm level management tools, posing additional barriers to adoption by farmers. From a banking perspective, the lack of precision of data directly impacts the structuring of financial products and services tailored to support the agricultural sector's transition to net-zero. Banks and financial institutions rely on timely, accurate, and detailed data to assess risk, determine creditworthiness, and develop financial products that align with sustainable practices.

The variability in methodologies across different GHG estimation tools complicates the standardization of emissions assessment and tracking progress towards net-zero goals. Each tool often employs different methodologies, specific scope, and boundary definitions, which can lead to varied emissions estimates for similar activities. This inconsistency complicates the comparison and aggregation of data, undermining efforts to form a unified strategy for emissions reduction across the agricultural sector.

For example, while some tools may calculate emissions based on direct measurements, others might use model-based approaches or emission factors whose parameters may not reflect regional or even field level conditions or specific farm practices in Canada. These assumptions can lead to discrepancies in emissions reporting, and in turn, the data which informs policies.

4.6.2 Challenges in post-farm gate and food processing intensity calculations

While the food processing sector benefits from detailed, region-specific data enabling precise intensity calculations, a critical gap exists in comprehensive aggregate intensity data. This deficiency hinders the ability to form a complete picture of the industry's impact on emissions, limiting the effectiveness of policies and strategies aimed at reducing the sector's carbon footprint. Effective monitoring and alignment with national and international standards are challenging due to these data gaps.

Methodological challenges also persist in the post-farm segment, where diverse operations and products require flexible and precise methodologies. Variations in data collection practices and the need for industry-specific metrics that integrate local processing factors must be addressed to enhance the reliability and applicability of GHG intensity calculations.

Table 1: Data challenges in Canadian agriculture and their impacts in achieving net-zero emissions

Level	Data type	Challenge	Impact
On-farm	Aggregate data available	Lack of regional and farm-specific data	Tools not fit-for-purpose, inaccurate GHG assessments
Post-farm	Region-specific data available	Lack of comprehensive aggregate data	Inability to construct overall metrics for food processing

To address these inconsistencies and improve the accuracy of GHG measurements effectively, it is essential to develop and adopt standardized methodologies that align with global frameworks. Such standardization would not only facilitate the tracking of net-zero progress but also enhance the global competitiveness of Canadian agricultural products.

4.7 Integrating national, sector-specific and value-chain goals

In 2021, Canada passed the *Canadian Net-Zero Emission Accountability Act*, committing to reduce emissions to net-zero by 2050. This was followed in 2022 by the federal government's 2030 Emissions Reduction Plan, which increased the 2030 interim emissions reduction goal to 40-45% below 2005 levels by 2030. Both targets are economy-wide and include agriculture and other land use sectors, however without providing agriculture-specific targets[47].

The absence of specific targets for the agricultural sector presents a significant challenge. The Canadian Net-Zero Emission Accountability Act sets ambitious national goals, but there is an ongoing need to develop specific, actionable targets for agriculture that align with these national objectives. This involves setting realistic benchmarks tailored to the unique challenges of agricultural emissions, which are heavily influenced by biological processes. Without clear, sector-specific targets, it is difficult to determine if Canadian agriculture is on the right path to reach net-zero by 2050.

Furthermore, value-chains and companies within the sector are increasingly setting their own targets and developing plans for achieving net-zero[48]. These corporate targets frequently utilize frameworks like the Science Based Targets Initiative (SBTi) and the GHG Protocol, which offer guidance in setting science-based emissions reduction targets including for land use and agriculture-specific emissions.

The SBTi's Forest, Land, and Agriculture (FLAG) project specifically addresses the unique challenges of the food, land, and agriculture sectors by providing a standardized method for setting science-based targets that include land-related emissions and removals. This guidance is crucial as it helps align company actions with global efforts to limit global warming, emphasizing the need for robust, science-based approaches to decarbonization that are coherent across different jurisdictions and sectors.

However, despite these advancements in corporate and value-chain target setting, these efforts are not fully aligned with the approaches governments are taking to setting net-zero targets and strategies. According to the

[47] Government of Canada (2021), Canada's 2021 Nationally Determined Contribution under the Paris Agreement, https://www4.unfccc.int/sites/ndcstaging/Pages/Party.aspx?party=CAN&prototype=1.
[48] https://dairyfarmersofcanada.ca/sites/default/files/2023-07/DFC_BMP%20Guide_2023-07-05.pdf
https://www.ggcroadto2050.ca/grain-growers-of-canada-launch-road-to-2050-policy-recommendations/

recent report on governing net-zero [49], these discrepancies in measurement and reporting can create barriers to effective net-zero strategies by fostering fragmented approaches rather than unified, industry-wide standards. The report underscores the importance of aligning national policies with pre-competitive, collaborative industry bodies to ensure that international companies have an approach that can effectively be measured, reported, and verified.

National policies must align with pre-competitive, collaborative industry bodies to ensure that international companies have an approach that can effectively be measured, reported, and verified, thereby accelerating net-zero adoption.

5. Policy recommendations to address net-zero challenges in Canadian agriculture

This report builds upon and extends the insights from two other foundational studies[50], recently published by CAPI and the Centre for Agri-Food Benchmarking, each contributing insights into the complexities of achieving net-zero emissions in Canadian agriculture. Recognizing the diverse agricultural landscapes across Canada, it aims to harmonize these specific, actionable recommendations with a broader strategic vision that comprehensively understands the complexities inherent in agriculture and fully integrates them into the conversation around net-zero targets and policies.

Considering these recommendations in the discourse around net-zero emissions in agriculture adds significant value to the effort of aligning net-zero targets with the operational realities and socioeconomic needs of the agricultural sector. It underscores the importance of policies that are not only effective but also adaptable to local conditions, ensuring broad adoptability and sustainability.

[49] https://netzeroclimate.org/wp-content/uploads/2024/06/ONZ_Standards_Mapping_Report_2024_2.pdf
[50] https://capi-icpa.ca/wp-content/uploads/2024/05/From-Education-to-Action_Final-report-2024-03-31.pdf

https://cdn.prod.website-files.com/616745ce30790127aaa8b000/6658b4a05d54cc514e0ba655_Greenhouse%20Gas%20Intensity%20Measurement%20(2.4).pdf

High-level policy recommendations

- **Policies should holistically integrate the full spectrum of agricultural complexities into net-zero strategies.**
- **Policies should be adaptive and responsive to the evolving scientific and technological landscape of agriculture, to facilitate practical and sustainable adoption by farmers.**
- **It is important to develop region-specific strategies. No single net-zero strategy is universally applicable across the country due to varying climatic conditions, soil types, and agricultural practices prevalent in different regions.**

Recommendations from the report "From Education to Action: A Review of Greenhouse Gas Tools in Pursuit of Net-Zero Agriculture"

- **Encourage broader adoption of GHG estimation tools tailored to the diverse needs of Canadian farmers, ensuring that the tools are practical and widely accessible.**
- **Increase efforts to clearly communicate the economic and environmental benefits of using GHG tools, such as potential access to carbon markets, which could enhance their appeal and utility for farmers.**
- **Develop and promote "fit-for-purpose" GHG tools that are specifically adapted to the various types of farming operations in Canada, ensuring they provide effective support for farmers' sustainability efforts.**
- **Work towards standardizing data sources and methodologies to enhance the credibility and recognition of GHG tool outputs, both domestically and internationally.**
- **Strengthen support for educational initiatives and the adoption of GHG tools through policies that integrate these tools into eligibility criteria for government funding programs.**

Recommendations from the report "Greenhouse Gas Intensity Measurement in Transportation and Food Processing"

- **Create standardized Lifecycle Assessment Analysis (LCA) guidelines that align with global standards to ensure consistency and comparability in GHG measurement across the Canadian agri-food sector.**
- **Develop Product Category Rules (PCRs) to facilitate easier and more consistent construction of environmental product declarations, enhancing the comparability of lifecycle assessments across commodities.**
- **Enhance guidance on accounting for GHG emissions related to transport activities within the agri-food sector to improve lifecycle assessments.**
- **Support the development and dissemination of robust emission factors for transportation and food processing activities, which are crucial for accurate GHG accounting.**
- **Encourage the incorporation of sub-sector-specific GHG intensity results into the National Index to improve the tracking of emissions performance across different segments of the agri-food sector.**