EXECUTIVE SUMMARY

2021 LIFE CYCLE ASSESSMENT OF CANADIAN MILK PRODUCTION

Dairy Farmers of Canada (DFC) has commissioned a Life Cycle Assessment (LCA) of Canadian milk production every five years since 2011. In the LCA,[1] the environmental impact of producing one kilogram of milk is measured across three indicators – carbon footprint, water consumption, and land use – from the production of farm inputs to the transportation of milk to the processor. These results are then compared to previous years, demonstrating progress made and areas of improvement for milk production in Canada.

The results from all LCAs help to benchmark and track progress of the sector's environmental impact at a national level. The 2021 LCA also serves to inform and update DFC's Sustainability Strategy[2] and associated resource, *Best Management Practices Guide to Mitigate Emissions on Dairy Farms,*[3] as farmers work toward reaching net-zero greenhouse gas (GHG) emissions from on-farm dairy production by 2050, a target announced by DFC in 2022. For the Canadian dairy farm sector, "net zero" means finding a balance between emissions created on farms and those reduced or sequestered by farms.

Compared to the global average, the production of one kilogram of Canadian milk emits less than half as much GHG emissions.[4] Though the LCA results show that the industry's carbon footprint is generally declining – nine per cent lower in 2021 than 2011 – GHG reductions per kilogram of milk plateaued in the 2016-2021 period. Water consumption increased overall by 42 per cent since 2011, mainly due to weather challenges that led to higher irrigation volumes between 2016-2021. However, improvements were made in the share of water per kilogram of milk needed in the barn for cleaning and animal drinking purposes, and have reduced in the 10-year interval by 19 per cent and 27 per cent, respectively. Land use per kilogram of milk has decreased 21 per cent since 2011.

Although progress continues to be made in several areas, it is important to note that progress is typically dynamic rather than linear when working with living things and nature. This LCA includes data collected in 2021, prior to the sector announcing its commitment to work towards reaching net zero by 2050, and DFC continues to promote best management practices to support farmers' ongoing sustainability efforts.

Note: There can be differences in data and models between various studies, but the Food and Agriculture Organization of the United Nations (FAO) benchmarking is useful to understand environmental performance of milk trends throughout different regions of the world.

METHODOLOGY

An LCA is an internationally recognized, science-based, routine diagnostic tool used for assessing the environmental profile of products and services throughout their life cycle. Guidelines on how to undertake LCAs are set by organizations including the International Organization for Standardization (ISO) and the International Dairy Federation (IDF).

The 2021 LCA followed the ISO 14040/14044 standards, and the latest 2022 IDF guidelines for a dairy LCA. Additionally, a third-party panel of experts performed a critical review of the study and concluded the methodology is consistent with these standards, scientifically and technically valid, and uses data sets appropriate for the goals and scope of the LCA.

All assessments are based on current international standards and methodologies at the time of each study, while providing a comparative analysis of farm practices, efficiencies, and environmental progress over time. Consequently, to be able to compare the 2021 results with the previous LCA studies, the methodology updates were applied to previous results, thus allowing this study to offer a coherent comparison of the environmental impact of producing a kilogram of milk across the three reference year assessments (2011, 2016 and 2021).

All data used in this LCA (see Table 1) is sourced from verified secondary sources, statistics and research literature available for the year 2021; no primary data was collected in this study. New information and data sources will be included in future studies as they become available, increasing the precision of the assessment of milk's environmental profile over time.

Table 1: Data sources used in this assessment

Parameter	Data Source
Milk production parameters*	Canadian Dairy Information Centre (CDIC, 2022)[5]
On-farm energy and water use	Cost of Production (COP) survey, Provincial associations (CDIC), Vanderzaag (2023)[6]
Manure management	Update of 2017 survey on Best Management Practices (BMPs) through secondary data sources (ECCC, 2021)[7]/expert opinion
Transport distances	2011 mail-in survey (AB, ON, QC, NB, NS, PE)
Feed quantities	COP survey (East and West); Provincial associations (West) (CDIC)
Crop yields	Statistics Canada (2021a)[8]
Fertilizer use	Sheppard et al. (2011a, b, c),[9] COP survey; Fertilizer Use Survey (2022)[10]
Diet composition	COP survey; Provincial associations (CDIC)

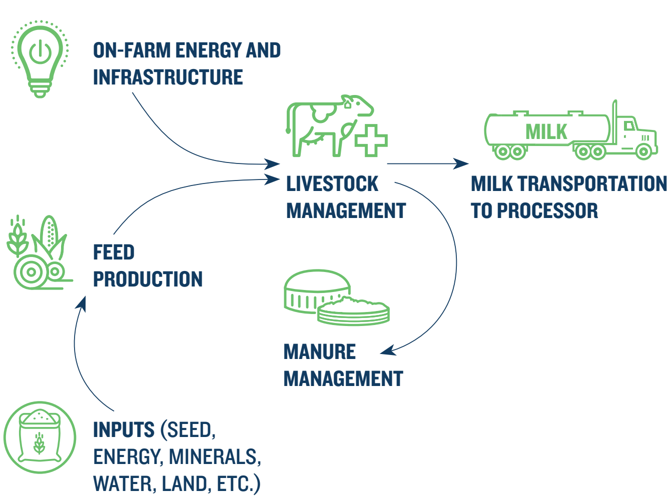
* Includes fat and protein content, dairy herd size, cattle weights, number of farms, cows, heifers, milk production by farm, and more.

SYSTEM BOUNDARIES OF THE LCA

LCAs must set system boundaries and functional units to be able to complete the assessment and to support the clear communication of results. The system boundaries of the LCA include the following stages of milk production: inputs (including seed, energy, minerals, water, land, etc.), feed production, livestock management, on-farm energy and infrastructure, manure management, and transportation of milk to the processor.

The functional unit and scope of the 2021 LCA study are: one kilogram of fat- and protein-corrected milk (FPCM) produced at a Canadian farm and transported to a processing facility.

Figure 1: System boundaries of the LCA



- **Inputs**: Includes all identifiable upstream inputs to provide a comprehensive view of the milk production system.
- **Feed production:** Extraction and processing of raw materials used to produce pesticides and synthetic fertilizers as well as their application on crops, manure spreading, direct emissions from agricultural soils, energy required for field operations and irrigation, and irrigation water.
- **Livestock management:** Bedding materials, drinking water, barn cleaning, and methane emissions from enteric fermentation (i.e., from the digestion process of dairy cattle).
- **Manure management:** Methane, nitrous oxide, and ammonia emissions produced during manure storage and treatment*.
- **On-farm energy and infrastructure:** Electricity for dairying, cattle housing, milk parlour equipment and buildings, and gasoline for regular operations.
- **Transport**: Transport of purchased feed, transport of purchased animals, and transport of raw milk to processors.

* Manure treatments refer to the types of manure management system used (e.g., composting, anaerobic digestion, liquid storage). The emissions related to manure application on agricultural fields and crops are included in the feed production stage.

KEY FINDINGS

Understanding where the environmental impact comes from helps to identify and prioritize efforts for future reductions. As shown in Figure 2, the contribution of each area of impact to the carbon footprint and land use indicators remained relatively constant over the 2011-2021 period. Feed production represents a greater proportion of the water consumption indicator compared to 2011.

In Figure 2, livestock management and feed production contribute to the majority of impacts across all three indicators. For the carbon footprint, the contribution of livestock management decreased between 2011 and 2021, primarily due to a 14% reduction in enteric emissions per kilogram of milk. This reduction was driven by improved production efficiency and an increase in the volume of milk produced per cow. Breeding and genetic selection toward higher feed efficiency likely contributes to this reduction as well. The proportion of the carbon footprint related to manure management increased from 19 per cent in 2011 to 22 per cent in 2021, due to switching from solid to liquid manure management systems. The contribution of feed production to water consumption increased from 67 per cent in 2011 to 83 per cent in 2021, largely due to changing irrigation needs for feed production. The contribution of feed production to land use remained the same between 2011 and 2021. On-farm efficiency improvements have resulted in reductions to overall land use impacts since 2011.

Figure 2: The average environmental profile of a kilogram of Canadian milk in 2011 and 2021

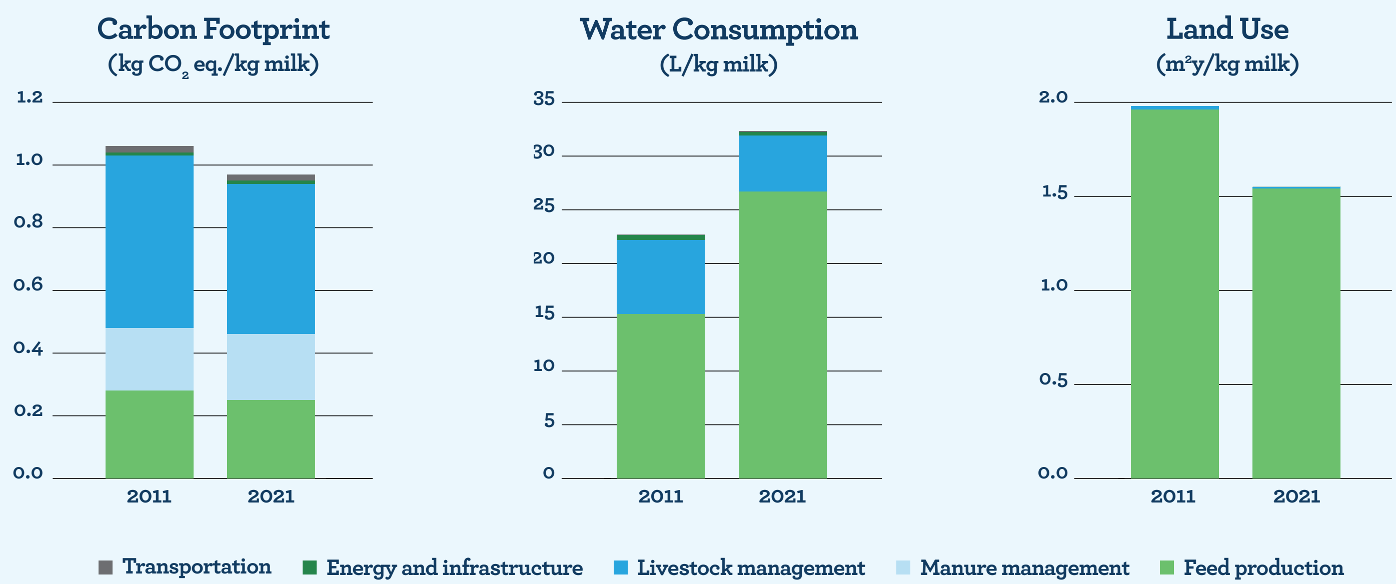
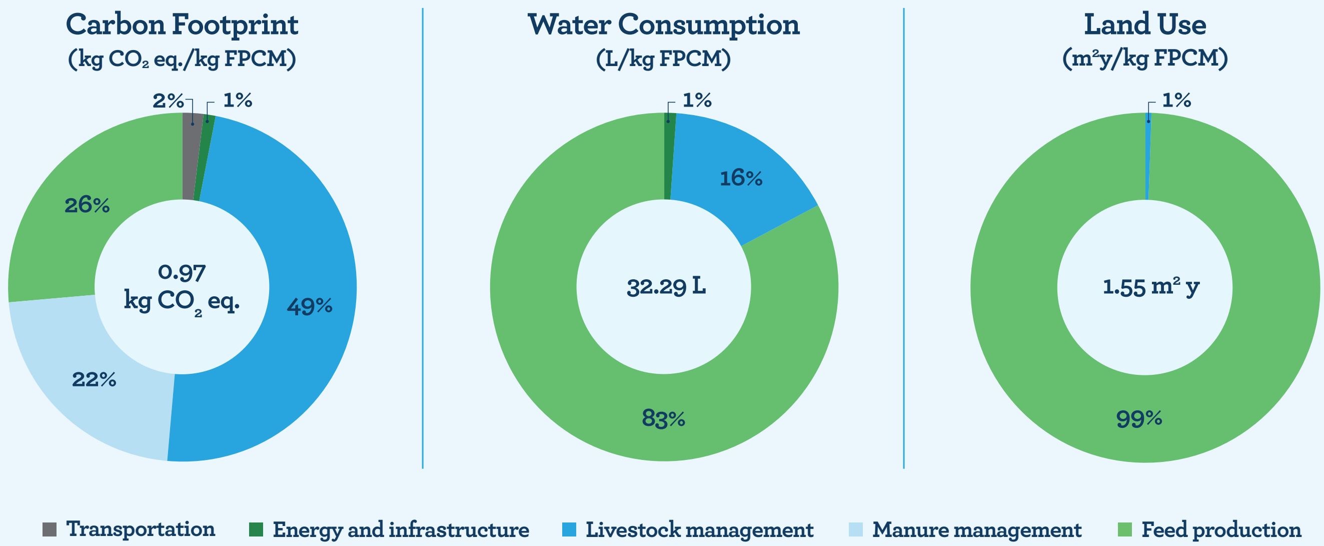


Figure 3 outlines the production factors that contribute to a kilogram of milk's environmental footprint across the three main indicators in 2021: carbon footprint, water consumption and land use. The sector's carbon footprint is 0.97 kg CO_2 equivalent per kilogram of milk. Livestock management accounts for 49 per cent of the total footprint, while feed production and manure management contribute 26 per cent and 22 per cent, respectively. The overall water consumption is 32.29 litres per kilogram of milk. Feed production represents 83 per cent of water consumption, with irrigation accounting for 98 per cent of the water consumed for feed production (e.g., haylage). The total land use is 1.55 m^2y per kilogram of milk. Feed production comprises 99 per cent of land use.

Figure 3: Breakdown of components of the environmental profile of a kilogram of Canadian milk in 2021



As shown below in Table 2, the share of water per kilogram of milk needed in the barn for cleaning and for animal drinking purposes was reduced by 19 per cent and 27 per cent since 2011, respectively. This reduction in water used in barns contrasts with the water consumption increase seen in field use, where irrigation is part of the response to adapting to drought years in some areas of the country.

Table 2: Water consumption related to livestock management

Livestock Management	2011	2021	Variation
Drinking water (m^3)	4.9	3.6	**-27%***
In-barn cleaning (m^3)	1.8	1.5	**-19%***

* Percentages may differ due to rounding.

Drought in Western Canada negatively impacted yields and irrigation rates in the 2021 LCA. Both parameters affected the water consumption per kilogram of milk. Weather variability can greatly influence water consumption required for feed production from year to year, and 2021 therefore saw an increase in irrigation volumes compared to the 2011 LCA.

RECOMMENDATIONS

The results of this LCA help identify where the environmental impact of producing a kilogram of Canadian milk comes from in order to identify where efforts to reduce impact can be most effective. Notwithstanding the limitations of working with the unpredictability of nature as well as the geographic differences across Canada, many of the improvements identified in the LCA point to ongoing on-farm efficiencies.

Cow productivity, in particular, has resulted in lowered impacts in GHG emissions and land use since 2011. The sector should continue to improve productivity through enhancing herd genetics, maintaining animal health and comfort, optimizing animal diets, and improving feed efficiency. Changing or fine-tuning manure management and application strategies can also reduce GHG emissions on the farm. As producing feed for animals requires the bulk of water consumption and land use, further efforts to increase feed efficiency would result in reductions in both indicators. New approaches to irrigation efficiency, soil health, and drought-resistant crops, involving funding for research, technology and innovation will be necessary to help mitigate the effects of precipitation inconsistency in drought-prone regions.

Relevant best practices for farmers to implement may include:

- Optimization of both feed quantities and nutrients within rations, and improved forage management can increase feed efficiency and reduce emissions, land use, and water consumption.
- Utilizing precision agriculture technologies can reduce fuel consumption while improving forage management and soil health. These improvements can increase yields, reduce water usage for feed production (e.g., irrigation), and enhance cow productivity.
- Enhancement of manure storage and application practices that reduce emissions can help lessen environmental impacts. These practices can include acidification, covering manure pits, separating solids from liquids, fully emptying manure storage two or more times per year, applying manure additives, composting, or creating renewable biogas from manure.
- Improvement of nutrient management plans and efficient use of fertilizers, along with maximizing the benefits of manure, helps reduce emissions and improve soil health. This, in turn, reduces the land and water needed for production.

Taking an overall, holistic view is important to identify the potential trade-offs of any specific action that is recommended. For example, an action may reduce GHGs but have impacts in other areas, so assessments should consider overall environmental, economic and social factors to understand the best path forward.

For further information on recommended best management practices, dairy farmers are encouraged to review DFC's *Best Management Practices Guide to Mitigate Emissions on Dairy Farms*.

NEXT STEPS

This LCA serves as a key tool to guide actions taken on farms, as well as within the dairy value chain, as the sector works to reduce the overall environmental impact of milk production while improving productivity, efficiency and sustainability. For industry partners like dairy processors, policymakers and food retailers, the LCA results can be used in their own environmental performance assessments to identify opportunities for collaboration to improve the value chain's overall footprint. These findings also help inform consumers of how Canadian milk continues to be produced with sustainability in mind.

The results from this LCA will continue to be analyzed to determine the most impactful practices farmers can implement to reduce GHG emissions and lessen the environmental impact of a kilogram of milk in their efforts towards reaching net zero by 2050. Favouring circularity, increasing biodiversity, sequestering carbon in landscapes, and more, are all pieces that contribute to the long-term success of Canada's dairy farms.

1 Groupe AGÉCO (2024). Environmental Life Cycle Assessment of Canadian Milk. (Report prepared for Dairy Farmers of Canada)

2 DFC (2023). Dairy Farming Forward to 2050: Dairy Farmers of Canada's Net-Zero Strategy. Available at: dairyfarmersofcanada.ca/sustainability

3 DFC (2023). Net Zero by 2050: Best Management Practices Guide to Mitigate Emissions on Dairy Farms. Available at: dairyfarmersofcanada.ca/sustainability

4 FAO (2019). Climate change and the global dairy cattle sector. Available at: fao.org/3/CA2929EN/ca2929en.pdf

5 CDIC (2017, 2022). Dairy Facts and Figures. Available at: dairyinfo.gc.ca/index_e.php?s1=dff-fcil

6 VanderZaag, A. (2023). Virtual Research Showcase | Reducing the Water Footprint of Milk Production – March 15, 2023. Available at: youtube.com/watch?v=uNzd_OS8kFk&t=618s&ab_channel=DairyResearchCluster

7 ECCC (2021). National Inventory Report, 1990–2019: Greenhouse gas sources and sinks in Canada. Canada's submission to the United Nations framework convention on climate change. Environment and Climate Change Canada.

8 Statistics Canada (2021a). Table 32-10-0359-01 Estimated areas, yield, production, average farm price and total farm value of principal field crops, in metric and imperial units. Available at: 150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210035901

9 Sheppard, S. C., Bittman, S. (2011a). Farm survey used to guide estimates of nitrogen intake and ammonia emissions for beef cattle, including early season grazing and biosphere effects. Animal Feed Science and Technology, vol. 166-167: 688-698.
Sheppard, S. C., Bittman, S., Swift, M., Beaulieu, M., Sheppard M. (2011b). Ecoregion and farm size differences in dairy feed and manure nitrogen management: A survey. Can. J. Anim. Sci., 1(3):459–473.
Sheppard, S. C., Bittman, S., Swift, M., Tait, J. (2011c). Modelling monthly NH_3 emissions from dairy in 12 Ecoregions of Canada. Can. J. Anim. Sci., 91:649–661

10 Stratus Ag Research (2022). Fertilizer Use Survey. 2018 - 2021 Crop Year. Fertilizer Canada. Accessed in September 2022. Available at: fertilizercanada.ca/resources/fertilizer-use-survey-2022/