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Part II: Policies to Promote Plant-Based Food Production and Consumption in Canada

Prepared for World Animal Protection

SUBMITTED TO

Lynn Kavanagh
World Animal Protection

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SUBMITTED BY

Navius Research Inc.
Box 48300 Bentall
Vancouver BC V7X 1A1

Contact@NaviusResearch.com

About Us

Navius Research Inc. is an independent and non-partisan consultancy based in Vancouver. We operate proprietary energy-economy modeling software designed to quantify the impacts of climate change mitigation policy on greenhouse gas emissions and the economy. We have been active in this field since 2008 and have become one of Canada's leading experts in modeling the impacts of energy and climate policy. Our analytical framework is used by clients across the country to inform energy and greenhouse gas abatement strategy.

We are proud to have worked with:

- All provincial and territorial governments, as well as the federal government.
- Utilities, industry associations and energy companies.
- Non-profit and research organizations with an interest in energy, climate change and economics.

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Executive Summary

Project overview

In August 2022, Navius completed an analysis for World Animal Protection to examine the role of animal-sourced food consumption in achieving Canada's greenhouse gas (GHG) emission targets.[1] The resulting report can be found here. This analysis involved the development of a customized version of Navius' gTech model, which allows for simulation of Canada's agriculture sector and food consumption patterns. It identified that shifting towards a plant-based diet could significantly reduce agricultural emissions, and as a result, decrease the cost of achieving Canada's emissions targets of a 40-45% reduction in GHG emissions by 2030 and net zero emissions by 2050.[2]

The following analysis builds on this previous study, this time examining the effectiveness of policies that could support plant-based agriculture and increase the consumption of plant-based foods in Canada. In particular, this analysis quantifies the impact of several possible policies – including an agricultural emissions cap, animal agriculture production limit, and a subsidy on plant-based alternatives – that are being explored around the world as a solution to limit emissions-intensive animal agriculture. It explores the impact of these policies on agricultural emissions, the food system and economic indicators in Canada with the objective of helping to guide World Animal Protection's advocacy efforts.

Approach

gTech is Navius' in-house energy economy model used for this analysis. gTech provides a comprehensive representation of all economic activity, energy consumption and greenhouse gas emissions in Canada. gTech is unique among energy-economy models because it combines features that are typically found in separate models:

- A realistic representation of how households and firms select technologies and processes that affect their energy consumption and greenhouse gas emissions;

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[1] Navius Research. (2022). *Animal-sourced food consumption and Canada's emissions targets.* Available from: https://www.naviusresearch.com/publications/world-animal-protection-emissions-targets/

[2] Government of Canada. (n.d.). *Net-Zero Emissions by 2050.* Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

- An exhaustive accounting of the economy at large, including how provinces and territories interact with each other and the rest of the world; and
- A detailed representation of energy supply, including liquid fuel (crude oil and biofuel), gaseous fuel (natural gas and renewable natural gas), hydrogen and electricity.

More information about gTech can be found in this report.

Policy scenarios

Four policy scenarios simulated for this analysis are discussed in this executive summary. These include:

1. Current policy

This scenario includes currently legislated provincial and federal policy including a carbon tax that rises to \$170/tCO_2e[3] and the Clean Fuel Regulations[4]. This scenario acts as a reference case against which the impact of all other policies can be measured.

2. Agriculture emissions cap

The federal government has proposed a cap on greenhouse gas (GHG) emissions from Canada's oil and gas sector.[5] A similar policy could be applied to the agricultural sector. Other jurisdictions have committed to reducing emissions in the agricultural sector through a GHG emissions cap - New Zealand, for example, has committed to a 24-47% reduction in biogenic

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[3] Government of Canada. (n.d.). *Update to the Pan-Canadian Approach to Carbon Pollution Pricing 2023-2030.* Available from: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information/federal-benchmark-2023-2030.html

[4] Government of Canada. (n.d.). *Clean Fuel Regulations, SOR/2022-140.* Available from: https://laws-lois.justice.gc.ca/eng/regulations/SOR-2022-140/page-1.html

[5] Government of Canada. (n.d.). *Options to cap and cut oil and gas sector greenhouse gas emissions to achieve 2030 goals and net-zero by 2050 – discussion document*. Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/oil-gas-emissions-cap/options-discussion-paper.html

methane emissions from agriculture by 2050 and net zero for all other agriculture emissions.[6]

This scenario caps GHG emissions from agriculture at levels that require a 30% reduction in emissions by 2030 and a 50% reduction by 2050 (from 2005 levels). This sectoral reduction requirement is less stringent than Canada's economy-wide emission reduction targets (40-45% reduction by 2030 and net zero by 2050).[7]

3. Animal agriculture production limit

Variations of a limit on animal agriculture production are being explored in other jurisdictions around the world. For example, there has been legislation tabled in the U.S. Senate which would ban new intensive livestock operations after 2025, with a full phaseout after 2040.[8] The Dutch government has also discussed cutting livestock numbers by a third to reduce emissions by 2030.[9]

This scenario uses a production limit on animal agriculture to simulate an effective moratorium on new animal agriculture production in Canada. Production is limited to current levels[10], ensuring no future growth in the animal agriculture sector. Instead, all new agricultural growth in Canada occurs in the plant-based agriculture sector.

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[6] OECD. (n.d). *New Zealand's plans for agricultural emissions pricing.* Available from: https://www.oecd.org/climate-action/ipac/practices/new-zealand-s-plans-for-agricultural-emissions-pricing-d4f4245c/

[7] Government of Canada. (n.d.). *Net-Zero Emissions by 2050.* Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

[8] *Farm System Reform Act of 2023*, 118th Congress 1st session. (2023). Available from: https://www.booker.senate.gov/imo/media/doc/farm_system_reform_act_of_20231.pdf

[9] Financial Times. (2022). *Dutch farmers in uproar over plans to curb animal numbers to cut nitrogen emissions.* Available from: https://www.ft.com/content/90e38fb5-e942-4afd-994d-048dc40579a2

[10] Modeled as a cap on animal agriculture production at the levels in the model's base year level (2015).

4. **Subsidy on plant-based food alternatives**

   Investment in plant-based food alternatives is occurring around the world, including the Canadian government providing funding for manufacturing of plant-based alternatives in Canada.[11]

   In this scenario, we simulate a subsidy on manufactured meat and dairy alternatives (e.g., beyond meat and oat milk) to incentivize their consumption by making them less expensive to consumers.[12] A 15% subsidy is provided to all manufactured meat and dairy alternatives.

Sensitivity analysis

For all policy scenarios described above, three different levels of meat and dairy consumption (low, medium and high) were simulated using a sensitivity analysis. The sensitivity analysis was used to explore the impact of behavioural changes on the effectiveness of these policies (i.e., what would the impact of the policy be if consumers are more or less likely to substitute animal-based products for plant-based products in the future).

Because gTech cannot directly simulate **behavioural policies**, such as education, awareness-raising, food labeling and advertising, this sensitivity analysis aims to capture the potential impact of policies that target consumer behaviour and make consumers more likely to shift their food consumption from animal-based to plant-based products. Note that unless otherwise specified, results are reported from the ‘high animal consumption’ sensitivity in which the likelihood of consumers to shift towards plant-based food consumption remains low (at current levels).

Results

Agriculture emissions cap

A GHG emissions cap on the agriculture sector is, by design, highly effective at reducing emissions. Capping agricultural emissions at a 30% reduction (from 2005 levels) by 2030 and a 50% reduction by 2050 results in a 29 Mt CO_2e reduction in

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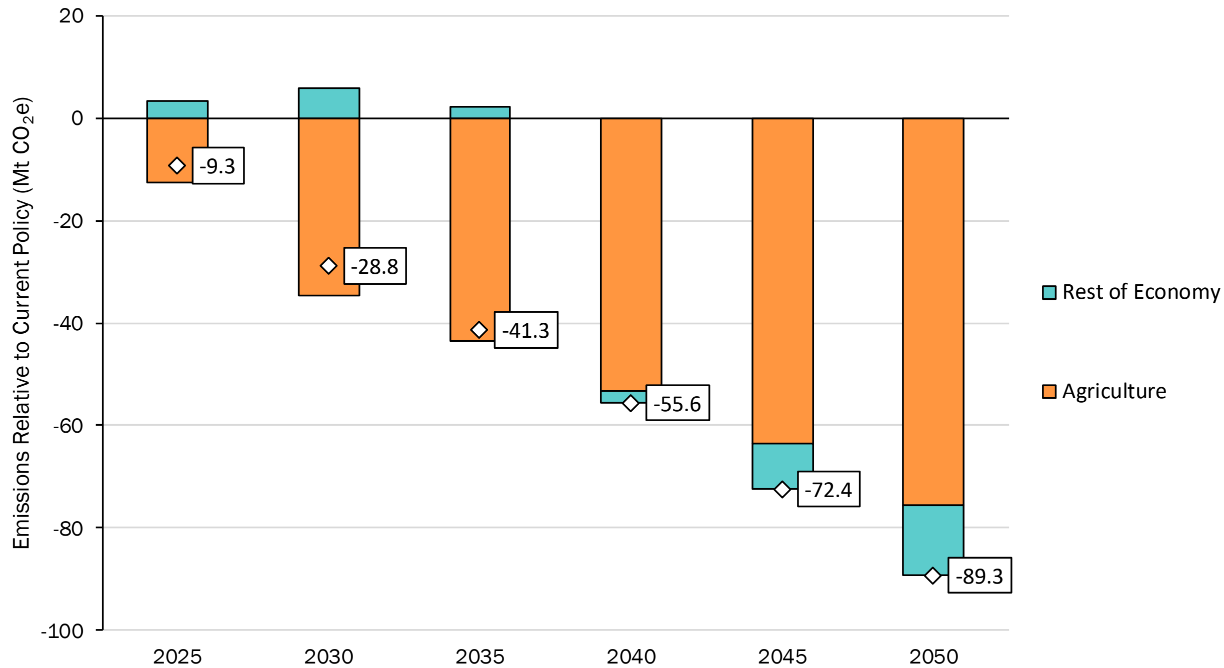
[11] Protein Industries Canada. (2023). *Protein Industries Canada receives federal funding for another five years.* Available from: https://www.proteinindustriescanada.ca/news-releases/protein-industries-canada-receives-federal-funding-for-another-five-years

[12] Plant-based food alternatives includes manufactured alternatives to meat and dairy such as plant-based meat or nut milks, however it does not include products such as fruits, vegetables, legumes or grains.

Canada's emissions in 2030 and a 89 Mt CO_2e reduction in 2050 relative to a current policy scenario, as shown in Figure 1.

Figure 1: Change in emissions in an agriculture emissions cap scenario (relative to current policy)



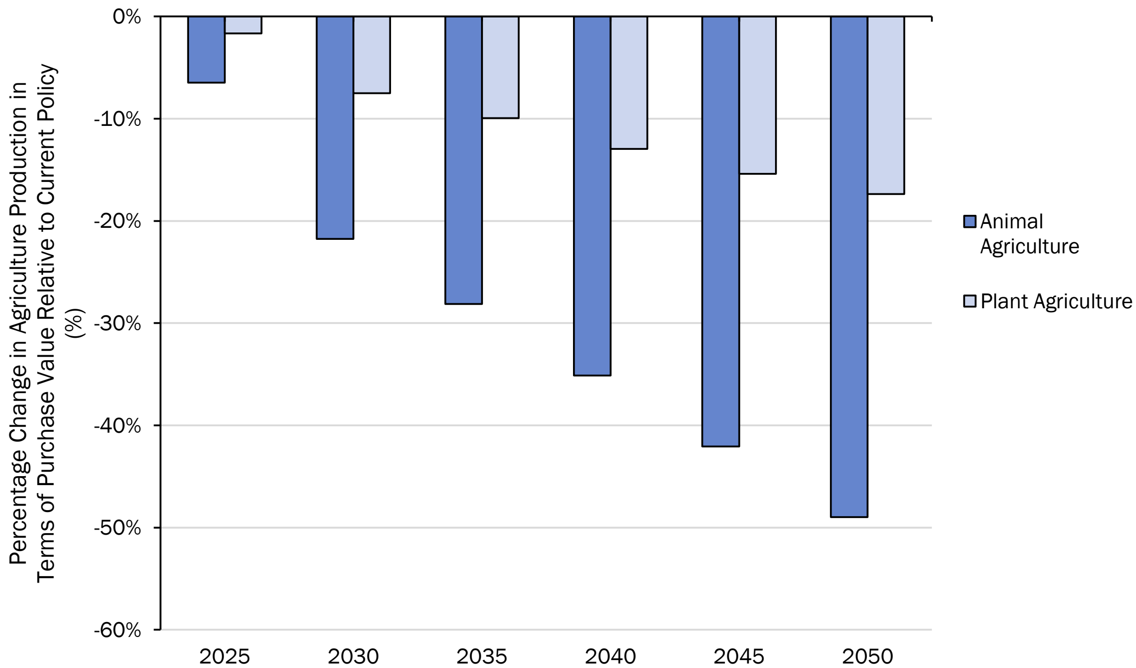
Most of these emissions reductions occur in the agricultural sector as abatement options such as electrification, bioenergy, and anaerobic digestors are adopted to reduce emissions to comply with the emissions cap. Additionally, the emissions cap incentivizes a shift away from animal agriculture towards plant-based agriculture. This is due to the high emissions intensity of animal agriculture relative to plant-based agriculture. In fact, recent research from the Canadian Climate Institute found that animal production and aquaculture is the most emissions intensive sector in Canada.[13]

As such, animal agriculture production in this scenario declines by 22% in 2030 and 50% in 2050 relative to current policy (Figure 2). The emissions cap also leads to a reduction in plant-based agriculture production. Plant-based production is 8% lower in 2030 and 17% lower in 2050 relative to current policy. This is due to a variety of factors, including a reduction in demand for animal feed, as well as a reduction in overall economic growth in this scenario (relative to a current policy scenario) leading

[13] Canadian Climate Institute. (2023). Calculating Emissions Intensity Across the Economy. Available from: https://440megatonnes.ca/insight/calculating-emissions-intensity-across-the-economy/

to a reduction in total agricultural production. Note that the economy continues to grow in this scenario, just at a slower rate than in the current policy scenario.

Figure 2: Change in agriculture production in an agriculture emissions cap scenario (relative to current policy)



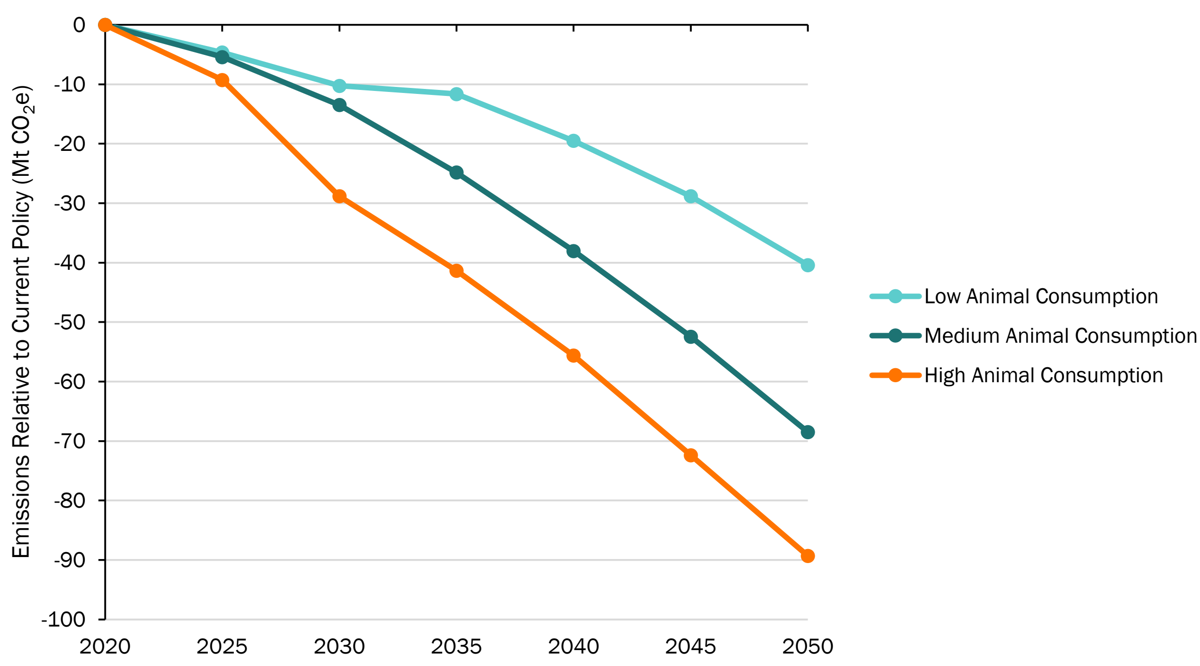
Different levels of meat and dairy consumption were modeled for each policy scenario in this analysis to explore the impact of behavioural change on the effectiveness of the policy instrument. In other words, what would the impact of an emissions cap on the agriculture sector be if consumers were more likely to substitute animal products for plant-based products? This sensitivity analysis helps us understand the potential interaction of an agriculture emissions cap with other behaviour-focused policies such as education or food labelling, which are intended to increase the willingness of consumers to shift away from animal products towards plant-based products.

The previous figures outline results of an agriculture emissions cap policy in a scenario where consumers are less likely to shift away from meat and dairy products to plant-based foods (high animal consumption sensitivity), which is intended to represent the current trajectory in absence of additional behaviour shifts (e.g., due to behaviour-focused policies such as education or food labelling). Simulating scenarios where consumers are more willing to shift their consumption towards plant-based alternatives has a significant impact on the effectiveness of an agriculture emissions cap, as shown in Figure 3 below.

Emissions reductions relative to current policy range from 10-28 Mt CO_2e in 2030 and 40-90 Mt CO_2e in 2050 in the agriculture emissions cap scenario depending on the animal consumption sensitivity. The policy has a smaller impact when consumers are more likely to shift towards a plant-based diet. This is because the reduction in animal agriculture that occurs in response to an emissions cap is to a greater extent already occurring under current policy due to reduced demand in a low animal consumption sensitivity. It is important to note however, that an agriculture emissions cap still has a large impact on emissions in a low animal consumption scenario.

This highlights that changing consumer behaviour could play a significant role in reducing emissions, as discussed in detail in our previous analysis for World Animal Protection.[14] Behavioural policies like informational campaigns or food labelling could play an important role in shifting consumer behaviour, which in turn influences Canada's food system and resulting emissions.

Figure 3: Change in emissions in an agriculture emissions cap scenario (relative to current policy) under three animal consumption sensitivities*



*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

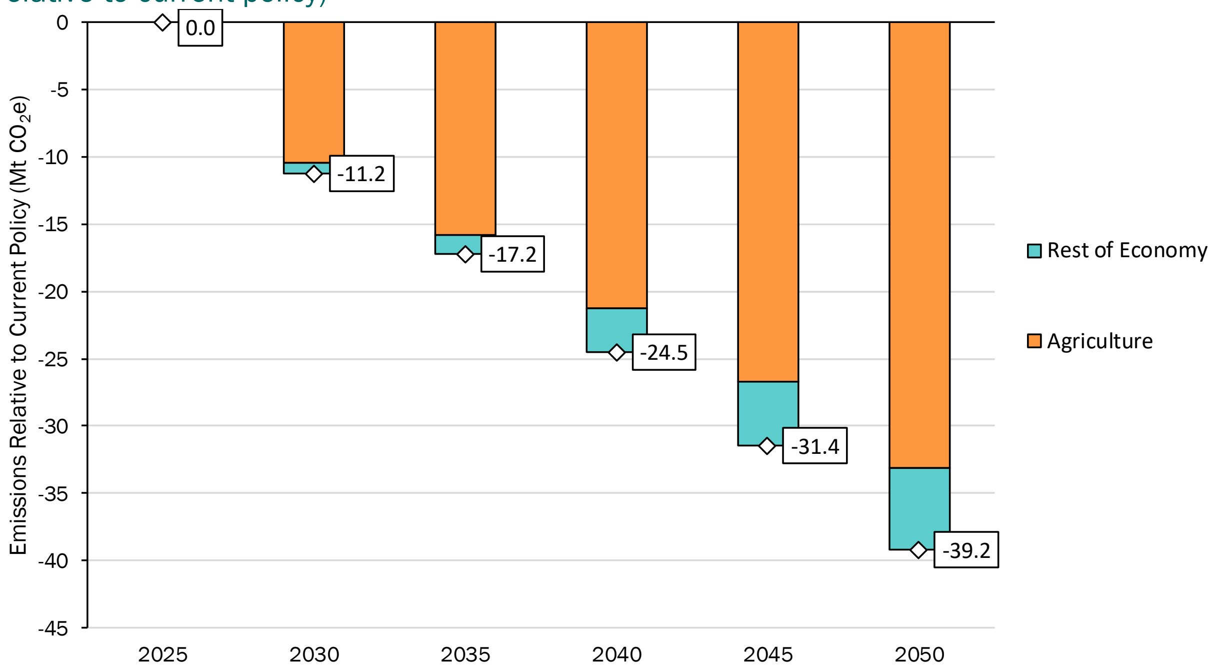
[14] Navius Research. (2022). *Animal-sourced food consumption and Canada's emissions targets.* Available from: https://www.naviusresearch.com/publications/world-animal-protection-emissions-targets/

Animal agriculture production limit

Animal agriculture has been identified as one of the most emissions intensive sectors in Canada.[15] Therefore, preventing growth of this sector has a significant impact on Canada's emissions. A policy that limits animal agriculture production to current levels results in a 11 Mt CO_2e reduction in Canada's emissions in 2030 and a 39 Mt CO_2e reduction in emissions in 2050, relative to current policy, as shown in Figure 4 below.

This is driven by a reduction in emissions from animals themselves, as fewer animals are farmed, as well as a reduction in emissions from input requirements to produce animals, including the growing of feed and use of fertilizer on that feed. Most emissions reductions in this scenario occur in the agriculture sector, and more specifically in the beef cattle sector (around 80% of total reductions), as this is the most emissions intensive agriculture sector. As such, reducing production in this sector relative to a current policy scenario has a large impact on Canada's emissions.

Figure 4: Change in emissions in an animal agriculture production limit scenario (relative to current policy)



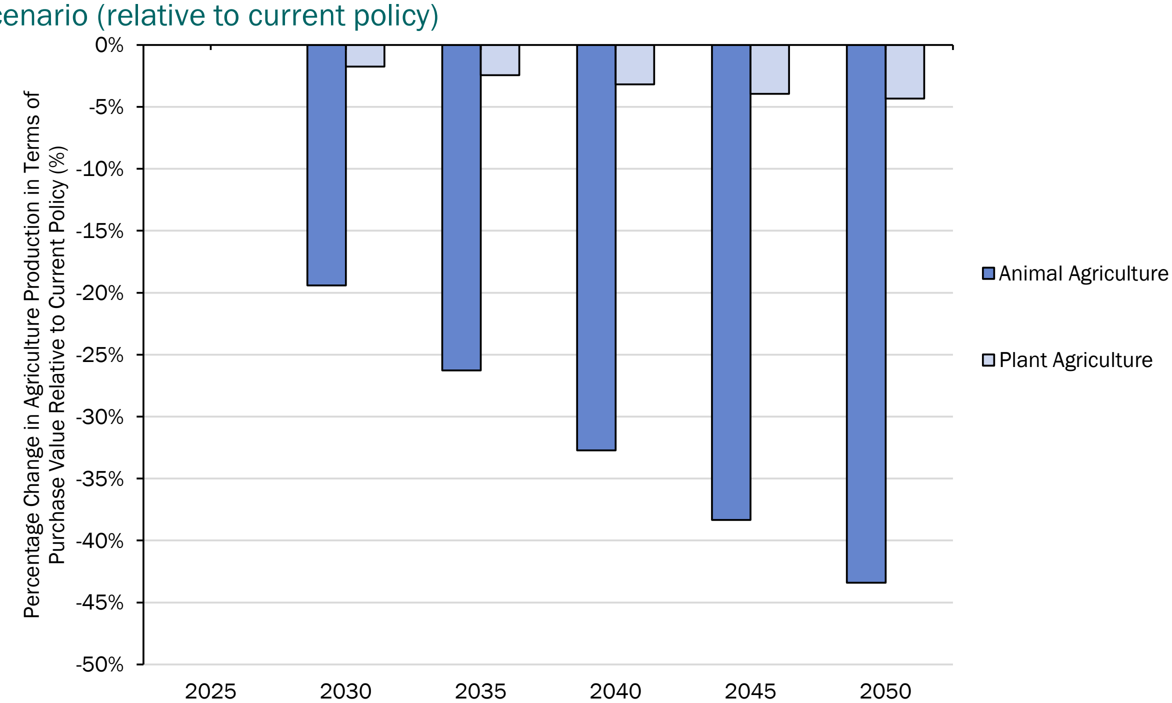
Limiting animal agriculture production has, by design, a significant impact on the number of animals produced in Canada. As shown in Figure 5, animal agriculture

[15] Canadian Climate Institute. (2023). *Calculating Emissions Intensity Across the Economy.* Available from: https://440megatonnes.ca/insight/calculating-emissions-intensity-across-the-economy/

production is 19% lower in 2030 and 43% lower in 2050 when production is limited to current levels relative to under current policy. The most significant reductions occur in the beef cattle sector. Beef cattle production is 23% lower in 2030 and 47% lower in 2050 compared to under current policy. Note that while animal agriculture production is lower in this scenario compared to the current policy scenario, animal agriculture production stays constant at current levels. In other words, production from the sector does not decrease.

Because farmed animals consume agricultural outputs from plant-based agriculture sectors as feed, a reduction in the number of animals produced (relative to current policy) also influences the level of output from plant-based agriculture. Additionally, as discussed in the next section, there is a reduction in overall economic growth in this scenario, leading to a reduction in total agricultural production. As a result, production from plant-based agriculture sectors is 2% lower in 2030 and 4% lower in 2050 in an animal agriculture production limit scenario relative to under current policy (Figure 5). Note that the plant-based agriculture sector continues to grow in the animal agriculture limit scenario, just at a slower level than in the current policy scenario.

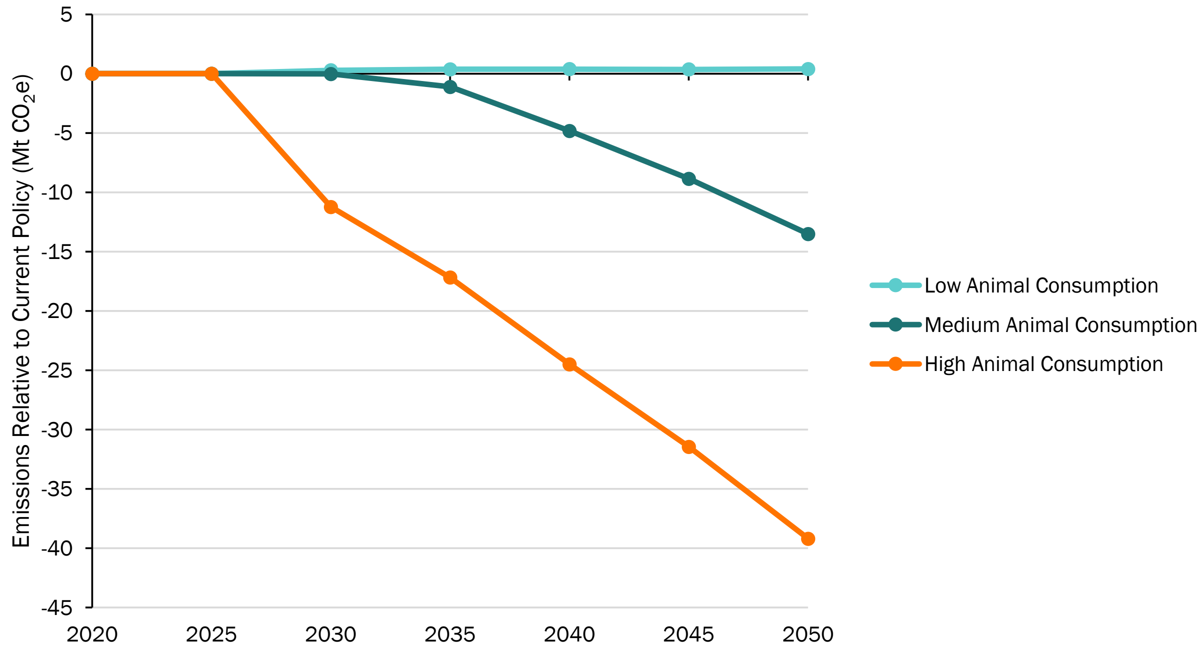
Figure 5: Change in agriculture production in an animal agriculture production limit scenario (relative to current policy)



The previous figures outline results of an animal agriculture production limit in a scenario where consumers are less likely to shift away from meat and dairy products to plant-based foods (i.e., high animal consumption sensitivity), which is intended to represent the current trajectory in absence of additional behaviour shifts (e.g., due to behaviour-focused policies such as education or food labelling). Simulating scenarios where consumers are more willing to shift their consumption has a significant impact on the effectiveness of an animal agriculture production limit, as shown in Figure 6 below.

Emissions reductions relative to current policy range from 0-11 Mt CO_2e in 2030 and 0-39 Mt CO_2e in 2050 in the animal agriculture production limit scenario depending on the animal consumption sensitivity. This policy has a smaller impact when consumers are more likely to shift towards a plant-based diet. In fact, in the low animal consumption sensitivity, when there is very high substitutability between plant-based products and animal products, a limit on animal agriculture production has no impact on Canada's emissions. This is because consumers are already shifting away from animal products in this sensitivity scenario, resulting in a decline in animal agriculture production over and beyond what the production limit policy requires. This suggests that if behavioural policies (such as informational campaigns or food labelling) could encourage consumers to shift consumption in line with the low animal consumption scenario, this could lead to a significant reduction in animal agriculture production and associated emissions in Canada.

Figure 6: Change in emissions in an animal agriculture production limit scenario (relative to current policy) under three animal consumption sensitivities*



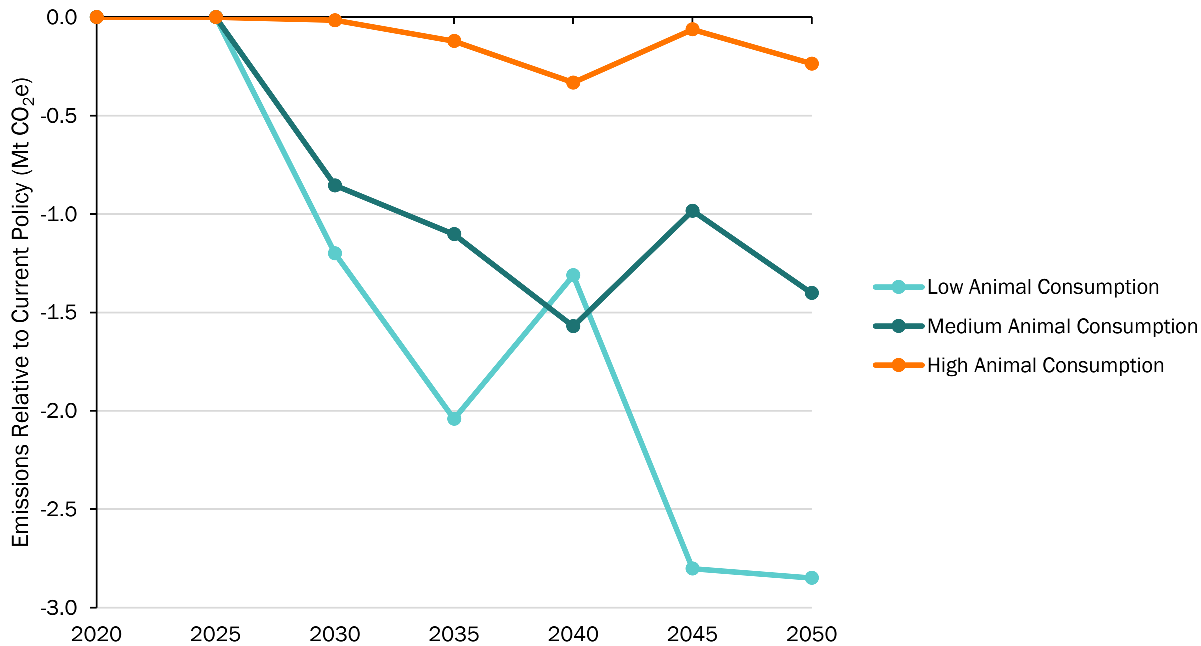
*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

Subsidy on plant-based food alternatives

This analysis found negligible impact of a plant-based subsidy on emissions and animal agriculture production in the high animal consumption trajectory, which is intended to represent the current trajectory in absence of additional behaviour shifts (e.g., due to behaviour-focused policies such as education or food labelling). However, the impact is amplified if consumers are more willing to shift away from meat and dairy towards plant-based products.

Emissions reductions relative to current policy range from 0-1 Mt CO_2e in 2030 and 0-3 Mt CO_2e in 2050 in the meat and dairy alternative subsidy scenario depending on the animal consumption sensitivity (Figure 7). Emissions reductions are greatest in the low animal consumption sensitivity when consumers are already likely to choose plant-based alternatives over meat or dairy products. This suggests that a subsidy on plant-based alternatives, although not an effective policy on its own, could be an effective policy in conjunction with behavioural policies, such as informational campaigns or food labelling, by reducing the cost of meat and dairy alternatives for consumers who are willing to shift their consumption. Conversely, it is important to note that results suggest a subsidy is likely to achieve very little unless the population is willing to shift towards a plant-based diet.

Figure 7: Change in emissions in an alternative food subsidy scenario (relative to current policy) under three animal consumption sensitivities*



*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

Note that there are other reasons to implement a subsidy beyond impacts on emissions. For example, subsidizing plant-based production could promote production and innovation within Canada through initiatives such as the Protein Industries Canada Cluster.[16] This could in turn reduce prices of plant-based alternatives, increasing the likelihood of a future with 'low animal consumption' (see Figure 7).

Comparison of policy instruments

This section offers a comparison of the policy instruments described above. It is intended to compare the impact of each policy on Canada's emissions, animal agriculture production, and economy. Note, however, that each policy simulated differs in its design, level of stringency, and intended function. For example, a GHG emissions cap on the agricultural sector is intended to reduce agricultural emissions, while an animal agriculture production limit is intended to prevent increased animal agriculture

[16] Government of Canada. (n.d.). *Canada's Protein Industries Cluster.* Available from: https://ised-isde.canada.ca/site/global-innovation-clusters/en/canadas-protein-industries-cluster

production (which indirectly reduces emissions relative to current policies which allow for growth in the sector). It is important to keep these differences in mind when reviewing the results presented in this section.

While agriculture GDP continues to grow out to 2050 in all scenarios, policies aimed at reducing agricultural emissions do have cost implications, as Canada's GDP grows at a slower rate in these scenarios relative to current policy.[17] Table 1 shows the average annual GDP growth rate in Canada in the high animal consumption sensitivity. Note that the GDP impact is lower for most policies in a low animal consumption future, as behavioural shifts towards a plant-based diet is already occurring. For example, in the low animal consumption sensitivity, the economy grows at 1.55% per year in the agriculture emissions cap scenario compared to 1.50% in the high animal consumption scenario.

Table 1: Average annual GDP growth rate

Policy	Average annual GDP growth rate (2020-2050)
Current policy	1.59%
Agriculture emissions cap	1.50%
Animal agriculture production limit	1.54%
Subsidy on plant-based food alternatives	1.59%

However, all policy instruments differ in terms of design, stringency, and objective, so simply comparing the GDP growth rate in each policy scenario is not sufficient for comparing their effectiveness. We can make a direct comparison between the policies by calculating the cost of the policy (impact to GDP) relative to the emissions or animal agriculture production reductions achieved.

Table 2 provides an index describing the reduction in GDP resulting from each policy relative to the level of emissions reductions achieved by the policy. It suggests that the GHG emissions cap is the most efficient policy at reducing emissions, costing the least per unit of emissions reduced. The animal production limit is more expensive, costing 60% more in 2030 and 10% more in 2050. While this policy is not intended to reduce emissions directly, limiting growth of this sector has a significant indirect impact on emissions due to animal agriculture's emissions intensive nature. As described

[17] Note that due to the limited impact of the plant-based subsidy, the difference in GDP between current policy and the subsidy is very small.

previously, the subsidy on plant-based food alternatives has a limited impact on emissions and is not a cost-efficient policy on its own.

Note that this analysis is heavily focused on the emissions benefit of implementing policies that encourage more plant-based food production and consumption in Canada. A reduction in animal agriculture could have other benefits beyond emissions impacts that are not quantified here, including land-use[18,19,20,21], water[22,23,24,25], biodiversity[26,27,28], and pandemic risk[29],[30],[31].

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[18] Clark, M.; Tilman, D. (2017). Comparative Analysis of Environmental Impacts of Agricultural Production Systems, Agricultural Input Efficiency, and Food Choice. *Environ. Res. Lett., 12 (6), 064016.* Available from: https://doi.org/10.1088/1748-9326/aa6cd5.

[19] Poore, J.; Nemecek, T.(2018). *Reducing Food's Environmental Impacts through Producers and Consumers. Science, 360 (6392), 987–992.* Available from: https://doi.org/10.1126/science.aaq0216

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[22] Ibid.

[23] Springmann, M.; Wiebe, K.; Mason-D'Croz, D.; Sulser, T. B.; Rayner, M.; Scarborough, P. (2018). Health and Nutritional Aspects of Sustainable Diet Strategies and Their Association with Environmental Impacts: A Global Modelling Analysis with Country-Level Detail. *The Lancet Planetary Health, 2 (10), e451–e461*. Available from: https://doi.org/10.1016/S2542-5196(18)30206-7.

[24] Gerten, D.; Heck, V.; Jägermeyr, J.; Bodirsky, B. L.; Fetzer, I.; Jalava, M.; Kummu, M.; Lucht, W.; Rockström, J.; Schaphoff, S.; Schellnhuber, H. J. (2020). Feeding Ten Billion People Is Possible within Four Terrestrial Planetary Boundaries. *Nat Sustain, 3 (3), 200–208.* Available from: https://doi.org/10.1038/s41893-019- 0465-1

[25] Kim BF, Santo RE, Scatterday AP, Fry JP, Synk CM, Cebron SR, Mekonnen MM, Hoekstra AY, De Pee S, Bloem MW, Neff RA (2020). Country-specific dietary shifts to mitigate climate and water crises. *Global environmental change, 1;62:101926.*

[26] Machovina, B.; Feeley, K. J.; Ripple, W. J.(2015). Biodiversity Conservation: The Key Is Reducing Meat Consumption. *Science of The Total Environment, 536, 419–431.*

[27] Coimbra, Z. H.; Gomes-Jr, L.; Fernandez, F. A. S. Human Carnivory as a Major Driver of Vertebrate Extinction. (2020). *Perspectives in Ecology and Conservation, 18 (4), 283–293.* Available from: https://doi.org/10.1016/j.pecon.2020.10.002.

[28] Gerten, D.; Heck, V.; Jägermeyr, J.; Bodirsky, B. L.; Fetzer, I.; Jalava, M.; Kummu, M.; Lucht, W.; Rockström, J.; Schaphoff, S.; Schellnhuber, H. J. (2020) Feeding Ten Billion People Is Possible within Four Terrestrial Planetary Boundaries. *Nat Sustain, 3 (3), 200–208.* Available from: https://doi.org/10.1038/s41893-019- 0465-1

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[31] White, R. J.; Razgour, O. (2020); Emerging Zoonotic Diseases Originating in Mammals: A Systematic Review of Effects of Anthropogenic Land use Change. *Mam Rev, 50 (4), 336–352*. Available from: https://doi.org/10.1111/mam.12201.

Table 2: Index describing the amount of GDP reduced relative to emissions reductions achieved (reductions from the GHG cap =1)

Policy	2030	2050
Agriculture emissions cap	1.0	1.0
Animal agriculture production limit	1.6	1.1
Subsidy on plant-based food alternatives	23.1	1.6

The agriculture emissions cap is a policy that is designed to target emissions rather than production directly. Therefore, it is a more expensive option if the goal is to reduce animal agriculture production in Canada, compared to an animal production limit, as shown in Table 3 below.

The animal agriculture production limit has a 30% smaller impact on GDP in 2030 per unit of animal agriculture reduced, and a 40% smaller impact on GDP in 2050 relative to the emissions cap. This indicates that this policy, which targets animal agriculture production more directly, is more cost effective than an emissions cap if the policy objective is to reduce animal agriculture production in Canada. The alternative food subsidy is an expensive policy as it does not have a significant impact on the food system.

Table 3: Index describing the amount of GDP reduced relative to the amount of animal agriculture production reduced (reductions from the GHG cap =1)

Policy	2030	2050
Agriculture emissions cap	1.0	1.0
Animal agriculture production limit	0.7	0.6
Subsidy on plant-based food alternatives	7.5	5.1

Key insights for policymakers

Results from this analysis provide five key insights, summarized below.

1. **Canada's agriculture sector can play a role in helping Canada achieve its emissions targets.** Reducing emissions from agriculture can play an important role in meeting Canada's 2030 emissions target, but stringent policy will be required with cost implications. A recent analysis of Canada's Emissions Reduction Plan (ERP) found that there is a 9 Mt CO_2e gap between announced

policies and Canada's 2030 emissions target.[32] Capping emissions from agriculture at 30% below 2005 levels in 2030 or keeping animal agriculture production constant at current levels could close this gap to Canada's 2030 target.[33]

2. **Canada's agriculture sector can continue to grow out to 2050 while helping Canada reduce emissions.** All policies simulated in this analysis lead to a reduction in Canada's emissions, while agriculture GDP continues to grow out to 2050 in all scenarios. Policies aimed at reducing agricultural emissions do have cost implications, as Canada's GDP grows at a slower rate in all policy scenarios relative to current policy.

3. **An emissions cap on Canada's agricultural sector is the most cost-effective policy for achieving emissions reductions.** This policy is designed to reduce emissions in the agriculture sector by encouraging adoption of available abatement technologies as well as encouraging a shift away from emissions-intensive animal agriculture towards plant-based agriculture. Of the policies explored in this analysis, this policy is the most efficient at reducing emissions, costing the least per unit of emissions reduced.

4. **An animal agriculture production limit is the most cost-effective policy for transforming Canada's food system.** While implementing an emissions cap on the agricultural sector achieves significant emissions reductions in Canada, it is not as effective at changing how food is produced and consumed in Canada. An animal agriculture production limit, which directly targets the production of animals, is more cost efficient than an emissions cap at reducing animal production in Canada. It is important to acknowledge that there are many environmental benefits of reduction in animal production, beyond the impact on

[32] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

[33] Based on a 2022 analysis of the ERP. Additional information about policy design has been released since then.

GHG emissions, which are not explored in this analysis, including land-use[34,35,36,37], water[38,39,40,41], biodiversity[42,43,44], and pandemic risk[45],[46],[47].

5. **Policy design should consider interactions between the policy and future behavioural changes and consumption patterns.** Behavioural changes can play a significant role on the impact of the policies explored in this analysis, amplifying their impact in some cases and reducing it in others. The effectiveness of an emissions cap and production limit decline if consumers are more willing to shift towards a plant-based diet, as changes to Canada's food system are occurring to a greater extent in the absence of additional policy. On the other hand, the effectiveness of a subsidy on plant-based food alternatives

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[35] Poore, J.; Nemecek, T.(2018). *Reducing Food's Environmental Impacts through Producers and Consumers. Science, 360 (6392), 987–992.* Available from: https://doi.org/10.1126/science.aaq0216

[36] Chai, B. C.; van der Voort, J. R.; Grofelnik, K.; Eliasdottir, H. G.; Klöss, I.; Perez-Cueto, F. J. A. (2019). Which Diet Has the Least Environmental Impact on Our Planet? A Systematic Review of Vegan, Vegetarian and Omnivorous Diets. *Sustainability, 11 (15), 4110.*

[37] Clark, M. A.; Springmann, M.; Hill, J.; Tilman, D. (2019). Multiple Health and Environmental Impacts of Foods. *Proc Natl Acad Sci USA, 116 (46), 23357–23362*. Available from: https://doi.org/10.1073/pnas.1906908116

[38] Ibid.

[39] Springmann, M.; Wiebe, K.; Mason-D'Croz, D.; Sulser, T. B.; Rayner, M.; Scarborough, P. (2018). Health and Nutritional Aspects of Sustainable Diet Strategies and Their Association with Environmental Impacts: A Global Modelling Analysis with Country-Level Detail. *The Lancet Planetary Health, 2 (10), e451–e461*. Available from: https://doi.org/10.1016/S2542-5196(18)30206-7.

[40] Gerten, D.; Heck, V.; Jägermeyr, J.; Bodirsky, B. L.; Fetzer, I.; Jalava, M.; Kummu, M.; Lucht, W.; Rockström, J.; Schaphoff, S.; Schellnhuber, H. J. (2020). Feeding Ten Billion People Is Possible within Four Terrestrial Planetary Boundaries. *Nat Sustain, 3 (3), 200–208.* Available from: https://doi.org/10.1038/s41893-019- 0465-1

[41] Kim BF, Santo RE, Scatterday AP, Fry JP, Synk CM, Cebron SR, Mekonnen MM, Hoekstra AY, De Pee S, Bloem MW, Neff RA (2020). Country-specific dietary shifts to mitigate climate and water crises. *Global environmental change, 1;62:101926.*

[42] Machovina, B.; Feeley, K. J.; Ripple, W. J.(2015). Biodiversity Conservation: The Key Is Reducing Meat Consumption. *Science of The Total Environment, 536, 419–431.*

[43] Coimbra, Z. H.; Gomes-Jr, L.; Fernandez, F. A. S. Human Carnivory as a Major Driver of Vertebrate Extinction. (2020). *Perspectives in Ecology and Conservation, 18 (4), 283–293.* Available from: https://doi.org/10.1016/j.pecon.2020.10.002.

[44] Gerten, D.; Heck, V.; Jägermeyr, J.; Bodirsky, B. L.; Fetzer, I.; Jalava, M.; Kummu, M.; Lucht, W.; Rockström, J.; Schaphoff, S.; Schellnhuber, H. J. (2020) Feeding Ten Billion People Is Possible within Four Terrestrial Planetary Boundaries. *Nat Sustain, 3 (3), 200–208.* Available from: https://doi.org/10.1038/s41893-019- 0465-1

[45] Kim, H.; Rebholz, C. M.; Hegde, S.; LaFiura, C.; Raghavan, M.; Lloyd, J. F.; Cheng, S.; Seidelmann, S. B. (2020). Plant-Based Diets, Pescatarian Diets and COVID-19 Severity: A Population-Based Case–Control Study in Six Countries. *BMJNPH, 4 (1), 257–266.* Available from: https://doi.org/10.1136/bmjnph 2021-000272.

[46] Intergovernmental Science-Policy Platform On Biodiversity And Ecosystem Services (IPBES). (2020). *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES);* Zenodo. Available from: https://doi.org/10.5281/ZENODO.4147317.

[47] White, R. J.; Razgour, O. (2020); Emerging Zoonotic Diseases Originating in Mammals: A Systematic Review of Effects of Anthropogenic Land use Change. *Mam Rev, 50 (4), 336–352*. Available from: https://doi.org/10.1111/mam.12201.

is amplified when consumers are more willing to shift towards a plant-based diet.

Table of Contents

1. Introduction

In August 2022, Navius completed an analysis for World Animal Protection to examine the role of animal-sourced food consumption in achieving Canada's greenhouse gas (GHG) emission targets.[48] The resulting report can be found here. This analysis involved the development of a customized version of Navius' gTech model, which allows for simulation of Canada's agriculture sector and food consumption patterns. It identified that shifting towards a plant-based diet could significantly reduce agricultural emissions, and as a result, decrease the cost of achieving Canada's emissions targets of a 40-45% reduction in GHG emissions by 2030 and net zero emissions by 2050.[49]

The following report builds on this previous analysis, this time examining the effectiveness of policies that could support plant-based agriculture and increase the consumption of plant-based foods in Canada. In particular, this analysis quantifies the impact of several possible policies – including an agricultural emissions cap, animal agriculture production limit, and a subsidy on plant-based alternatives – that are being explored around the world as a solution to limit emissions-intensive animal agriculture. It explores the impact of these policies on agricultural emissions, the food system and economic indicators in Canada with the objective of helping to guide World Animal Protection's advocacy efforts.

This report presents the findings of this analysis and is structured as follows:

- Chapter 2 outlines the analytical approach used for this analysis.
- Chapter 3 presents results from the analysis.
- Chapter 4 concludes with key insights for policy makers and a discussion of areas for future research.

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48 Navius Research. (2022). *Animal-sourced food consumption and Canada's emissions targets.* Available from: https://www.naviusresearch.com/publications/world-animal-protection-emissions-targets/

49 Government of Canada. (n.d.). *Net-Zero Emissions by 2050.* Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

2. Analytical approach

The following section outlines the analytical approach taken for this analysis, including the model used, scenario design, and key modeling assumptions.

2.1. Introduction to Navius' model

Canada's energy-economy is complex. Energy consumption, which is the main driver of anthropogenic greenhouse gas emissions, results from the decisions made by millions of Canadians. For example, households must choose what type of vehicles they will buy and how to heat their homes; industry must decide whether to install technologies that might cost more but consume less energy; municipalities must determine whether to expand transit service; and investors need to decide whether to invest their money in Canada or somewhere else. Currently, about 10% of Canada's GHG emissions come from the agriculture sector[50] and its share is expected to increase in the future. Shifting agricultural production from animal-sources to plant-based foods can decrease the environmental impact of this sector due to the emissions intensive nature of animal agriculture.

All levels of government in Canada have implemented policies designed to encourage or require firms and consumers to take actions to reduce their emissions. Climate and energy policies will have effects throughout the economy and interact with each other. For example, the federal vehicle emission standard and carbon pricing efforts seek to reduce greenhouse gas emissions from passenger vehicles, as do a variety of provincial policies (such as BC's low carbon fuel standard, the proposed federal clean fuel standard and zero-emission vehicle mandates in Québec and proposed in BC). The interactive effects among such policies can be complex. The economic effects of all federal and provincial climate initiatives implemented together are even more complex.

Estimating the regional, sectoral, technological and economic impacts of reducing emissions therefore requires a modeling framework that captures the complexity of the energy-economic system.

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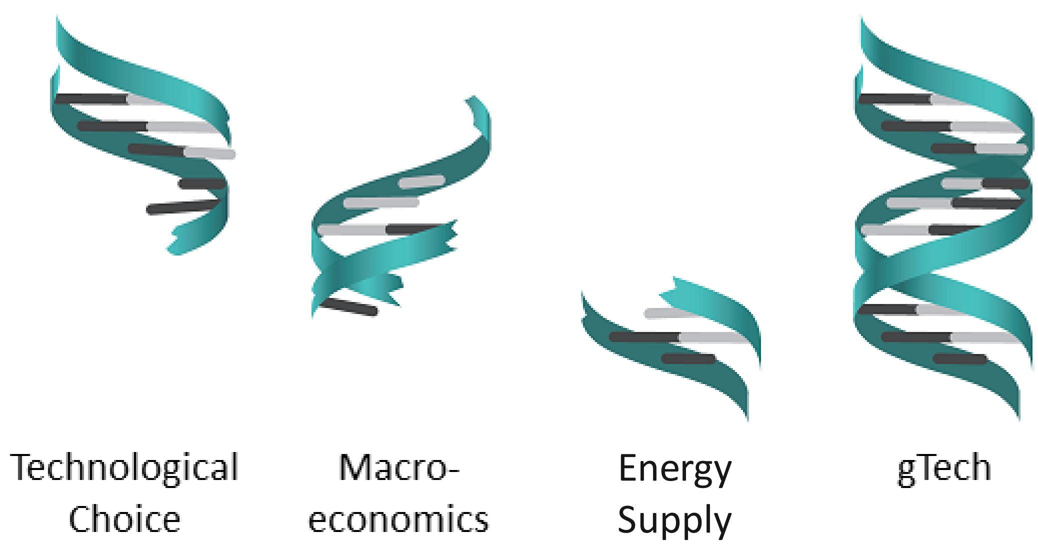
[50] Note that this includes agricultural emissions as classified in the Canada's National Inventory Report. This means it does not include the emissions from e.g., the production and transportation of fertilizers.

gTech is Navius in-house energy economy model used for this analysis. gTech provides a comprehensive representation of all economic activity, energy consumption and greenhouse gas emissions in Canada. gTech is unique among energy-economy models because it combines features that are typically only found in separate models:

- A realistic representation of how households and firms select technologies and processes that affect their energy consumption and greenhouse gas emissions;
- An exhaustive accounting of the economy at large, including how provinces and territories interact with each other and the rest of the world; and
- A detailed representation of energy supply, including liquid fuel (crude oil and biofuel), gaseous fuel (natural gas and renewable natural gas), hydrogen and electricity.

Figure 8: The gTech model



gTech builds on three of Navius' previous models (CIMS, GEEM and OILTRANS/IESD), combining their best elements into a comprehensive integrated framework.

2.1.1. Simulating technological choice

Technological choice is one of the most critical decisions that influence greenhouse gas emissions in Canada. For example, if a household chooses to purchase an electric vehicle over a gasoline car, that decision will reduce their emissions. Similarly, if a mining facility chooses to electrify its operations, that decision reduces its emissions.

gTech provides a detailed accounting of the types of energy-related technologies available to households and businesses. In total, gTech includes over 300 technologies across more than 50 end-uses (e.g., light-duty vehicle travel, residential space heating, industrial process heat, management of agricultural manure).

Naturally, technological choice is influenced by many factors. Table 4 summarizes key factors that influence technological choice and the extent to which these factors are included in gTech.

Table 4: Technological choice dynamics captured by gTech

Criteria	Description
Purchasing (capital) costs	Purchasing costs are simply the upfront cost of purchasing a technology. Every technology in gTech has a unique capital cost that is based on research conducted by Navius. Everything else being equal (which is rarely the case), households and firms prefer technologies with a lower purchasing cost.
Energy costs	Energy costs are a function of two factors: (1) the price for energy (e.g., cents per litre of gasoline) and (2) the energy requirements of an individual technology (e.g., a vehicle's fuel economy, measured in litres per 100 km). In gTech, the energy requirements for a given technology are fixed, but the price for energy is determined by the model. The method of "solving" for energy prices is discussed in more detail below.
Time preference of capital	Most technologies have both a purchasing cost as well as an energy cost. Households and businesses must generally incur a technology's purchasing cost before they incur the energy costs. In other words, a household will buy a vehicle before it needs to be fueled. As such, there is a tradeoff between near-term capital costs and long-term energy costs. gTech represents this tradeoff using a "discount rate". Discount rates are analogous to the interest rate used for a loan. The question then becomes: is a household willing to incur greater upfront costs to enable energy or emissions savings in the future? Many energy modelers use a "financial" discount rate (commonly between 5% and 10%). However, given the objective of forecasting how households and firms are likely to respond to climate policy, gTech employs behaviourally realistic discount rates of between 8% and 25% to simulate technological choice. Research consistently shows that households and firms do not make decisions using a financial discount rate, but rather use significantly higher rates.[51] The implication is that using a financial discount rate would overvalue future savings relative to revealed behaviour and provide a poor forecast of household and firm decisions.

[51] For example, see: Rivers, N., & Jaccard, M. (2006). Useful models for simulating policies to induce technological change. *Energy policy*, *34*(15), 2038-2047; Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. Resource and Energy Economics 31, 221-238.

Criteria	Description
Technology specific preferences	In addition to preferences around near-term and long-term costs, households (and even firms) exhibit "preferences" towards certain types of technologies. These preferences are often so strong that they can overwhelm most other factors (including financial ones). For example, buyers of passenger vehicles can be concerned about the driving range and available charging infrastructure of vehicles, some may worry about the risk of buying new technology, and some may see the vehicle as a "status symbol" that they value[52]. gTech quantifies these technology-specific preferences as "non-financial" costs, which are added to the technology choice algorithm.
The diverse nature of Canadians	Canadians are not a homogenous group. Individuals are unique and will weigh factors differently when choosing what type of technology to purchase. For example, one household may purchase a Toyota Prius while their neighbour purchases an SUV and another takes transit. gTech uses a "market share" equation in which technologies with the lowest net costs (including all the cost dynamics described above) achieve the greatest market share, but technologies with higher net costs may still capture some market share[53]. As a technology becomes increasingly costly relative to its alternatives, that technology earns less market share.
Changing costs over time	Costs for technologies are not fixed over time. For example, the cost of electric vehicles has come down significantly over the past few years, and costs are expected to continue declining in the future[54]. Similarly, costs for many other energy efficient devices and emissions-reducing technologies have declined and are expected to continue declining. gTech accounts for whether and how costs for technologies are projected to decline over time and/or in response to cumulative production of that technology.
Policy	One of the most important drivers of technological choice is government policy. Current federal, provincial and territorial initiatives in Canada are already altering the technological choices households and firms make through various policies: (1) incentive programs, which pay for a portion of the purchasing cost of a given technology; (2) regulations, which either require a group of technologies to be purchased or prevent another group of technologies from being purchased; (3) carbon pricing, which increases fuel costs in proportion to their carbon content; (4) variations in other tax policy (e.g., whether or not to charge GST on a given technology); and (5) flexible regulations, like the federal clean fuel standard which will create a market for compliance credits. gTech simulates the combined effects of all these policies implemented together.

[52] Kormos, C., Axsen, J., Long, Z., Goldberg, S., 2019. Latent demand for zero-emissions vehicles in Canada (Part 2): Insights from a stated choice experiment. Transportation Research Part D: Transport and Environment 67, 685-702.
[53] Rivers, N., & Jaccard, M. (2006). Useful models for simulating policies to induce technological change. *Energy policy*, *34*(15), 2038-2047.
[54] Nykvist, B., Sprei, F., & Nilsson, M. (2019). Assessing the progress toward lower priced long range battery electric vehicles. *Energy Policy*, 124, 144-155.

2.1.2. Understanding the macroeconomic impacts of policy

As a full macroeconomic model (specifically, a "general equilibrium model"), gTech provides insight about how policies affect the economy at large. The key macroeconomic dynamics captured by gTech are summarised in Table 5.

Table 5: Macroeconomic dynamics captured by gTech

Dynamic	Description
Comprehensive coverage of economic activity	gTech accounts for all economic activity in Canada as measured by Statistics Canada national accounts[55]. Specifically, it captures all sector activity, all gross domestic product, all trade of goods and services and the transactions that occur between households, firms and government. As such, the model provides a forecast of how government policy affects many different economic indicators, including gross domestic product, investment, household income and jobs.
Full equilibrium dynamics	gTech ensures that all markets in the model return to equilibrium (i.e., that the supply for a good or service is equal to its demand). This means that a decision made in one sector is likely to have ripple effects throughout the entire economy. For example, greater demand for electricity requires greater electricity production. In turn, greater production necessitates greater investment and demand for goods and services from the electricity sector, increasing demand for labor in construction services and ultimately leading to higher wages. The model also accounts for price effects. For example, the electricity sector can pass policy compliance costs on to households, who may alter their demand for electricity and other goods and services (e.g., by switching to technologies that consume other fuels and/or reducing consumption of other goods and services).
Sector detail	gTech provides a detailed accounting of sectors in Canada. In total, gTech simulates how policies affect over 80 sectors of the economy. Each of these sectors produces a unique good or service (e.g., the mining sector produces ore, while the trucking sector produces transport services) and requires specific inputs into production.
Labor and capital markets	Labour and capital markets must also achieve equilibrium in the model. The availability of labor can change with the "real" wage rate (i.e., the wage rate relative to the consumption level). If the real wage increases, the availability of labor increases. The model also accounts for "equilibrium unemployment".

[55] Statistics Canada. Supply and Use Tables. Available from: www150.statcan.gc.ca/n1/en/catalogue/15-602-X

Dynamic	Description
Interactions between regions	Economic activity in Canada is highly influenced by interactions among provinces/territories, with the United States and with countries outside of North America. Each province in the model interacts with other regions via (1) the trade of goods and services, (2) capital movements, (3) government taxation and (4) various types of "transfers" between regions (e.g., the federal government provides transfers to provincial and territorial governments). The version of gTech used for this project accounts for the 10 Canadian provinces, the 3 territories in an aggregated region and the United States. The model simulates each of the interactions described above, and how interactions may change in response to policy.
Households	On one hand, households earn income from the economy at large. On the other hand, households use this income to consume different goods and services. gTech accounts for each of these dynamics, and how either changes with policy.

2.1.3. Understanding energy supply markets

gTech accounts for all major energy supply markets, such as electricity, refined petroleum products and natural gas. Each market is characterized by resource availability and production costs by province, as well as costs and constraints (e.g., pipeline capacity) of transporting energy between regions.

Low carbon energy sources can be introduced within each fuel stream in response to policy, including renewable electricity and bioenergy. The model accounts for the availability and cost of bioenergy feedstocks, allowing it to provide insight about the economic effects of emission reduction policy, biofuels policy and the approval of pipelines.

2.1.4. gTech: The benefits of merging macroeconomics with technological detail

By merging the three features described above (technological detail, macroeconomic dynamics, and energy supply dynamics), gTech can provide extensive insight into the effects of climate and energy policy.

First, gTech can provide insights related to technological change by answering questions such as:

- How do policies affect technological adoption (e.g., how many electric vehicles are likely to be on the road in 2030)?

- How does technological adoption affect greenhouse gas emissions and energy consumption?

Second, gTech can provide insights related to macroeconomics by answering questions such as:

- How do policies affect national and provincial gross domestic product?
- How do policies affect individual sectors of the economy?
- Are households affected by the policy?
- Does the policy affect energy prices or any other price in the model (e.g., food prices)?

Third, gTech answers questions related to its energy supply modules such as:

- Will a policy generate more supply of renewable fuels?
- Does policy affect the cost of transporting refined petroleum products, and therefore the price of gasoline in Canada?

Finally, gTech expands our insights into areas where there is overlap between its various features:

- What is the effect of investing carbon revenue into low- and zero-carbon technologies? This question can only be answered with a model like gTech.
- What are the macroeconomic impacts of technology-focused policies (e.g., how might a zero-emissions vehicle standard impact GDP)?
- Do biofuels-focused policies affect (1) technological choice and (2) the macroeconomy?

This modeling toolkit allows for a comprehensive examination of the impacts of policies to encourage plant-based production and consumption in Canada.

2.1.5. Limits to forecasting

Despite using the best available forecasting methods and assumptions, the evolution of our energy economy is uncertain. In particular, forecasting GHG emissions is subject to two main types of uncertainty.

First, all models are simplified representations of reality. Our models are, effectively, a series of mathematical equations that are intended to forecast the future. This raises key questions: "are the equations selected a good representation of reality?" and "do the equations selected overlook important factors that may influence the future?". The use of computable general equilibrium models is well founded in the academic literature. In addition, Navius undertakes significant efforts to calibrate and back-cast the model to ensure that it captures key dynamics in the energy-economic system. However, Navius' tools do not account for every dynamic that will influence technological change. For example, household and firm decisions are influenced by many factors, which cannot be fully captured by even the most sophisticated model. The inherent limitation of energy-economy forecasting is that virtually all projections of the future will differ, to some extent, from what ultimately transpires.

Second, the assumptions used to parameterize the models are subject to uncertainty. These assumptions include, but are not limited to, oil prices, improvements in labour productivity and a stable climate. If any of the assumptions used prove incorrect, the resulting forecast could be affected.

2.2. Scenario design

2.2.1. Policy scenarios

Four policy scenarios are discussed in this report, which include:

1. **Current policy:** This scenario includes currently legislated provincial and federal policy including a carbon tax that rises to $170/t$CO_2e$[56] and the Clean Fuel Regulations[57]. This scenario acts as a reference case against which the impact of all other policies can be measured.

2. **Agriculture emissions cap:** The federal government has proposed cap on GHG emissions from Canada's oil and gas sector.[58] A similar policy could be applied

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[56] Government of Canada. (n.d.). *Update to the Pan-Canadian Approach to Carbon Pollution Pricing 2023-2030.* Available from: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information/federal-benchmark-2023-2030.html

[57] Government of Canada. (n.d.). *Clean Fuel Regulations, SOR/2022-140.* Available from: https://laws-lois.justice.gc.ca/eng/regulations/SOR-2022-140/page-1.html

[58] Government of Canada. (n.d.). *Options to cap and cut oil and gas sector greenhouse gas emissions to achieve 2030 goals and net-zero by 2050 – discussion document*. Available from:

to the agricultural sector. Other jurisdictions have committed to reducing emissions in the agricultural sector through a GHG emissions cap, such as New Zealand, which has committed to a 24-47% reduction in biogenic methane emissions from agriculture by 2050 and net zero for all other agriculture emissions.[59] This scenario caps GHG emissions from agriculture at levels that require a 30% reduction in emissions by 2030 and a 50% reduction by 2050 (from 2005 levels). This sectoral reduction requirement is less stringent than Canada's economy-wide reduction targets (40-45% reduction by 2030 and net zero by 2050).[60]

3. **Animal agriculture production limit:** This scenario uses a production limit on animal agriculture to simulate an effective moratorium on new animal agriculture production in Canada. Production is limited to current levels[61], ensuring that there is no growth in the animal agriculture sector. Instead, all new agricultural growth in Canada occurs in the plant-based agriculture sector. Variations of an animal agriculture production limit are being explored in other jurisdictions. For example, there has been legislation tabled in the U.S. Senate which would ban new intensive livestock operations after 2025, with a full phaseout after 2040.[62] The Dutch government has also discussed cutting livestock numbers by a third to reduce emissions by 2030.[63]

4. **Subsidy on plant-based food alternatives:** In this scenario, we simulate a subsidy on manufactured meat and dairy alternatives (e.g., beyond meat and oat milk) to incentivize their consumption by making them less expensive to consumers.[64] Investment in plant-based food alternatives is occurring around

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https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/oil-gas-emissions-cap/options-discussion-paper.html

59 OECD. (n.d). *New Zealand's plans for agricultural emissions pricing.* Available from: https://www.oecd.org/climate-action/ipac/practices/new-zealand-s-plans-for-agricultural-emissions-pricing-d4f4245c/

60 Government of Canada. (n.d.). *Net-Zero Emissions by 2050.* Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

61 Modeled as a limit on animal agriculture production at the levels in the model's base year level (2015).

62 *Farm System Reform Act of 2023*, 118th Congress 1st session. (2023). Available from: https://www.booker.senate.gov/imo/media/doc/farm_system_reform_act_of_20231.pdf

63 Financial Times. (2022). *Dutch farmers in uproar over plans to curb animal numbers to cut nitrogen emissions.* Available from: https://www.ft.com/content/90e38fb5-e942-4afd-994d-048dc40579a2

64 Plant-based food alternatives includes manufactured alternatives to meat and dairy such as plant-based meat or nut milks, however it does not include products such as fruits, vegetables, legumes or grains.

the world, including the Canadian government providing funding for manufacturing of plant-based alternatives in Canada.[65] A 15% subsidy is provided to all manufactured meat and dairy alternatives.

Note that for all policies described above, we assume revenue produced from the policy is recycled back to households. We also assume no new climate policy is implemented in the U.S. This is an important assumption because what occurs in the U.S. has a large impact on the results. For example, Canadian consumers might choose to consume imported meat from the U.S., which due to the design of our scenarios would not be subject to the policies described above. This report is focused on the impacts of policy on production and manufacturing of food within Canada and does not tackle impacts of policy implementation on agriculture and food product imports.

2.2.2. Sensitivity scenarios

For all policy scenarios described above three different levels of meat and dairy consumption (low, medium and high) were simulated using a sensitivity analysis. The sensitivity analysis was used to explore the impact of behavioural changes on the effectiveness of the polices simulated in this analysis (i.e., what is the impact of the policy if consumers are more or less likely to substitute animal products for plant-based products).

Because gTech cannot directly simulate **behavioural policies,** such as education, awareness-raising, food labeling and advertising, this sensitivity analysis aims to capture the potential impact of policies that target consumer behaviour and make consumers more likely to shift their food consumption from animal-based to plant-based products.

Three dynamics, including the share of meat and dairy consumption that is plant-based alternatives, the declining capital cost of meat and dairy alternatives, and the elasticity of substitution between animal and plant-based alternatives, were used to simulate different levels of meat and dairy consumption over time. Table 6 provides a summary of the three meat and dairy consumption scenarios simulated in this analysis. See section 2.3.4 for a more detailed explanation of how these meat and

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[65] Protein Industries Canada. (2023). *Protein Industries Canada receives federal funding for another five years.* Available from: https://www.proteinindustriescanada.ca/news-releases/protein-industries-canada-receives-federal-funding-for-another-five-years

dairy consumption forecasts were simulated. Note that unless otherwise specified, results are reported from the 'high animal consumption' sensitivity.

Table 6: Uncertainty in animal product consumption examined in this analysis

Low Animal Consumption	Medium Animal Consumption	High Animal Consumption
• The share of meat consumption that is meat substitutes and the share of dairy consumption that is dairy substitutes increases significantly from 2020 to 2050 • The cost of meat and dairy alternatives declines significantly over time • There is very high substitutability between plant-based products and animal products	• The share of meat consumption that is meat substitutes and the share of dairy consumption that is dairy substitutes increases from 2020 to 2050 • The cost of meat and dairy alternatives declines over time • There is high substitutability between plant-based products and animal products	• The share of meat consumption that is meat substitutes and the share of dairy consumption that is dairy substitutes stays at current levels • The cost of meat and dairy alternatives stays at current levels • There is low substitutability between plant-based products and animal products

2.3. Key modeling assumptions

This section summarizes key modeling assumptions related to the agriculture sector used in this analysis.

2.3.1. Agriculture sectors in gTech

Canada's agriculture sector is disaggregated into a number of sub-sectors in gTech which are outlined in Table 7. The disaggregation of these sectors is based on a variety of sources, including Statistics Canada's Supply-Use Tables and Environment and Climate Change Canada's National Inventory Report.[66] Note that seafood production is not included in the agriculture sector in gTech, but is captured in a separate sector.

[66] A more detailed description of how emissions from these sub-sectors are characterized in gTech can be found in this report: https://iafbc.ca/wp-content/uploads/2022/02/BC-Agriculture-GHG-Mitigation-2021.pdf

Table 7: Modeled agriculture sub-sectors

Category	Modeled sector
Animals	Dairy cattle
	Beef cattle
	Poultry
	Other animals
Fruits, Vegetables and Legumes	Vegetables
	Fruits and nuts
	Other (includes lentils, beans, chickpeas and miscellaneous crops)
	Greenhouse (includes greenhouses, nursery and floriculture products)
Grains and Oilseeds	Grains (wheat and other grains)
	Oilseeds (soy, canola, rapeseed)
Agriculture services	Agriculture services

2.3.2. Mitigation options for agricultural emissions

Multiple mitigation options for the agriculture sector are available in gTech. In addition to reducing emissions from energy consumption, there are some mitigation options available for livestock that are relatively low-cost with high abatement potential. These options, including manure composting, feed additives and anaerobic digestion are explained below.

Table 8 provides an overview of the mitigation actions included in this analysis. Options to reduce emissions from non-combustion sources are less well understood than those for combustion sources. As a result, combustion, enteric fermentation and manure management abatement options are included in this modeling, while abatement opportunities for agricultural soils and land-use and land-use change and forestry (LULUCF) are excluded due to a lack of available data to parameterize these opportunities in gTech. To characterize abatement practices for livestock, this analysis relies on a recent report from the University of British Columbia.[67]

[67] Borden, K., Hamilton, M., Li, Carson, Norgaard, A., Smukler, S. 2021. Opportunity assessment of agricultural GHG reductions and carbon sinks. Report prepared for BC Ministry of Agriculture, Food and Fisheries. Provided to Navius Research by Anna Stemberger, BC Ministry of Agriculture, Food and Fisheries on August 4, 2021.

Table 8: Overview of modeled greenhouse gas mitigation options for agriculture

Abatement action	Combustion		Non-combustion			
	Stationary	Transport	Enteric fermentation	Manure management	Agricultural soils	LULUCF
Energy						
Battery electric vehicles		X				
Fuel cell electric vehicles	X	X				
Bioenergy	X	X				
Electric heat	X					
Livestock						
Anaerobic digestion				X		
Cattle feed additive			X			
Manure composting				X		

Zero-emission vehicles

Plug-in electric and hydrogen fuel cell vehicles are available to reduce emissions from transportation in agriculture and are characterized based on the costs summarized in Table 9. These alternative-fuel drivetrains are available as an option for off-road farming vehicles (as well as for light-duty, medium-duty and heavy-duty road vehicles). The potential adoption of these technologies is a function of their upfront costs (for vehicles and charging infrastructure where appropriate), energy costs, and a dynamic representation of the barriers to their adoption (i.e., the implied cost of limited charging/fueling infrastructure, range concerns, unfamiliarity with the technologies, lack of supply).

Table 9: Zero emission vehicle costs

Technology/fuel	Cost	Sources
Plug-in electric vehicles	Battery pack costs decline from $492/kWh in 2015 to a minimum of $82/kWh.	Bloomberg New Energy Finance. (2020). Electric vehicle outlook; ICCT. (2019). Update on electric vehicle costs in the United States through 2030; Nykvist, B., F. Sprei, et al. (2019). "Assessing the progress toward lower priced long range battery electric vehicles." Energy Policy 124: 144-155.
Hydrogen fuel cell electric vehicles	Fuel cell stack system costs decline from $300/kW in 2015 to a minimum of $73/kW. Fuel tanks decline from $30/kWh in 2015 to a minimum of $11/kWh.	SA Consultants. (2016). Final report: Hydrogen storage system cost analysis; SA Consultants. (2017). Mass production cost estimation of direct H2 PEM fuel cell systems for transportation applications; IEA. (2020). Breakdown of cost-reduction potential for electrochemical devices by component category.

Bioenergy

Various forms of bioenergy can be introduced in the liquid or gaseous fuel streams as summarized in Table 10, which can reduce both stationary and transport combustion emissions in the agriculture sector. Please note that the abatement costs shown are illustrative and will change dynamically in the model as a function of various factors including fossil energy prices and renewable fuel feedstock costs.

Table 10: Summary of bioenergy abatement options

Technology/Fuel	Approximate abatement cost ($/tonne CO_2e)	Sources
Second generation renewable natural gas	248	G4 Insights Inc. (2018). Our Technology; International Energy Agency Energy Technology System Analysis Programme (IEA ETSAP). (2013). Biogas and bio-syngas production; International Renewable Energy Association (IRENA). (2013). Road transport: the cost of renewable solutions; (S&T) Consultants Inc. (2012). Update of Advanced Biofuel Pathways in GHGenius.
Ethanol	156	
Cellulosic ethanol	172	
Biodiesel	116	
Hydrogenated renewable diesel	149	
Second generation renewable gasoline/diesel	411	

Notes: Abatement costs are illustrative and will vary in the modeling as they respond to changes in energy prices, technology learning and fuel carbon intensities, all of which are endogenously determined in gTech. Values are in 2020 CAD/tCO_{2e} captured, based on a 15% discount rate and 30-year project life. Second generation renewable natural gas: feedstock at $70/dry tonne, approximate wholesale cost of $16/GJ. Ethanol: corn at $169/tonne, approximate wholesale cost of $23/GJ. Cellulosic ethanol: feedstock at $70/dry tonne, approximate wholesale cost of $31/GJ. Biodiesel: Canola seed at $414/tonne, approximate wholesale cost of $25/GJ. Hydrogenated renewable diesel: canola seed at $414/tonne, approximate wholesale cost of $26/GJ. Second generation renewable gasoline/diesel: feedstock at $70/dry tonne, approximate wholesale cost of $44/GJ.

Electric heating

Another source of emissions from agriculture is the heating of barns and other farm facilities, including livestock heating, crop drying, equipment warming and keeping greenhouse temperatures constant.[68] Currently, natural gas and propane are the main sources of heat on farms in Canada. However, replacing this with RNG (as noted above) or electric heating systems can help reduce emissions.

Anaerobic digestion

Organic residues such as manure and crop residue can be used to create renewable natural gas (RNG) through the process of anaerobic digestion. Anaerobic digestion captures manure emissions and therefore reduces livestock emissions. Captured methane is then turned into RNG and can displace natural gas elsewhere in the economy.

The assumed cost of producing renewable natural gas via anaerobic digestion is provided in Table 11.[69]

Table 11: Characterization of anaerobic digestion

Technology	Archetype production (TJ/yr)	Upfront cost (million 2019$)	Operating cost (2019$/GJ)	Cost of RNG output (2019$/GJ)
Anerobic digestion	23	1.7	1.9	12.7

Source: International Energy Agency (IEA) Energy Technology System Analysis Program (ETSAP) (2013). Biogas and Bio-syngas Production. https://iea-etsap.org/E-TechDS/PDF/P11_BiogasProd_ML_Dec2013_GSOK.pdf.
Notes: (1) Production of RNG is constrained to agricultural output. (2) Excludes value of digestate. (3) Norgaard et al. (2021) assume that 62.5% (+/-20%) of agricultural residues could be used to create renewable natural gas, based on a recent study finding that 50-75% of feedstocks in BC were considered as “easily accessible”.

68 Shipley Energy. The Benefits of Natural Gas in the Agriculture Industry. Available from: https://www.shipleyenergy.com/resources/commercial/the-benefits-of-natural-gas-in-the-agriculture-industry
69 Note that despite it’s potential, there are known challenges associated with the application of manure methane digesters that should be considered. These are explored in this report: https://www.iatp.org/meeting-methane-pledge-us-can-do-more-agriculture

Manure composting

Composting is an alternative manure storage method that can be used to reduce GHG emissions. Specifically, aerobic composting reduces the amount of CH_4 produced by anaerobic decomposition of organic matter.

The abatement potential and cost of manure composting is summarized in Table 12.

Table 12: Characterization of manure composting

Livestock type	Reduction factor (t CO_2e/1000 hd/yr)	Upfront cost	Operating cost	Abatement cost ($/t CO_2e)
Dairy cattle	751	21,429	0	6 (4-11)
Beef cattle	361	21,429	0	12 (8-23)
Total	**659**	**21,429**	**0**	**7 (5-13)**

Source: Norgaard et al. (2021).
Notes: (1) Upfront cost is that of building a composting facility suitable for 1000 heads of cattle, with a volume of 25 cubic yards and a lifespan of 15-25 years. (2) No operating costs specified. (3) We assume that the GHG reduction factor can be extended to 2050.

Feed additives

Feed additives can reduce methane associated with enteric fermentation. This abatement action is based on the additive 3-nitrooxypropanol (3NOP), a synthetic compound which inhibits methanogenic bacteria from performing the final step of methane production in livestock's rumen. The abatement potential and cost of feed additives is summarized in Table 13.

Table 13: Characterization of feed additives

Livestock type	Reduction factor (t CO_2e/1000 hd/yr)	Upfront cost	Operating cost ($/head/yr)	Abatement cost ($/t CO_2e)
Dairy cattle	925	0	25 (10-50)	27 (9-70)
Beef cattle	1,522	0	25 (10-50)	16 (5-48)
Total	**1,066**	0	**25 (10-50)**	**12 (8-58)**

Source: Norgaard et al. (2021).
Notes: (1) Costs are preliminary because 3NOP feed additive is not yet approved for use in Canada. (2) Abatement cost range reflects uncertainty in cost and GHG reduction potential. (3) We assume that the GHG reduction factor can be extended to 2050.

2.3.3. Food manufacturing sectors in gTech

Canada's food manufacturing sector is disaggregated into five sub-sectors for this analysis, outlined in Table 14. Disaggregation of these sectors is based on Statistics Canada's Supply-Use Tables. The dairy alternatives (e.g., oat milk) and meat alternatives (e.g., Beyond Meat) sectors become available in 2020 and parameterization of these sectors is based on the "other food" sector from the Supply-Use Tables. This is a critical assumption because the inputs (including agricultural goods, manufacturing goods, labour, etc.) consumed by the meat and dairy alternatives sectors impacts several factors such as the emissions and GDP of these sectors. Note that the meat and dairy alternatives cannot be traded between Canada and the U.S in the model.

Table 14: Modeled food manufacturing sub-sectors

Category	Modeled sector
Food manufacturing	Meat
	Dairy
	Other foods
	Meat alternatives
	Dairy alternatives

2.3.4. Simulating changes in meat and dairy consumption

Future consumption of animal products was varied in this analysis by simulating different levels of substitutability between meat/dairy foods and plant-based foods. This was done by modeling three key dynamics:

1. **What share of meat and dairy consumption is plant-based alternatives over time.**

Each sector in the economy is given a choice of the ratio in which they will meet meat/dairy demand through plant-based substitutes. This is determined in the model via a production function that is informed by a baseline market share of alternatives, elasticity of substitution between the products, as well as other factors such as prices of inputs and outputs. To inform the baseline share that enters the production function, we use an article from the Good Food Institute, which suggests that meat alternatives made up 1.4% of meat product demand and dairy alternatives made up 15% of dairy product demand in 2020.[70] This baseline share of meat and dairy alternatives that informs the production function changes over time and varies by scenario.[71] It increases most in the low animal consumption scenario and does not increase in the high animal consumption scenario.

2. How the cost of meat and dairy alternatives come down over time.

Because the cost of meat and dairy alternatives is expected to come down over time[72], we simulate a declining capital cost function for these sectors in gTech. Based on an assumption that dairy alternatives are 11% more expensive than dairy, and meat alternatives are 43% more expensive than meat in 2020[73], we vary the level to which the cost of plant-based alternatives decline over time. The cost declines most in the low animal consumption scenario and does not decline in the high animal consumption scenario.

3. How much consumers substitute meat and dairy for plant-based alternatives.

When shifting food consumption away from meat and dairy, consumers can consume more meat and dairy alternatives such as Beyond Meat or oat milk, or they can consume more of other foods, such as grains, vegetables and legumes. This is simulated in gTech using an elasticity of substitution, a measure of how easily consumers will substitute between animal products and plant-based alternatives. The elasticity of substitution describes how the ratio of output of two goods change relative to the ratio of their prices. To parameterize the elasticity of substitution between meat/dairy and plant-based alternatives we draw on several studies[74], and to parameterize the elasticity of substitution between meat/dairy and other foods we use a 2012 USDA study[75].

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[70] Good Food Institute. (2020). 2020 US retail market data for the plant-based industry. Available from: https://gfi.org/marketresearch/

[71] Future share of meat and dairy alternatives is based on this Bloomberg article: https://www.bloomberg.com/company/press/plant-based-foods-market-to-hit-162-billion-in-next-decade-projects-bloomberg-intelligence/

[72] EY Food and Agriculture. (2021). Protein reimagined: Challenges and opportunities in the alternative meat industry. Available from: https://www.ey.com/en_us/food-system-reimagined/protein-reimagined-challenges-and-opportunities-in-the-alternative-meat-industry

[73] Good Food Institute. (2022). Reducing the price of alternative proteins. Available from: https://gfi.org/wp-content/uploads/2021/12/Reducing-the-price-of-alternative-proteins_GFI_2022.pdf

[74] Yang & Dharmasena. (2021). U.S. Consumer Demand for Plant-Based Milk Alternative Beverages: Hedonic Metric Augmented Barten's Synthetic Model. *Foods, 10(265);* Oosterwijk. (2020). *Price Elasticity of The Demand for Plant-Based Milk in the Middle Atlantic Division;* Zhao, Wang, Hu, Zheng. (2022). Meet the meatless: Demand for new generation plant-based meat alternatives. *Appl Econ Perspect Policy, 1-18;* Tonsor, Lusk & Schroeder. (2021). *Impacts of New Plant-Based Protein Alternatives on U.S. Beef Demand.*

[75] USDA. (2012). *The Demand for Disaggregated Food-Away-From-Home and Food-at-Home Products in the United States.*

Note that change in animal product consumption was also varied in the U.S. in this analysis via the same three dynamics described above.

3. Results

Results of this analysis are provided in this section. The section is structured as follows:

- Section 3.1 discusses impacts of the agriculture emissions cap.
- Section 3.2 discusses impacts of the animal agriculture production limit.
- Section 3.3 discusses impacts of a subsidy on plant-based alternatives.
- Section 3.4 provides a comparison the three policy instruments described above.

Unless otherwise specified, results are presented for the high animal consumption sensitivity (see section 2.2.2).

3.1. Agriculture emissions cap

One policy examined in this analysis is a GHG emissions cap on the agricultural sector. Sectoral emissions caps have been proposed for other industries in Canada, such as the proposed federal emissions cap on Canada's oil and gas sector.[76] Other jurisdictions, such as New Zealand, have set clear emissions reductions targets for their agricultural emissions[77], including a 24-47% reduction in biogenic methane emissions from agriculture by 2050 and net zero for all other agriculture emissions.[78]

In light of these examples, World Animal Protection asked Navius to examine a scenario that caps GHG emissions from Canada's agriculture sector at a level that requires a 30% reduction in emissions by 2030 and a 50% reduction by 2050 (from

[76] Government of Canada. (n.d.). *Options to cap and cut oil and gas sector greenhouse gas emissions to achieve 2030 goals and net-zero by 2050 – discussion document*. Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/oil-gas-emissions-cap/options-discussion-paper.html

[77] OECD. (n.d). *New Zealand's plans for agricultural emissions pricing.* Available from: https://www.oecd.org/climate-action/ipac/practices/new-zealand-s-plans-for-agricultural-emissions-pricing-d4f4245c/

[78] Parliamentary Counsel Office. (n.d). *Climate Change response (Zero Carbo) Amendment Act 2019, Part 1A Climate Change Commission, Subpart 1 – Establishment and appointments*. Available from: https://www.legislation.govt.nz/act/public/2019/0061/latest/LMS183848.html#LMS183790

2005 levels). This sectoral reduction requirement is less stringent than Canada's economy-wide reduction targets (40-45% reduction by 2030 and net zero by 2050).[79]

The next sections discuss the impact of an agriculture emissions cap on Canada's emissions, food system, economy, and the interaction of this policy with behavioural change.

3.1.1. Emissions

A GHG emissions cap on the agriculture sector is, by design, highly effective at reducing emissions. Capping agricultural emissions at a 30% reduction (from 2005 levels) by 2030 and a 50% reduction by 2050 results means a 29 Mt CO_2e reduction in Canada's emissions in 2030 and a 90 Mt CO_2e reduction in 2050 relative to a current policy scenario, as shown in Figure 9.

Most of these emissions reductions occur in the agricultural sector as abatement options such as electrification, bioenergy, and anaerobic digestors are adopted to reduce emissions to comply with the emissions cap. Additionally, the emissions cap incentivizes a shift away from animal agriculture towards plant-based agriculture. This is due to the high emissions intensity of animal agriculture relative to plant-based agriculture. In fact, recent research from the Canadian Climate Institute found that animal production and aquaculture is the most emissions intensive sector in Canada.[80] Shifting away from animal agriculture reduces emissions for two main reasons. First, there is a reduction in emissions from animals themselves as fewer animals are farmed. Second, there is a reduction in emissions from input requirements to produce animals, including the growing of feed and use of fertilizer on that feed.

To put this emissions impact into context, a recent analysis of Canada's Emissions Reduction Plan (ERP) found that there is a 9 Mt CO_2e gap between announced policies and Canada's 2030 emissions target.[81] This indicates that implementing an

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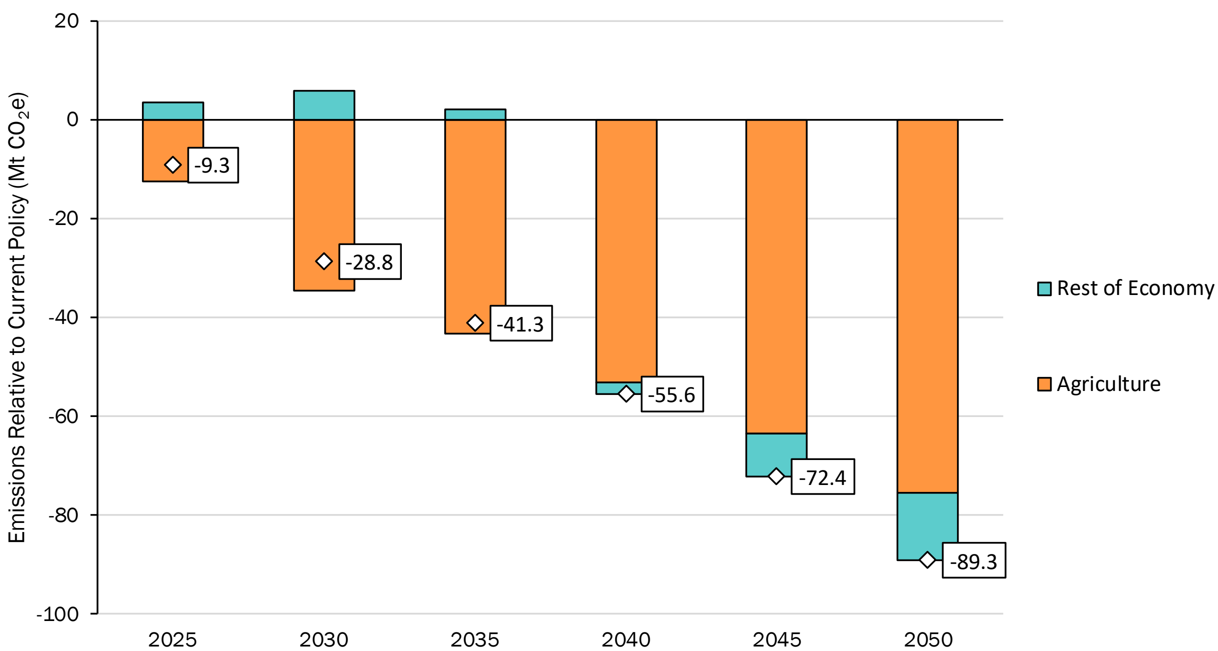
[79] Government of Canada. (n.d.). *Net-Zero Emissions by 2050.* Available from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

[80] Canadian Climate Institute. (2023). Calculating Emissions Intensity Across the Economy. Available from: https://440megatonnes.ca/insight/calculating-emissions-intensity-across-the-economy/

[81] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

agriculture emission cap at the stringency simulated in this analysis could close the gap to meeting Canada's 2030 emissions target.[82]

Figure 9: Change in emissions in an agriculture emissions cap scenario (relative to current policy)



3.1.2. Food system

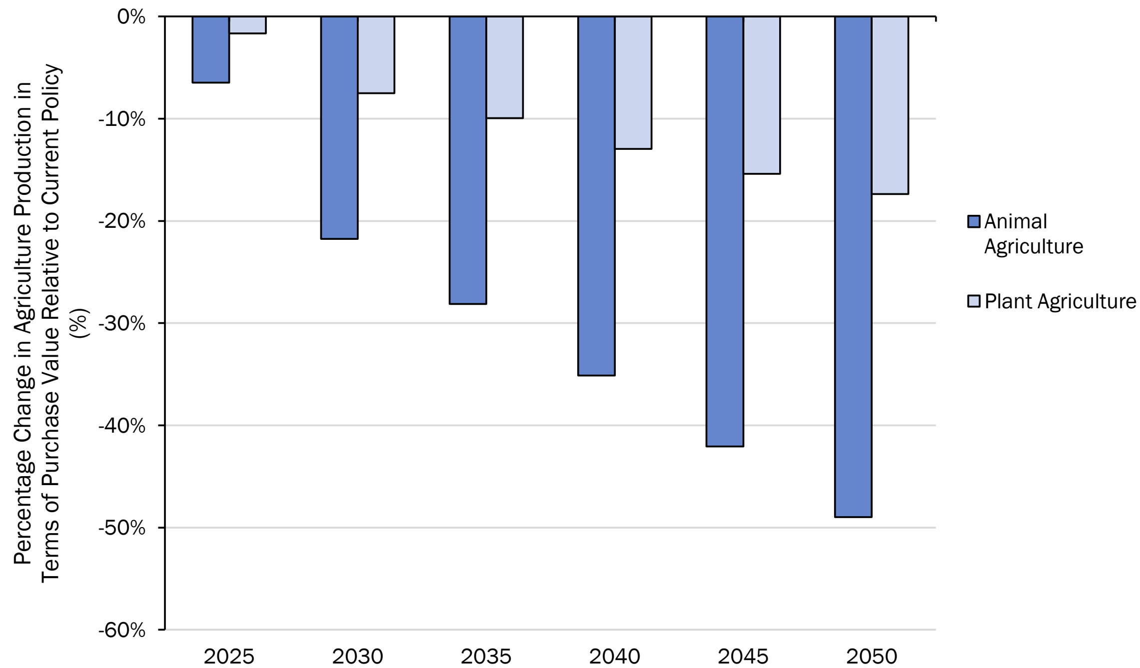
As discussed above, while a GHG emissions cap on the agriculture sector incentivizes adoption of abatement technologies to reduce emissions to comply with the policy, it also incentivizes a shift to less emissions-intensive forms of agriculture, and as a result, leads to a decline in animal agriculture production. In response to this policy, animal agriculture production declines by 22% in 2030 and 50% in 2050 relative to current policy (Figure 10). This is primarily driven by a reduction in beef cattle, as this sector is the most emissions intensive.

As shown in Figure 10, the emissions cap also leads to a reduction in plant-based agriculture production. Plant-based production is 8% lower in 2030 and 17% lower in 2050 relative to current policy. This is due to a variety of factors, including a reduction in demand for animal feed, as well as a reduction in overall economic growth in this

[82] Based on a 2022 analysis of the ERP. Additional information about policy design has been released since then.

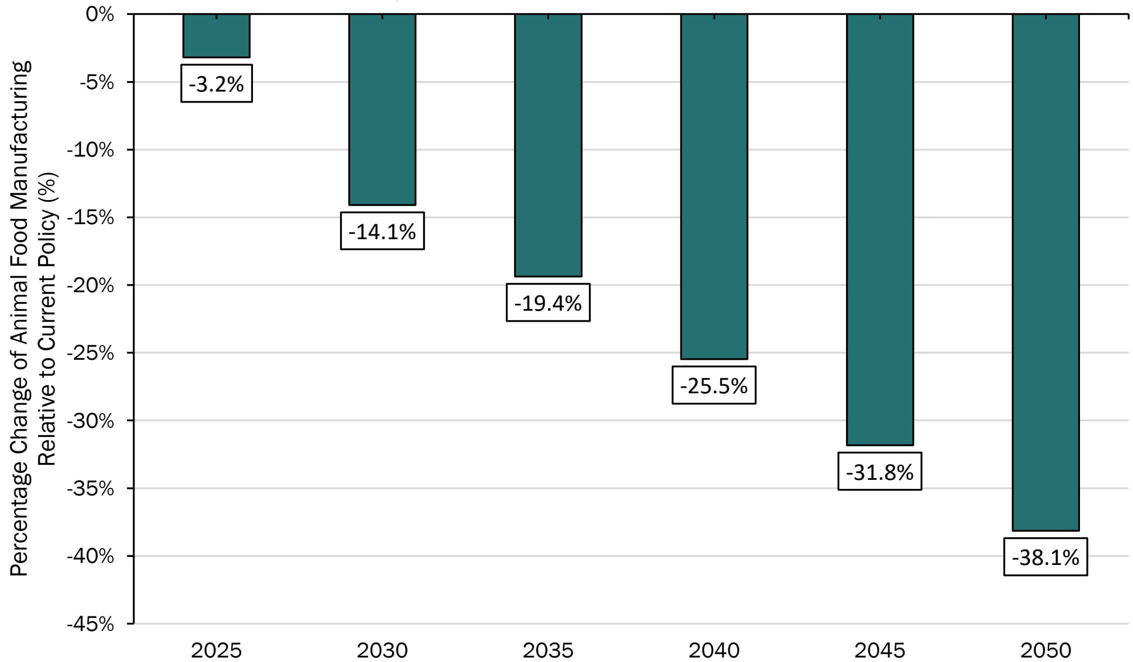
scenario (relative to a current policy scenario) leading to a reduction in total agricultural production.

Figure 10: Change in agriculture production in an agriculture emissions cap scenario (relative to current policy)



As agricultural production changes in Canada in response to the emissions cap, the food manufacturing sector also changes, shifting away from the manufacturing of meat and dairy products towards manufacturing of plant-based products. Under an agriculture emissions cap, manufactured meat and dairy products decrease by 14% in 2030 and 38% in 2050 relative to current policy, as shown in Figure 11. It is mostly driven by a reduction in meat production due to its high emissions intensity relative to dairy production.

Figure 11: Change in meat and dairy manufacturing in an agriculture emissions cap scenario (relative to current policy)

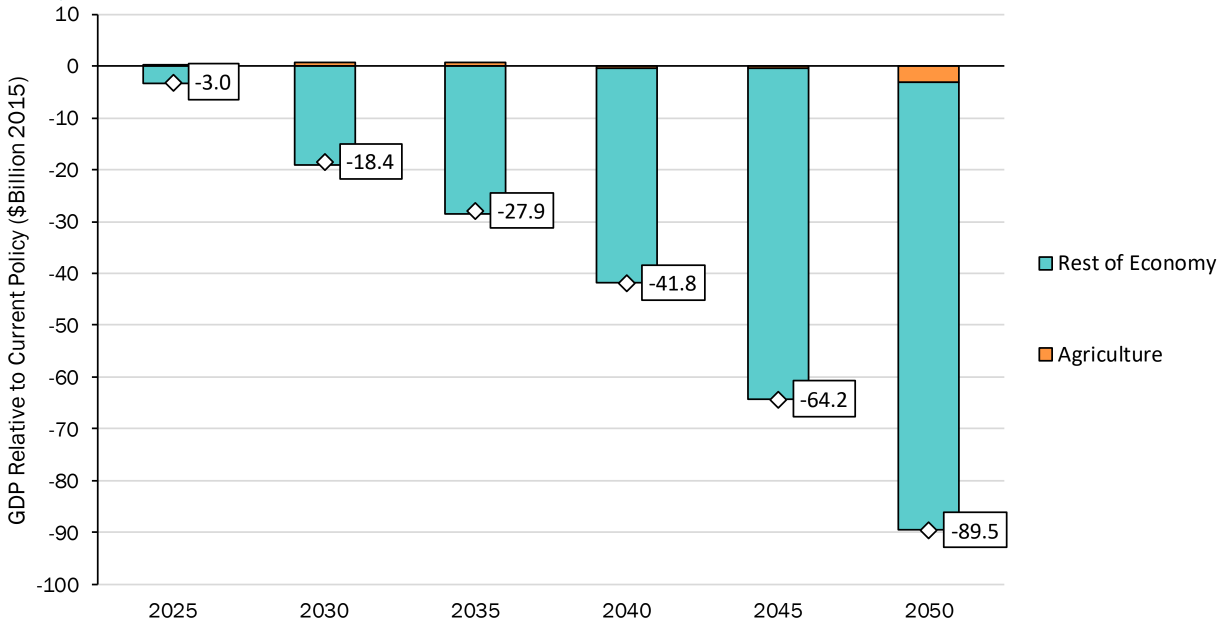


3.1.3. Economy

Canada's economy continues to grow out to 2050 in the agriculture emissions cap scenario. Canada's GDP grows at an average annual rate of 1.50% per year from 2020 to 2050 when agricultural emissions are capped, while Canada's agriculture sector GDP grows at a rate of 2.41% per year in this scenario.

The rate of growth is slower than growth under a current policy scenario in which an agriculture emissions cap is not implemented. Canada's average annual GDP growth rate under current policy is 1.59% per year, and the agriculture growth rate is 2.49%. This slower growth rate translates to a reduction in GDP of $30 billion in 2030 and $90 billion in 2050 relative to current policy, as shown in Figure 12.

Figure 12: Change in GDP in an agriculture emissions cap scenario (relative to current policy)



3.1.4. Role of behavioural change

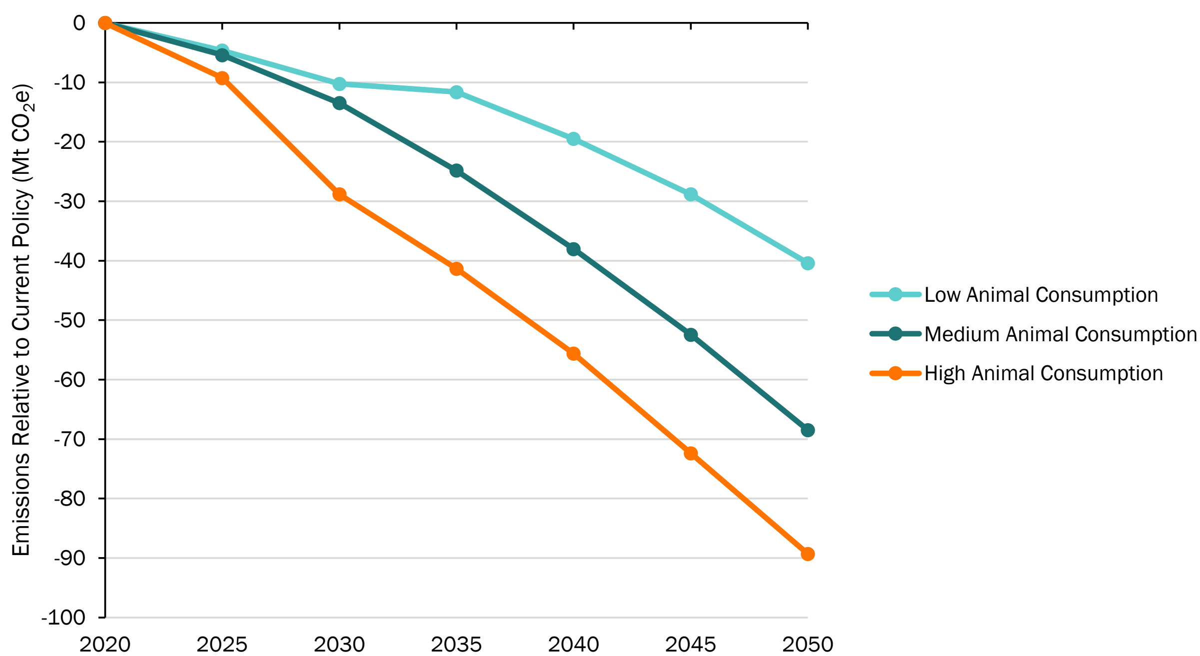
As outlined in section 2.2.2, different levels of meat and dairy consumption were modeled for each policy scenario in this analysis to explore the impact of behavioural change on the effectiveness of the policy instrument. In other words, what would the impact of an emissions cap on the agriculture sector be if consumers were more likely to substitute animal products for plant-based products? This sensitivity analysis helps us understand the potential interaction of an agriculture emissions cap with other behaviour-focused policies such as education or food labelling, which are intended to increase the willingness of consumers to shift away from animal products towards plant-based products.

The previous sections outline results of an agriculture emissions cap policy in a scenario where consumers are less likely to shift away from meat and dairy products to plant-based foods (high animal consumption sensitivity). Simulating scenarios where consumers are more willing to shift their consumption towards plant-based alternatives has a significant impact on the effectiveness of an agriculture emissions cap, as shown in Figure 13 below.

Emissions reductions relative to current policy range from 10-28 Mt CO_2e in 2030 and 40-90 Mt CO_2e in 2050 in the agriculture emissions cap scenario depending on the animal consumption sensitivity. The policy has a smaller impact when consumers are more likely to shift towards a plant-based diet. This is because the reduction in animal agriculture (described in section 3.1.2) that occurs in response to an emissions cap is to a greater extent already occurring under current policy due to reduced demand in a low animal consumption sensitivity. It is important to note however, that an agriculture emissions cap still has a large impact on emissions in a low animal consumption scenario.

This highlights that changing consumer behaviour could play a significant role in reducing emissions, as discussed in detail in our previous analysis for World Animal Protection.[83] Behavioural policies like informational campaigns or food labelling could play an important role in shifting consumer behaviour, which in turn influences Canada's food system and resulting emissions.

Figure 13: Change in emissions in an agriculture emissions cap scenario (relative to current policy) under three animal consumption sensitivities*



*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

[83] Navius Research. (2022). *Animal-sourced food consumption and Canada's emissions targets.* Available from: https://www.naviusresearch.com/publications/world-animal-protection-emissions-targets/

3.2. Animal agriculture production limit

Another policy examined in this analysis is a production limit on animal agriculture, used to simulate an effective moratorium on new animal agriculture production in Canada. Variations of an animal agriculture production limit are being explored in other jurisdictions. For example, legislation has been tabled in the U.S. which would ban new intensive livestock operations after 2025 and phase them out after 2040.[84] The Dutch government has also discussed cutting livestock numbers by a third to reduce emissions by 2030.[85] For this analysis, World Animal Protection asked Navius to examine a scenario in which animal agriculture production is limited to current levels, ensuring that no new animal agriculture production occurs in Canada.[86] Instead, all new agricultural growth in Canada will come from plant-based agriculture.

The following sections outline the impact of an animal agriculture production limit on Canada's emissions, food system, economy, and the interaction of this policy with behavioural change.

3.2.1. Emissions

Animal agriculture has been identified as one of the most emissions intensive sectors in Canada.[87] Therefore, preventing growth of this sector has a significant impact on Canada's emissions. A policy that limits animal agriculture production to current levels results in a 11 Mt CO_2e reduction in Canada's emissions in 2030 and a 39 Mt CO_2e reduction in emissions in 2050, relative to current policy, as shown in Figure 14 below.

This is driven by a reduction in emissions from animals themselves, as fewer animals are farmed, as well as a reduction in emissions from input requirements to produce animals, including the growing of feed and use of fertilizer on that feed. Most emissions reductions in this scenario occur in the agriculture sector, and more specifically in the beef cattle sector (around 80% of total reductions), as this is the

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84 *Farm System Reform Act of 2023*, 118th Congress 1st session. (2023). Available from: https://www.booker.senate.gov/imo/media/doc/farm_system_reform_act_of_20231.pdf

85 Financial Times. (2022). *Dutch farmers in uproar over plans to curb animal numbers to cut nitrogen emissions.* Available from: https://www.ft.com/content/90e38fb5-e942-4afd-994d-048dc40579a2

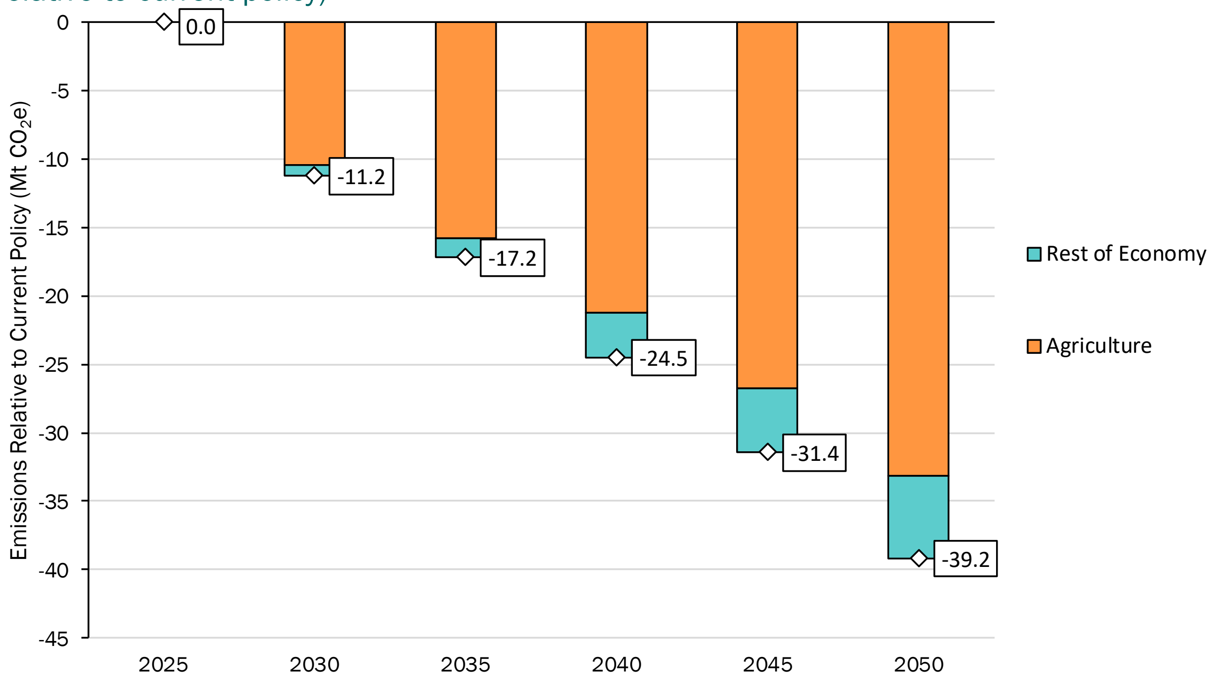
86 Modeled as a cap on animal agriculture production at the model's base year level (2015).

87 Canadian Climate Institute. (2023). *Calculating Emissions Intensity Across the Economy.* Available from: https://440megatonnes.ca/insight/calculating-emissions-intensity-across-the-economy/

most emissions intensive agriculture sector. As such, reducing production in this sector relative to a current policy scenario has a large impact on Canada's emissions.

To put the emissions reductions from this policy into context, a recent analysis of Canada's Emissions Reduction Plan (ERP) found that there is a 9 Mt CO_2e gap between announced policies and Canada's 2030 emissions target.[88] This indicates that implementing a production limit on animal agriculture at current levels could close the gap to meeting Canada's 2030 emissions target.[89]

Figure 14: Change in emissions in an animal agriculture production limit scenario (relative to current policy)



3.2.2. Food system

Limiting animal agriculture production has, by design, a significant impact on the number of animals produced in Canada. As shown in Figure 15, animal agriculture production is 19% lower in 2030 and 43% lower in 2050 when production is limited to current levels relative to under current policy. The most significant reductions occur in

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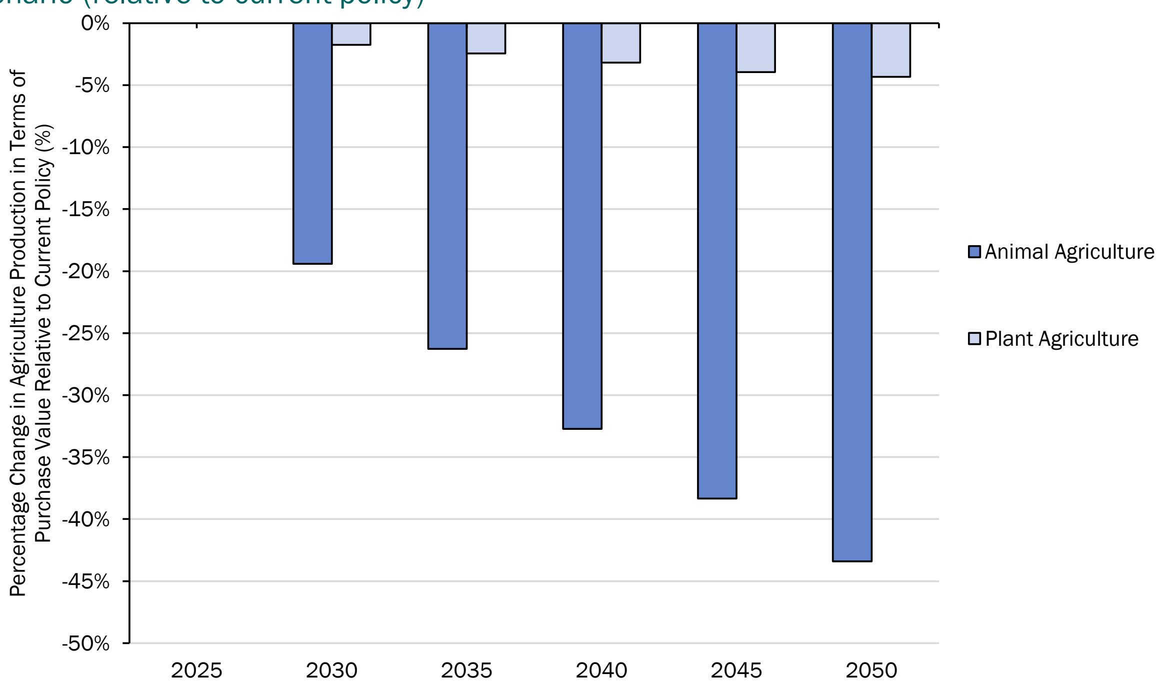
[88] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

[89] Based on a 2022 analysis of the ERP. Additional information about policy design has been released since then.

the beef cattle sector. Beef cattle production is 23% lower in 2030 and 47% lower in 2050 compared to under current policy.

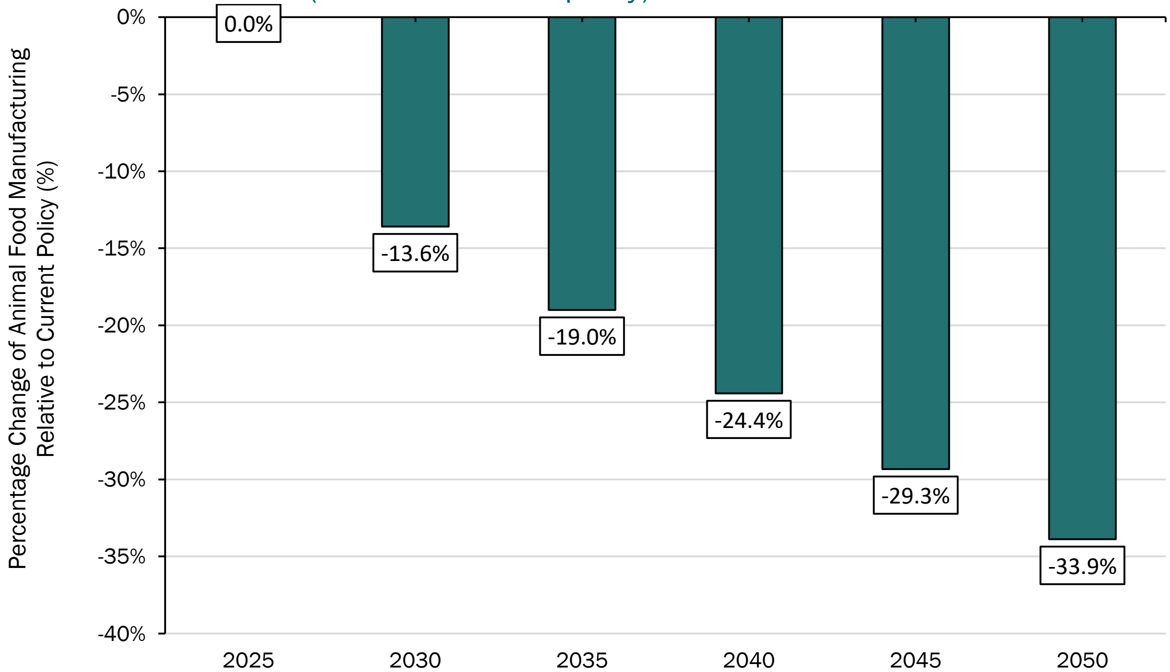
Because farmed animals consume agricultural outputs from plant-based agriculture sectors as feed, a reduction in the number of animals produced (relative to current policy) also influences the level of output from plant-based agriculture. Additionally, as discussed in the next section, there is a reduction in overall economic growth in this scenario, leading to a reduction in total agricultural production. As a result, production from plant-based agriculture sectors is 2% lower in 2030 and 4% lower in 2050 in an animal agriculture production limit scenario relative to under current policy (Figure 15).

Figure 15: Change in agriculture production in an animal agriculture production limit scenario (relative to current policy)



As agricultural production changes in response to the production limit, the food manufacturing industry reduces production of manufactured animal-based products. Figure 16 shows changes in meat and dairy manufacturing in a scenario where animal agriculture production is limited to current level relative to a current policy scenario. It indicates that under a production limit, manufacturing of meat and dairy products is 14% lower in 2030 and 34% lower in 2050 relative to current policy.

Figure 16: Change in meat and dairy manufacturing in an animal agriculture production limit scenario (relative to current policy)



3.2.3. Economy

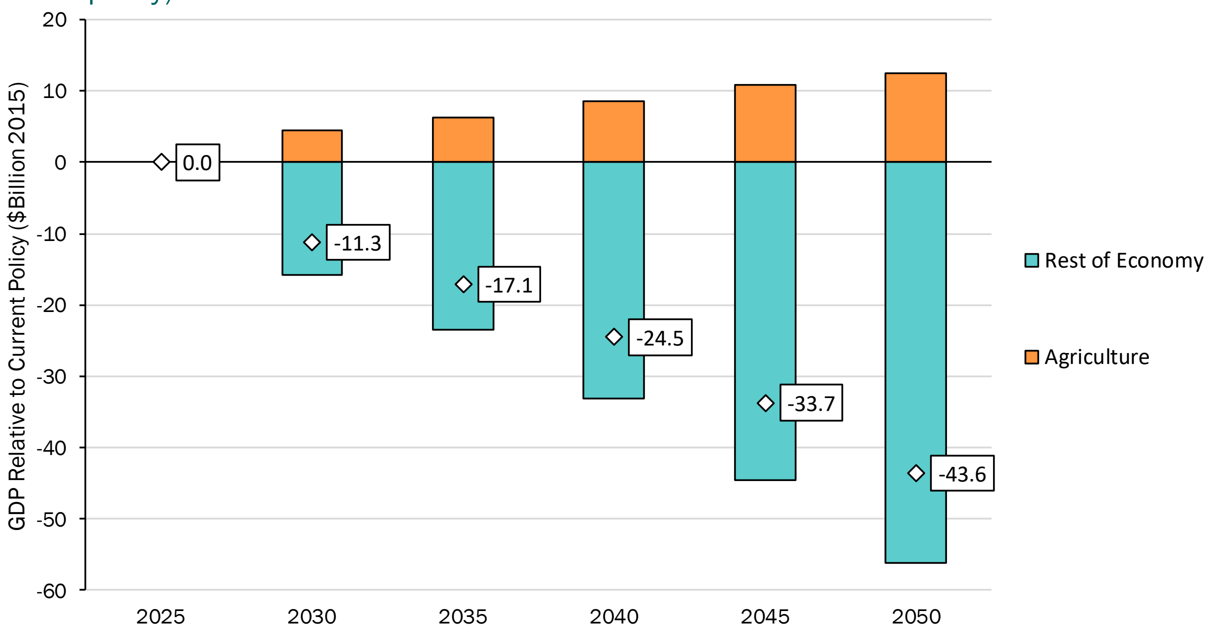
Canada's economy and agriculture sector continues to grow over time in a scenario where animal agriculture production is limited to current levels. Canada's GDP grows at an average annual rate of 1.54% from 2020 to 2050 in a production limit scenario. This rate of growth is slightly slower than under a current policy scenario without a production limit in place, in which case Canada's economy grows at an average annual rate of 1.59%. This smaller GDP growth rate translates to a reduction in economy-wide GDP of $11 billion in 2030 and $44 billion in 2050, as shown in Figure 17.

At the same time, GDP in Canada's agriculture sector grows at an average annual rate of 3.05% per year in a production limit scenario, which represents a larger growth rate for this sector than under current policy, where the sector grows at a rate of 2.49% per year. This is shown in Figure 17 as an increase in agricultural GDP of $4.5 billion in 2030 and $13 billion in 2050 relative to current policy.

GDP in the agriculture sector increases in response to a production limit policy as animal agriculture commodities become more scarce, driving up their price. For example, the price of manufactured meat is 10% higher in 2030 and 29% higher in 2050 relative to current policy, while the price for dairy is 19% higher in 2030 and

74% higher in 2050. This drives up the value of the agriculture sector, increasing GDP in the sector.

Figure 17: Change in GDP in an animal agriculture production limit scenario (relative to current policy)



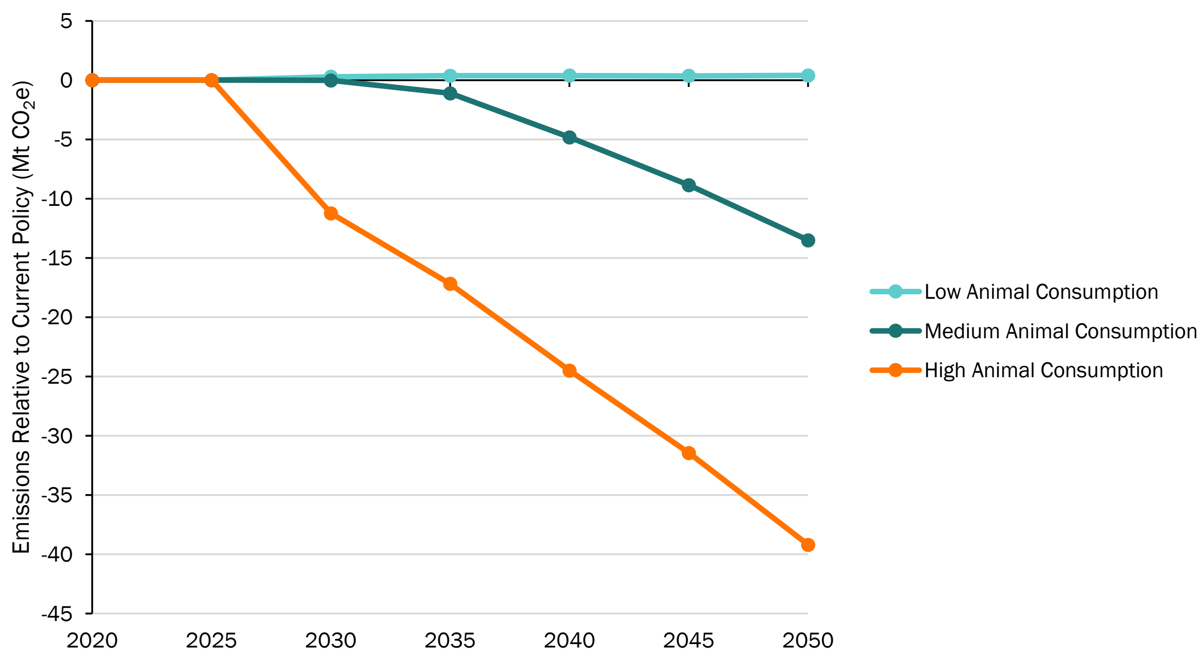
3.2.4. Role of behavioural change

As outlined in section 2.2.2, different levels of meat and dairy consumption were modeled for each policy scenario in this analysis to explore the impact of behavioural change on the effectiveness of the policy. In other words, what would be the impact of a production limit on animal agriculture if consumers were more likely to substitute animal products for plant-based products?

The previous sections outline results of an animal agriculture production limit in a scenario where consumers are less likely to shift away from meat and dairy products to plant-based foods (i.e., high animal consumption sensitivity). Simulating scenarios where consumers are more willing to shift their consumption has a significant impact on the effectiveness of an animal agriculture production limit, as shown in Figure 18 below.

Emissions reductions relative to current policy range from 0-11 Mt CO_2e in 2030 and 0-39 Mt CO_2e in 2050 in the animal agriculture production limit scenario depending on the animal consumption sensitivity. This policy has a smaller impact when consumers are more likely to shift towards a plant-based diet. In fact, in the low animal consumption sensitivity, when there is very high substitutability between plant-based products and animal products, a limit on animal agriculture production has no impact on Canada's emissions. This is because consumers are already shifting away from animal products in this sensitivity scenario, resulting in a decline in animal agriculture production over and beyond what the production limit policy requires. This suggests that if behavioural policies (such as informational campaigns or food labelling) could encourage consumers to shift consumption in line with the low animal consumption scenario, this could lead to a significant reduction in animal agriculture production and associated emissions in Canada.

Figure 18: Change in emissions in an animal agriculture production limit scenario (relative to current policy) under three animal consumption sensitivities*



*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

3.3. Alternative food subsidy

Another way to encourage a shift towards plant-based products is through subsidies. Investment in plant-based food alternatives is occurring around the world, including in Canada where the Canadian government is providing significant funding for manufacturing of plant-based alternatives.[90] We simulated a 15% subsidy on manufactured meat and dairy alternatives.

This analysis found negligible impact of the plant-based subsidy on emissions, the food system, and the economy, but found that the impact is amplified if consumers are more willing to switch away from meat and dairy towards plant-based products. Therefore, the role of behavioural change is the focus for this section.

As illustrated in Figure 19 below, emissions reductions relative to current policy range from 0-1 Mt CO_2e in 2030 and 0-3 Mt CO_2e in 2050 in the plant-based alternative subsidy scenario depending on the animal consumption sensitivity. Emissions reductions are greatest in the low animal consumption sensitivity when consumers are already likely to choose plant-based alternatives over meat or dairy products. This suggests that a subsidy on plant-based alternatives, although not an effective policy on its own, could be an effective policy in conjunction with behavioural policies, such as informational campaigns or food labelling, by reducing the cost of meat and dairy alternatives for consumers who are willing to shift their consumption. Conversely, it is important to note that results suggest a subsidy is likely to achieve very little unless the population is willing to shift towards a plant-based diet.

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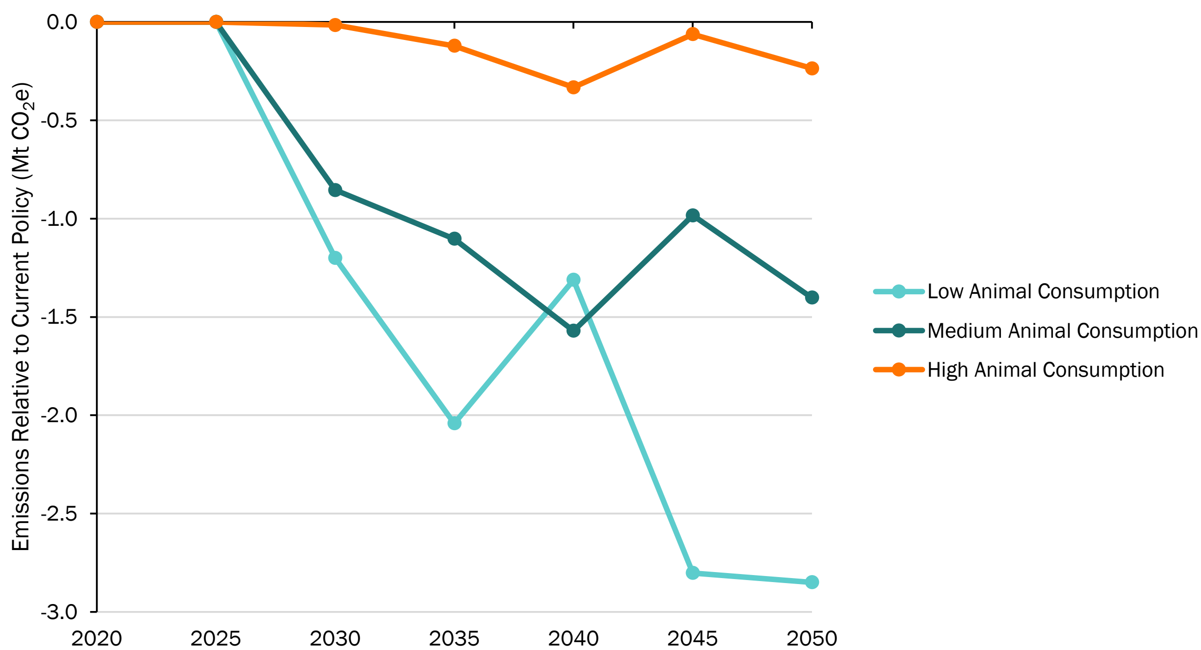
[90] Protein Industries Canada. (2023). *Protein Industries Canada receives federal funding for another five years.* Available from: https://www.proteinindustriescanada.ca/news-releases/protein-industries-canada-receives-federal-funding-for-another-five-years

Figure 19: Change in emissions in an alternative food subsidy scenario (relative to current policy) under three animal consumption sensitivities*



*The three animal consumption sensitivities represent different consumption trajectories that could be driven by behavioral policies like food labeling and education. The high animal consumption trajectory represents the current trajectory.

Note that there are other reasons to implement a subsidy beyond impacts on emissions. For example, subsidizing plant-based production could promote production and innovation within Canada through initiatives such as the Protein Industries Canada Cluster.[91] This could in turn reduce prices of plant-based alternatives, increasing the likelihood of a future with 'low animal consumption' (see Figure 19).

3.4. Comparison of policy instruments

This section offers a comparison of the policy instruments described in the previous sections. It is intended to compare the impact of each policy on Canada's emissions, food system, and economy. Note however, that each policy simulated differs in its design, level of stringency, and intended function. For example, a GHG emissions cap on the agricultural sector is intended to reduce agricultural emissions, while an animal agriculture production limit is intended to reduce production of animals (which

[91] Government of Canada. (n.d.). *Canada's Protein Industries Cluster.* Available from: https://ised-isde.canada.ca/site/global-innovation-clusters/en/canadas-protein-industries-cluster

indirectly reduces emissions). It is important to keep these differences in mind when reviewing the results presented in this section.

Section 3.4.1 compares the impact on emissions, while section 3.4.2 compares the impact on Canada's food system. The relative costs of the policies are discussed in both sections.

3.4.1. Emissions

Figure 20 shows the change in emissions (relative to current policy) for each of the three policy instruments explored in this analysis. The GHG emissions cap has by far the largest impact on emissions, reducing them by 29 Mt CO_2e in 2030 and 89 Mt CO_2e in 2050 relative to current policy. This is to be expected, as it is the only policy instrument discussed in this analysis that directly targets agricultural emissions, while other policy instruments impact emissions indirectly.

Limiting production of animal agriculture to current levels also has a significant impact on emission outcomes, reducing emissions by 11 Mt CO_2e in 2030 and 39 Mt CO_2e in 2050 relative to current policy. As discussed in previous sections, animal agriculture production is emissions intensive, with this sector identified as one of the most emissions intensive in Canada.[92] Therefore, limiting growth in this sector has a large impact on Canada's emissions.

A 15% subsidy on plant-based food has a negligible impact on emissions, as seen in Figure 20. A subsidy is less effective because of its relative compulsoriness. In other words, even if a product is subsidized, it does not necessarily mean consumers will start to consume the product. This is why the effect of this policy is amplified if consumers are more willing to switch away from meat and dairy towards plant-based products, as described in section 3.3.

To put the emissions reductions for the three policy instruments into context, a recent analysis of Canada's Emissions Reduction Plan (ERP) found that there is a 9 Mt gap between announced policies and Canada's 2030 emissions target.[93] Limiting emissions from agriculture at 30% below 2005 levels in 2030, or limiting animal

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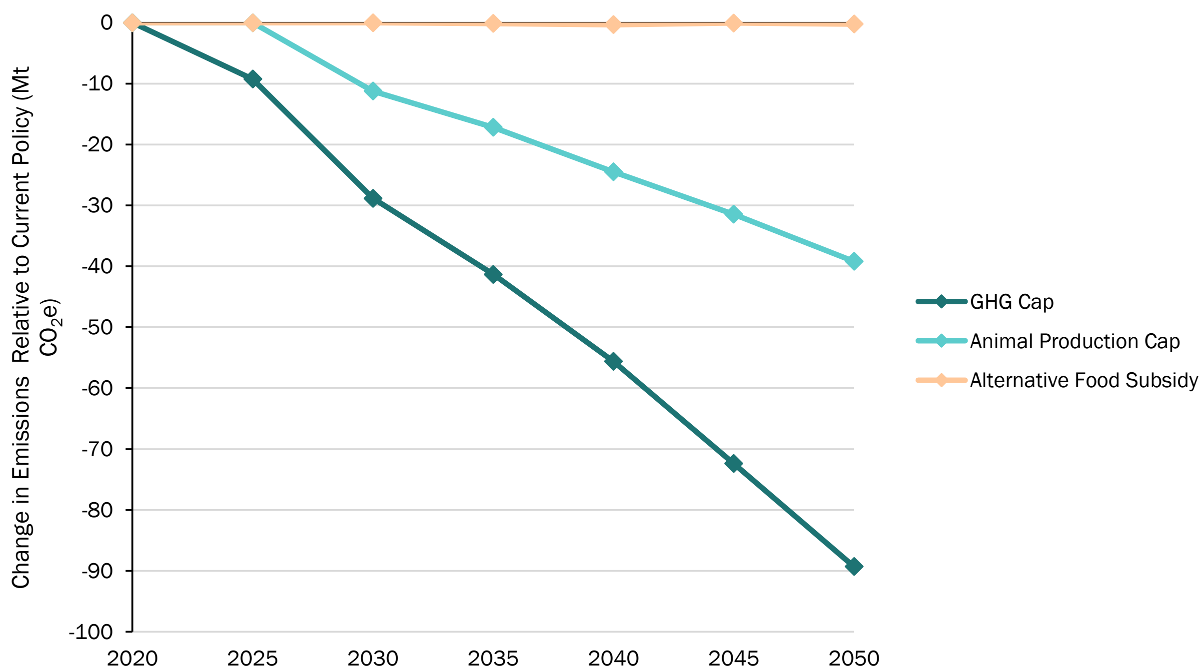
[92] Canadian Climate Institute. (2023). *Calculating Emissions Intensity Across the Economy.* Available from: https://440megatonnes.ca/insight/calculating-emissions-intensity-across-the-economy/

[93] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

agriculture production at current levels could close the gap to Canada's 2030 emissions target.

Figure 20: Change in emissions in response to three policy instruments (relative to current policy)



While all policy instruments described above differ in terms of design, stringency and objective, a direct comparison can be made between them by calculating the cost of the policy (impact to GDP) relative to the emissions reductions achieved.

Table 15 provides an index describing the reduction in GDP resulting from each policy relative to the level of emissions reductions achieved by the policy. It suggests that the GHG emissions cap is the most efficient policy at reducing emissions, costing the least per unit of emissions reduced. The animal production limit is more expensive, costing 60% more in 2030 and 10% more in 2050. While this policy is not intended to reduce emissions directly, limiting growth of this sector has a significant indirect impact on emissions due to animal agriculture's emissions intensive nature. As described previously, the subsidy on plant-based food alternatives has a limited impact on emissions and is not a cost-efficient policy.

Table 15: Index describing the amount of GDP reduced relative to emissions reductions achieved (reductions from the GHG cap =1)

Policy	2030	2050
GHG Cap	1.0	1.0
Animal Production Limit	1.6	1.1
Alternative Food Subsidy	23.1	1.6

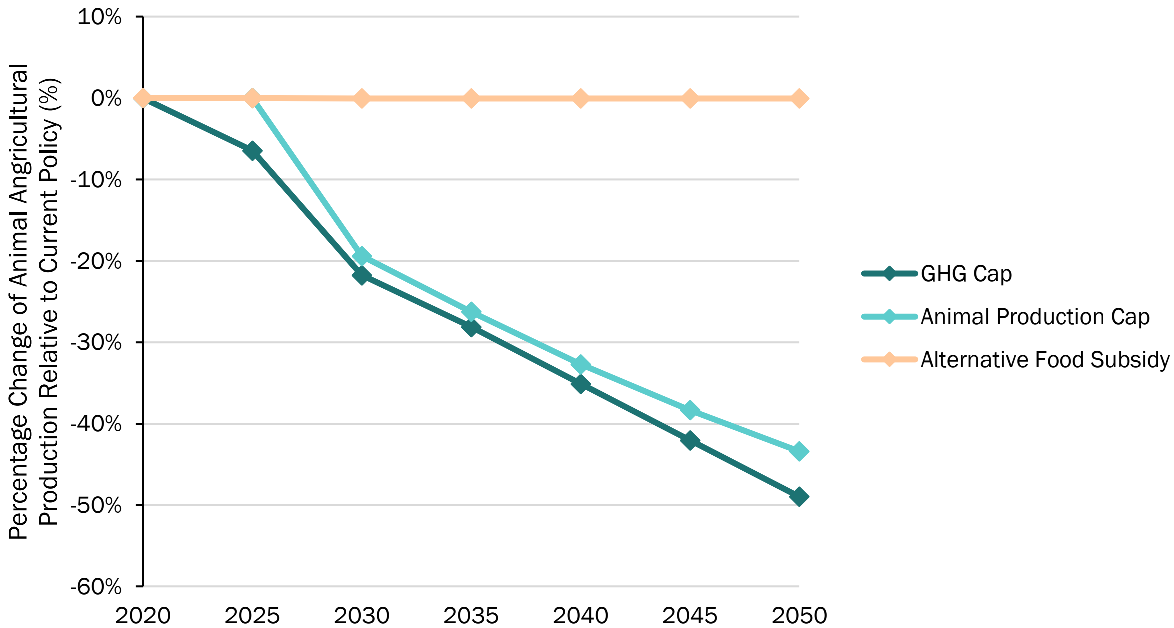
3.4.2. Food system

Figure 21 shows the percentage change in animal agriculture production (relative to current policy) for each of the three policy instruments explored in this analysis. The GHG emissions cap on agriculture has the largest impact on the number of farmed animals in Canada. Although this policy is designed to reduce emissions from the agriculture sector, it results in a reduction in animal agriculture to comply with the policy due to the emissions intensive nature of this sector. This scenario results in 22% less animal production in 2030 and 49% less animal production in 2050 relative to current policy.

Preventing the growth of farmed animals in Canada by limiting animal agriculture production to current levels has a comparable impact on animal agriculture production in Canada. Animal agriculture production is 19% lower in 2030 and 43% lower in 2050 in this scenario relative to current policy. This outcome is expected, as this policy is intended to reduce animal agriculture production in Canada.

The 15% subsidy on plant-based food products has a negligible impact on the food system due to its voluntary nature as described previously. Note that the impact of this policy is greater in scenarios in which consumers are more likely to switch away from meat and dairy products towards a plant-based diet, as outlined in section 3.3.

Figure 21: Change in animal agriculture production in response to three policy instruments (relative to current policy)



While all policy instruments described above differ in terms of design, stringency and objective, a direct comparison can be made between them by calculating the cost of the policy (impact to GDP) relative to the reductions in animal agriculture produced.

While the agriculture emissions cap results in the greatest reduction in animal agriculture production, this is a function of its stringency. Because it is a policy that is designed to target emissions rather than production directly, it is a more expensive option if the goal is to reduce animal agriculture production in Canada, compared to an animal production limit.

As shown in Table 16, the animal agriculture production limit has a 30% smaller impact on GDP in 2030 per unit of animal agriculture reduced, and a 40% smaller impact on GDP in 2050 relative to the emissions cap. This indicates that this policy, which targets animal agriculture production more directly, is more cost efficient than an emissions cap if the policy objective is to reduce animal agriculture production in Canada. The alternative food subsidy is an expensive policy as it does not have a significant impact on the food system.

Table 16: Index describing the amount of GDP reduced relative to the amount of animal agriculture production reduced (reductions from the GHG cap =1)

Policy	2030	2050
GHG Cap	1.0	1.0
Animal Production Limit	0.7	0.6
Alternative Food Subsidy	7.5	5.1

4. Conclusions

This section provides a summary of key insights in Section 4.1 and a discussion of areas for future research in Section 4.2.

4.1. Key insights for policy makers

Results from this analysis provide five key insights, summarized below.

1. **Canada's agriculture sector can play a role in helping Canada achieve its emissions targets.** Reducing emissions from agriculture can play an important role in meeting Canada's 2030 emissions target, but stringent policy will be required with cost implications. A recent analysis of Canada's Emissions Reduction Plan (ERP) found that there is a 9 Mt CO_2e gap between announced policies and Canada's 2030 emissions target.[94] Capping emissions from agriculture at 30% below 2005 levels in 2030 or keeping animal agriculture production constant at current levels could close this gap to Canada's 2030 target.[95]

2. **Canada's agriculture sector can continue to grow out to 2050 while helping Canada reduce emissions.** All policies simulated in this analysis lead to a reduction in Canada's emissions, while agriculture GDP continues to grow out to 2050 in all scenarios. Policies aimed at reducing agricultural emissions do have cost implications, as Canada's GDP grows at a slower rate in all policy scenarios relative to current policy.

3. **An emissions cap on Canada's agricultural sector is the most cost-effective policy for achieving emissions reductions.** This policy is designed to reduce emissions in the agriculture sector by encouraging adoption of available abatement technologies as well as encouraging a shift away from emissions-intensive animal agriculture towards plant-based agriculture. Of the policies explored in this analysis, this policy is the most efficient at reducing emissions, costing the least per unit of emissions reduced.

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[94] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

[95] Based on a 2022 analysis of the ERP. Additional information about policy design has been released since then.

4. **An animal agriculture production limit is the most cost-effective policy for transforming Canada's food system.** While implementing an emissions cap on the agricultural sector achieves significant emissions reductions in Canada, it is not as effective at changing how food is produced and consumed in Canada. An animal agriculture production limit, which directly targets the production of animals is more cost efficient than an emissions cap at reducing animal production in Canada.

5. **Policy design should consider interactions between the policy and future behavioural changes and consumption patterns.** Behavioural changes can play a significant role on the impact of the policies explored in this analysis, amplifying their impact in some cases and reducing it in others. The effectiveness of an emissions cap and production limit decline if consumers are more willing to shift towards a plant-based diet, as changes to Canada's food system are occurring to a greater extent in the absence of additional policy. On the other hand, the effectiveness of a subsidy on plant-based food alternatives is amplified when consumers are more willing to shift towards a plant-based diet.

4.2. Areas for future research

There are a few important limitations of this analysis that highlight potential areas for future research.

First, this analysis assumed no new climate policy is implemented in the U.S. This is an important assumption because what occurs in the U.S. could have an important impact on the results. For example, Canadian consumers might choose to consume imported meat from the U.S., which due to the design of the scenarios in this analysis would not be subject to the policies explored. This report is focused on the impacts of policy on production and manufacturing of food within Canada and did not tackle impacts of policy implementation on imports. Future research could explore this relationship by looking at scenarios in which the U.S. also implements policy to reduce agricultural emissions or animal production, or in which Canada imposes a tariff on imported meat and dairy products.

Similarly, exports and imports of meat and dairy alternatives were not explored in this analysis. Future research could examine how the policies explored in this analysis could contribute to giving Canada a competitive advantage in the meat/dairy alternative sector to export these products to the U.S.

Second, this analysis makes frequent comparison to a recent analysis of Canada's Emissions Reduction Plan (ERP) and the gap remaining to Canada's 2030 emissions target.[96] This is done to put into context the relative impact of each policy instrument on Canada's emissions relative to reduction goals. Note that ERP policies were not explicitly simulated in this analysis. Future analysis could explicitly model the ERP policies together with the agriculture and food production policies explored in this analysis to examine the interaction between them.

Third, many abatement options are available to reduce emissions from the agriculture sector in this analysis. However, abatement opportunities for agricultural soils and land-use and land-use change and forestry (LULUCF) are excluded. Options to reduce emissions from non-combustion sources are less well understood than those for combustion sources. As such, data is lacking to parameterize these opportunities in the model. With better data availability, future analyses could include additional abatement opportunities for agricultural soils and LULUCF.

Finally, this analysis is heavily focused on the emissions benefit of implementing policies that encourage more plant-based food production and consumption in Canada. It is important to acknowledge that there are other environmental benefits of this shift, beyond the impact on GHG emissions, which are not explored in this

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[96] Canadian Climate Institute. (2022). Independent Assessment: 2030 Emissions Reduction Plan. Available from: https://climateinstitute.ca/wp-content/uploads/2022/04/ERP-Volume-2-FINAL.pdf

analysis, including land-use[97,98,99,100], water[101,102,103,104], biodiversity[105,106,107], and pandemic risk[108],[109],[110].

[97] Clark, M.; Tilman, D. (2017). Comparative Analysis of Environmental Impacts of Agricultural Production Systems, Agricultural Input Efficiency, and Food Choice. *Environ. Res. Lett., 12 (6), 064016.* Available from: https://doi.org/10.1088/1748-9326/aa6cd5.

[98] Poore, J.; Nemecek, T.(2018). *Reducing Food's Environmental Impacts through Producers and Consumers. Science, 360 (6392), 987–992.* Available from: https://doi.org/10.1126/science.aaq0216

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[105] Machovina, B.; Feeley, K. J.; Ripple, W. J.(2015). Biodiversity Conservation: The Key Is Reducing Meat Consumption. *Science of The Total Environment, 536, 419–431.*

[106] Coimbra, Z. H.; Gomes-Jr, L.; Fernandez, F. A. S. Human Carnivory as a Major Driver of Vertebrate Extinction. (2020). *Perspectives in Ecology and Conservation, 18 (4), 283–293.* Available from: https://doi.org/10.1016/j.pecon.2020.10.002.

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[108] Kim, H.; Rebholz, C. M.; Hegde, S.; LaFiura, C.; Raghavan, M.; Lloyd, J. F.; Cheng, S.; Seidelmann, S. B. (2020). Plant-Based Diets, Pescatarian Diets and COVID-19 Severity: A Population-Based Case–Control Study in Six Countries. *BMJNPH, 4 (1), 257–266.* Available from: https://doi.org/10.1136/bmjnph 2021-000272.

[109] Intergovernmental Science-Policy Platform On Biodiversity And Ecosystem Services (IPBES). (2020). *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES);* Zenodo. Available from: https://doi.org/10.5281/ZENODO.4147317.

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World Animal Protection Discussion of Results

Discussion of regulatory policies and potential reactions

An overwhelming body of evidence indicates that reducing animal agriculture production to support a transition to more plant-based diets will substantially reduce global greenhouse gas emissions (GHG) thus being an important pathway to climate change mitigation.[111,112,113,114,115] As highlighted earlier in the report, previous research from Navius also showed the potential positive impact of reduced meat and dairy consumption in helping Canada meet its 2030 and 2050 emission reduction targets.[116]

In this analysis, the impact of three policy scenarios on Canada's GHG emissions reduction targets were analyzed and explained earlier in the report: agriculture emissions cap, animal agriculture production limit and subsidy on plant-based food alternatives. The results indicate that reducing emissions from agriculture can play an important role in meeting Canada's emissions reduction targets by implementing policies that encourage less animal food consumption by Canadians.

While there are economic impacts associated with each of the three policy scenarios, this is generally the case across all sectors of the economy that must meet climate targets. And as the recent report by the Commissioner for the Environment and Sustainable Development notes, emissions from the Canadian agriculture sector have grown significantly, with the growth exceeding all other sectors except oil and gas.[117] There is a legitimate debate about the impacts of the policy scenarios, and this debate

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111 https://www.thelancet.com/action/showPdf?pii=S0140-6736%2817%2931358-2

112 https://www.uni-bonn.de/en/news/082-2022

113 https://www.nature.com/articles/d41586-019-02409-7

114 https://eatforum.org/knowledge/diets-for-a-better-future/

115 What's cooking? As assessment of potential impacts of selected novel alternatives to conventional animal products. UNEP, 2023. https://www.unep.org/resources/whats-cooking-assessment-potential-impacts-selected-novel-alternatives-conventional

116 https://www.worldanimalprotection.ca/sites/default/files/media/2022-08-30-World-Animal-Protection-Navius-FINAL.pdf

117 https://www.nationalobserver.com/2024/06/05/opinion/Climate-change-factory-farming-emissions?utm_source=National+Observer&utm_campaign=226d4436a8-EMAIL_CAMPAIGN_2024_06_05_01_20&utm_medium=email&utm_term=0_cacd0f141f-226d4436a8-%5BLIST_EMAIL_ID%5D

should focus on how to mitigate the economic impacts on small- and medium-scale farmers, who are often among those most harmed by the effects of climate change.

In this context the following policy considerations should be taken into account:

1) Limiting the growth of animal agriculture need not take a 'one size fits all' approach. A sustainable food system is not simply about reducing the number of animals farmed, but addressing the nature of farming systems, the practices employed, and the scale of individual farms. This can be achieved by reducing animal numbers through targeted policies that limit the growth of large-scale, industrial operations. At the same time, promoting small-scale operations using regenerative, mixed farming, agroecology practices can help farmers maintain their autonomy and protect livelihoods. For example, The Farm System Reform Act reintroduced in the US House of Representatives and Senate in February 2023 would prohibit the construction of new large Concentrated Animal Feeding Operations (CAFOs) and the expansion of those currently operating. It would also require large CAFOs, defined as facilities exceeding a certain number of animals to cease operating above the animal limit by 2040 and establish grants to help farmers transition their practices. [118]

2) Canada's plant-based protein sector is expected to grow at 14% annually, with economic benefits estimated to be as high as 31 trillion USD or 13% of GDP by 2050 and presents a significant opportunity for agricultural and food innovation.[119] The government has already financially supported the sector but there is much more that can be done via incentives on the producer side such as funding support to first time farmers, funding to promote organic agriculture or subsidies to promote green farming initiatives (See *Danish Action Plan for Plant-Based Foods)*.[120] Financial support for farmers to encourage the transition to small scale livestock and/or crop production, other plant-based agriculture, and/or adopting agroecology methods is needed.

3) Behaviour change policies could help to reduce or mitigate the need for stringent regulatory approaches (e.g., emissions cap or limit on animal agriculture growth). A subsidy on plant-based food alternatives alone was not found to be an effective policy in encouraging the uptake of more plant-based diets (and less meat and dairy by default) and reducing agricultural emissions. However, in conjunction with behaviour change policies, it has the potential to shift consumer behaviour, thereby limiting the growth of animal agriculture and reducing the need for strong regulatory measures. The effects of

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[118] https://www.booker.senate.gov/news/press/booker-introduces-package-of-bills-to-reform-us-food-system and https://awionline.org/legislation/farm-system-reform-act
[119] https://nrc.canada.ca/en/research-development/research-collaboration/programs/plant-based-protein-market-global-canadian-market-analysis
[120] https://fvm.dk/fileadmin/user_upload/Dokumentation/Danish-Action-Plan-for-Plant-based-Foods.pdf

the plant-based subsidy were amplified when consumers are more likely to shift towards more plant-based foods and consume less animal-based foods. Actions that may nudge consumers in this manner may include information campaigns around the benefits of following the Canada Food Guide, carbon emissions labelling, and increasing the availability of plant-based food in the marketplace. The federal government can lead by example by procuring more plant-based food in federal institutions and through federally-funded food programs like the National School Food Program.

Canada's agriculture sector must do more to contribute to the nation's emission reduction strategy.[121] Implementing low carbon, technological solutions on farms is important but not enough. What we eat and how it's produced must be critically examined and appropriate changes made to ensure a low carbon food system for the future. The policies assessed in this report offer a solution that aligns with Canada's climate goals and with Canada's Sustainable Agriculture Strategy currently in development.

Limitations of analysis scope

It is important to note that there are other environmental implications of shifting food consumption to be more plant-based beyond impacts to greenhouse gas emissions, which are not explored in this analysis. Although these impacts are not accounted for in the modeling, they will increase the environmental benefits of reducing animal consumption and are therefore worth mentioning.

Currently, agriculture land accounts for around half of all habitable land on earth, where 83% is used for animal agriculture including feed crops.[122] Switching to a more plant-based diet would partially free up these land areas -- including marginal lands that are often inefficient at producing food, but ecologically valuable -- which could become available for conservation, restoration and reforestation. In addition, agriculture is the leading cause of biodiversity degradation globally, mainly due to the production of crops needed for animal feed.[123] Research suggests that this degraded land can recover its original carbon stocks and biodiversity levels if transitioned away from agricultural

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[121] https://www.oag-bvg.gc.ca/internet/docs/parl_cesd_202404_05_e.pdf
[122] Poore, J.; Nemecek, T. Reducing Food's Environmental Impacts through Producers and Consumers. Science 2018, 360 (6392), 987–992. https://doi.org/10.1126/science.aaq0216 .
[123] Machovina, B., Feeley, K., & Ripple, W. (2015). Biodiversity conservation: The key is reducing meat consumption. Science of the Total Environment, 536, 419-431. doi:10.1016/j.scitotenv.2015.07.022

land.[124] Lastly, animal agriculture uses 43% of all the water consumed by the global food system and is responsible for a disproportional amount of water pollution.[125],[126] Switching to a lower animal consumption diet would therefore reduce not only greenhouse gas emissions, as quantified in this analysis, but could also reduce land use, water consumption, and water pollution, while increasing biodiversity levels. There are also substantial health benefits from reducing animal consumption.[127]

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[124] Silver, W. L., Ostertag, R. & Lugo, A. E. The potential for carbon sequestration through reforestation of abandoned tropical agricultural and pasture lands. Restor. Ecol. 8, 394–407 (2000).
[125] Davis, K. F., Gephart, J. A., Emery, K. A., Leach, A. M., Galloway, J. N., & D'Odorico, P. (2016). Meeting future food demand with current agricultural resources. Global Environmental Change, 39, 125-132.
[126] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
[127] https://www.lshtm.ac.uk/research/centres/centre-climate-change-and-planetary-health/news/416196/small-changes-diets-can-have-substantial-benefits-both-health-and-environment