EXECUTIVE SUMMARY

CONTEXT AND OBJECTIVES

To provide the industry with a better understanding of the environmental performance of current milk production in Canada, Dairy Farmers of Canada (DFC) commissioned Groupe AGÉCO to conduct a life cycle assessment (LCA) of milk production. Based on data from 2016, the study aims to set out a scientifically robust and transparent environmental assessment of current practices of the industry. DFC had already commissioned Groupe AGÉCO in 2010 to perform an LCA based on 2011 data in the context of the Dairy Research Cluster. LCA results were published in 2012 and eventually integrated into the *Dairy Farms +* online tool in 2016, now available to every Canadian dairy farmer for self-assessment and benchmarking.

The study therefore aims to characterize the environmental performance of Canadian milk production in 2016 and compare it with 2011. The LCA methodology used in the initial study was updated to take into account the evolution of farm practices, which are gaining in efficiency, as well as recent changes in the databases and LCA methodologies.

More specifically, the objectives of this study are to:

1. Update the 2011 environmental LCA results to take into account methodological changes resulting from revisions to the relevant international standards and impact assessment methods used to calculate the results;
2. Quantify the environmental impact of milk production in Canada in 2016; and
3. Provide DFC with a comparative analysis of the 2011 and 2016 results using the updated methodology.

While a social life cycle assessment (SCLA) was included in the 2012 LCA study, this study solely focuses on the environmental aspects of milk production in 2011 and 2016. No SCLA was performed for 2016.

ENVIRONMENTAL LCA

The proposed approach for measuring and updating the environmental profile of milk production in Canada is the Life Cycle Assessment (LCA), a systematic quantitative assessment used by organizations to gauge environmental performance. It is guided by the International Organization for Standardization (ISO 14040/14044) and used to evaluate a broad spectrum of impacts. In order to ensure comparability with current and future similar studies, the 2018 LCA study follows the 2015 International Dairy Federation (IDF) guidelines on standard life cycle assessment methodology, initially published in 2010 and revised in 2015.

DATA COLLECTION

A thorough data-collection strategy was developed to gather secondary data as well as generic Life Cycle Inventory (LCI) data for the year 2016. Primary data were collected at the business level through an online survey that was sent to dairy farmers across Canada in 2017.

Table 0.1
Summarv of data sources used for the main LCA

Parameter	Data source
Milk production parameters	Canadian Dairy Information Centre (CDIC, 2017)
On-farm energy and water use	Cost of Production (COP) studies of milk in Canada (ON, QC, NB, NS, PE) for calendar years 2011 and 2016
Manure management	2017 survey on BMPs and COP studies (ON, QC, NB, NS, PE) for calendar years 2011 and 2016
Transport distances	2011 mail-in survey (AB, ON, QC, NB, NS, PE)
Feed quantities	COP studies (ON, QC, NB, NS, PE) for calendar years 2011 and 2016, crosschecked with Valacta's data
Crop yields	Statistics Canada (2018a)
Fertilizer use	Sheppard et al. (2010), Stratus Ag Research (2015), CRAAQ (2015)
Diet composition	COP studies (ON, QC, NB, NS, PE) for calendar years 2011 and 2016, crosschecked with Valacta's data

Questions addressed on-farm practices and technologies used in 2011 and 2016 and allowed to document the main changes in the life cycle of milk production during this five-year period. Part of the survey data, including data on practices related to manure management and storage, crop tillage, and husbandry practices, were directly integrated into the LCA model. Survey data were also used to support result interpretation and the analysis of environmental profiles between 2011 and 2016. Table 0.1 summarizes the main sources used for the 2016 LCA model for both 2011 and 2016.

UPDATE OF THE 2011 LCA RESULTS

A reassessment of the environmental profile of milk production in 2011 was required because of the methodological changes between 2011 and 2016, as determined by the relevant standards and impact assessment methods. This update was necessary to ensure a coherent comparison of impact results with 2016. Adjustments to the initial LCA model involved the following:

- Updating the LCA methodology to the 2015 IDF guidelines because the initial 2011 model followed the 2010 IDF guidelines;
- Updating the LCA model based on the current ecoinvent LCA database (v3.4) because the version 2.2 of the ecoinvent database was previously used;

- Updating the global warming potential factors of the Fourth Assessment Report (AR4) with the ones of the Fifth Assessment Report (AR5) (IPCC, 2014);
- Adjusting the model parameters using the most current secondary data. In order to ensure proper comparison between the 2011 and 2016 environmental profiles, both LCA models relied on the same sources of secondary data when no change is expected over time (see Table 0.1); and
- Integrating information on beneficial management practices (BMPs) from the 2017 survey on BMPs in the LCA model.

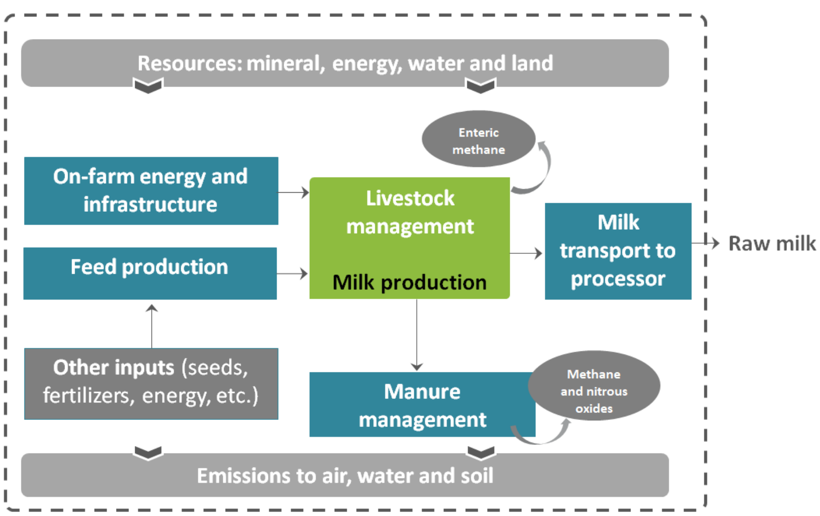
Functional unit and system boundaries

This study assesses the life cycle of Canadian milk production in 2016 for which the system boundaries consider a cradle-to-farm gate approach. This approach assesses the life cycle of milk production from raw material extraction to milk transport between the farm and the processor's gate. More specifically, the assessment considers the resources, energy requirements and emissions related to the production and use of on-farm inputs (e.g. fertilizers, electricity, barn infrastructure), feed production, on-farm activities (e.g. growing crops, storing manure, barn cleaning), and transport activities. The life cycle assessment includes milk transport from the farm to the processor's[1] gate.

The functional unit for this study is
one kilogram of fat- and protein-corrected milk (FPCM) produced at a Canadian farm and transported to a processing facility.

The system is divided into the same life cycle stages as the 2011 model, as presented in Figure 0-1.

Figure 0-1
System boundaries for the LCA model of milk production in Canada



[1] The milk processing stage is not included in the LCA model.

RESULTS

In this study, three main environmental issues were assessed: carbon footprint, water consumption, and land use. In addition to the main indicators, a series of on-farm indicators provide an overview of the evolution of some environmentally relevant inputs used by dairy farmers on their farms. The results of the average environmental profile of one kilogram of fat- and protein-corrected milk produced in Canada are summarized in Table 0.2. Results are expressed per kilogram of FPCM and can be converted to per litre of milk by using a conversion factor of 0.97 litres milk per kilogram of FPCM.

Table 0.2
Summary of environmental indicators and on-farm indicators for the 2011 and 2016 analyses

	2011[2,3]	2016
Environmental issues		
Carbon footprint (kg CO_2 eq./kg milk)	1.00	0.92
Water consumption (L/kg milk)	27.3	25.8
Land use (m^2y/kg milk)	1.9	1.7
On-farm indicators		
Nitrogen synthetic fertilizers (kg N/kg milk)	1.33E-03	1.03E-03
Potassium synthetic fertilizers (kg K/kg milk)	6.90E-04	6.54E-04
Phosphorous synthetic fertilizers (kg P/kg milk)	8.87E-04	8.55E-04
Forages[4] (kg dry/kg milk)	0.72	0.72
Concentrates[5] (kg dry/kg milk)	0.28	0.26

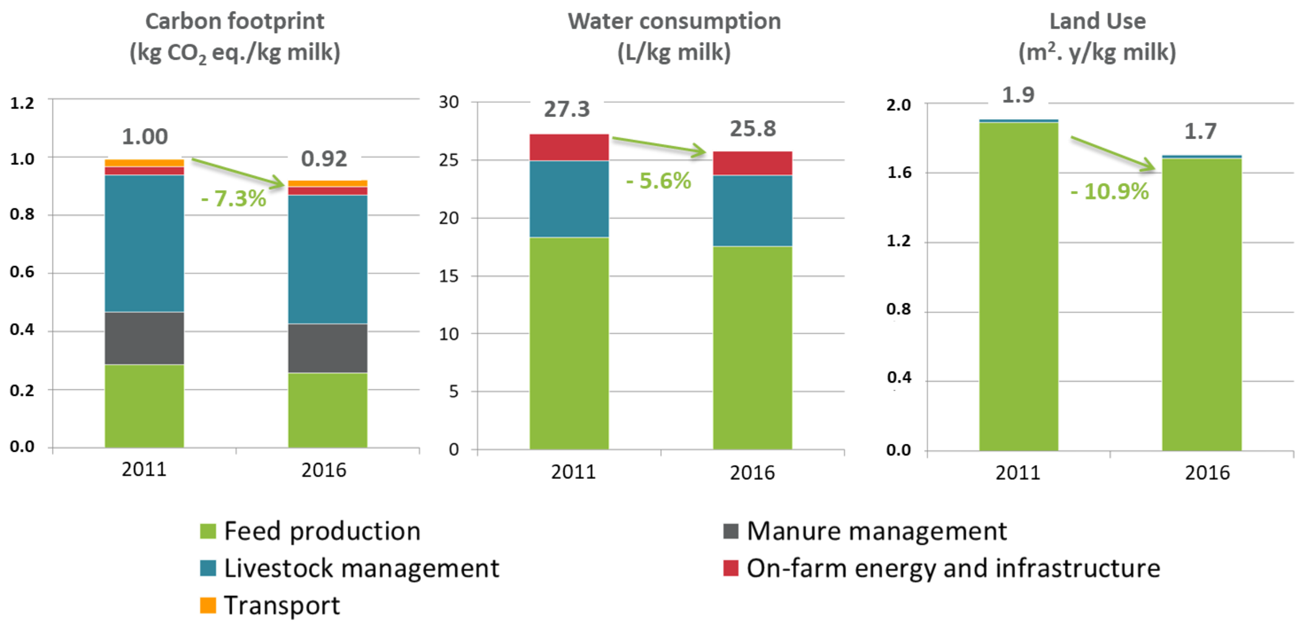
The carbon footprint, water consumption, and land use associated with milk production decreased by 7.3%, 5.6%, and 10.9%, respectively, between 2011 and 2016. As observed in Figure 0-2, the contribution of the main life cycle stages to environmental impacts in 2016 is very similar to the 2011 environmental profile.

Livestock management is the main contributor to the carbon footprint due to emissions from enteric fermentation, which represents 48% of the total GHG emissions in 2016 and 47% of GHG emissions in 2011. Resulting mainly from increased cow productivity, enteric emissions have decreased from 0.47 to 0.44 kg CO_2 eq. per kilogram of FPCM between 2011 and 2016. On the other

[2] Results are presented per kilogram of FPCM. One kilogram of FPCM is equivalent to 0.97 litres of milk.
[3] The 2011 results presented in the table are based on the revised LCA model, which means that the 2011 data was modeled using current methodologies. While the initial 2012 study had calculated 1.01 kg CO_2 equivalent per kg of milk, this revision yields 1.00 kg CO_2 equivalent per kg of milk.
[4] Forages include haylage, hay, and corn silage.
[5] Concentrates include corn, mixed grains, soy, and commercial feed.

hand, feed production contributes to 68% of water consumption due to feed crop irrigation, even though most of the feed crops produced in Canada are not irrigated. Feed production also accounts for 99% of the land use indicator.

Figure 0-2
Relative contribution of the life cycle stages to the average environmental profile of producing one kilogram of Canadian milk



Study results indicate that increased milk production per cow is the main driver to explain improvements in the environmental profiles during this five-year period. Indeed, the quantity of milk produced per cow increased by 12.8% between 2011 and 2016. At the same time, cows in 2016 consumed approximately 9% more feed than in 2011. Because the quantity of enteric and manure emissions are directly linked to the amount of feed consumed, this implies that each cow in 2016 produced higher levels of enteric and manure emissions. However, because of higher levels of milk production, the amount of GHG emissions produced per kilogram of milk decreased compared to 2011. Apart from changes in the quantities of feed intake, the proportion of corn silage in the cows' ration has increased slightly in 2016 at the expense of feeds with a higher carbon footprint (e.g. corn, commercial feed, hay, and haylage). While this change contributed to reduce GHG emissions related to feed production, its influence on the carbon footprint is less significant than the increased milk production.

Although the amount of feed consumed per cow increased between 2011 and 2016, higher milk production led to a reduction in water consumption and land use inventory indicators. For water consumption, this result is also explained by the assumption that irrigation rates have remained constant during this five-year period. This assumption was made due to a lack of historical data and the high variability in irrigation rates between 2011 and 2016, which do not provide a reliable measure of the current trends in irrigation practices in Canada. A sensitivity analysis was carried out and demonstrated that an increase in irrigation rates would have led to an increase in the total water consumption between 2011 and 2016.

Results from an online survey sent to dairy farmers in Canada in 2017 highlights that a significant number of them have optimized and updated several of their practices in the last five years[6]. Table 0.3 presents some important BMPs that have been adopted between 2011 and 2016.

Table 0.3
Summary of changes in BMPs between 2011 and 2016 and benefits for the environmental footprint of milk production

Topic	2011–2016 change	Benefit
Feed efficiency and quality	13% increase in respondents who have optimized ration formulation and feeding between 2011 and 2016.	Reduced feed-related environmental impacts
	21% increase in respondents who have improved forage management in order to increase feed quality between 2011 and 2016.	Increased cow productivity
Manure management	A growing number of respondents empty manure storage more frequently.	Reduced N_2O and CH_4 emissions from manure
	The proportion of manure managed through composting and anaerobic digestion has nearly doubled between 2011 and 2016.	
Crop production	Since 2011, 55% of respondents have reduced the use of conventional tillage practices.	Reduced N_2O emissions from applied nitrogen fertilizers in western provinces; reduced fuel use
	Between 2011 and 2016, the number of respondents who have adopted a diversified crop rotation on some or all of their crop fields increased by 50%.	Increased yields, reduced land use and water consumption
	The proportion of respondents who use precision agriculture technologies has doubled and, in some cases[7], tripled since 2011.	Reduced fuel use for crop and forage production; potential for yield increase

[6] Approximately 570 dairy farmers provided answers to the survey.
[7] The proportion of respondents who use Driver Assistance Guidance has more than tripled in BC, ON, and QC; the proportion of respondents who use Controlled Traffic Farming has more than tripled in BC, SK, and MB; the proportion of respondents who use reacting technologies (variable nutrient application rate) has more than tripled in ON and QC; and the proportion of respondents who use reacting technologies (variable irrigation rate) has more than tripled in MB and QC.

Although the impact of these changes cannot be easily isolated from other factors, these statistics highlight the fact that a significant number of farmers have optimized and updated several of their practices between 2011 and 2016. Given the sensitivity of environmental impacts to the feed production stage, beneficial management practices that focus on improving feeding strategies and agricultural practices related to on-farm feed production have the potential to reduce the environmental footprint of milk production.

CONCLUSION

Here is a summary of the study's main findings:

- The carbon footprint, water consumption, and land use of Canadian milk production decreased by 7.3%, 5.6%, and 10.9%, respectively, between 2011 and 2016;
- The contribution of life cycle stages to overall impacts remained fairly constant between 2011 and 2016, with enteric emissions being the main contributor to the carbon footprint, and feed production contributing to the bulk of water consumption and land use inventory indicators;
- Productivity is the key parameter explaining improvements in the environmental profiles of milk production between 2011 and 2016. Cow productivity is sensitive to several parameters and practices that are often interrelated. The environmental assessment of any proposed action should therefore always take into consideration its impact on productivity;
- The key impact findings of this study can be addressed by adopting beneficial management practices (BMPs) related to feed, energy, and manure management. Answers to the survey indicate that a growing number of producers have optimized several of their practices related to feed production. More specifically, a higher number of dairy farmers have improved forage management and implemented feeding strategies to optimize cows' rations. The production of feeds has also benefitted from the use of several practices such as crop rotation and reduced tillage practices; and
- Although the sensitivity analyses demonstrated that there is still significant potential to improve the environmental footprint of milk production, they also highlight potential risks such as the increase in irrigation use and the use of feed additives based on palm oil. It is therefore recommended that these aspects be closely monitored in future years.

Dairy Farmers of Canada (DFC)

DFC is the national policy, lobbying and promotional organization representing Canada's farmers. DFC strives to create stable conditions for the Canadian dairy sector, today and in the future. It works to maintain policies that foster the viability of Canadian dairy farming and promote dairy products and their health benefits.