Environmental and Socioeconomic Life Cycle Assessment Of Canadian Milk

Prepared for Dairy Farmers of Canada

By

Quantis

GROUPE AGÉCO

CIRAIG

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This report has been prepared by the Canadian offices of Quantis and AGECO with the collaboration of CIRAIG and UQÀM. Please direct all questions regarding this report to:

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Quantis is a leading life cycle assessment (LCA) consulting firm specialized in supporting companies to measure, understand and manage the environmental impacts of their products, services and operations. Quantis is a global company with offices in the United States, Canada, Switzerland and France and employs close to 70 people, amongst which several are internationally renowned experts in the LCA field.

Quantis offers cutting-edge services in environmental footprinting (multiple indicators including carbon and water), eco design, sustainable supply chains and environmental communication. Quantis also provides innovative LCA software, Quantis SUITE 2.0, which enables organizations to evaluate, analyze and manage their environmental footprint with ease. Fuelled by its close ties with the scientific community and its strategic research collaborations, Quantis has a strong track record in applying its knowledge and expertise to accompany clients in transforming LCA results into decisions and action plans.

AGECO was created in 2000 as a spin-off from Laval University in Quebec City by a group of professors well recognized in Quebec and Canada in the domain of socioeconomic analysis applied to the agri-food sector, natural resources and the environment. AGECO performs impact assesment studies, policy and regulatory analyses, socioeconomic studies, surveys, structural analyses, studies of management tools as well as strategic channel planning. First and foremost, AGECO is a team. A team trained in economics and the social sciences, specialized in agrifood, natural and environmental resources. The team is known for its ability to understand the socioeconomic, political and strategic situations.

AGECO is a pioneer in Social Life Cycle Assessment (S-LCA) and in the implementation of the social and economic dimensions of sustainable development in all sectors of the economy. Over the last 3 years, AGECO has developed an expertise in S-LCA both in theory and practice. Members of the Group were actively involved in the development of the methodological approach through the UNEP-SETAC Social LCA working Group and acted as co-authors of the guidelines published in 2009. AGECO is now applying this ISO based approach to several projects in partnership with CIRAIG (centre of expertise in life cycle issues based at Polytechnique, Montréal) and Quantis. The trust and loyalty of our customers have led us to expand our services in Quebec, Canada, Europe, and Africa—a testament to the relevance and quality of AGECO expertise.

The Interuniversity Research Centre for the Life Cycle of Products, Processes, and Services (**CIRAIG**) collaborated on the environmental life cycle assessment. Founded initially by École Polytechnique de Montréal, in collaboration with Université de Montréal and HEC Montréal, the CIRAIG was created to meet the demands of industry and governments to develop leading edge academic expertise on sustainable development tools. The CIRAIG now includes a team from the Department of Strategy, Social and Environmental Responsibility that is located within the School of Management Sciences of the Université du Québec à Montréal (UQÀM). This team deals specifically with the social and socioeconomic dimension of life cycle assessment. The CIRAIG is the only university research centre on life cycle in Canada. It is also one of the largest internationally.

Université du Québec à Montréal (**UQÀM**) is a public, French-speaking and internationally renowned University. With nearly 1200 professors and 2300 lecturers it offers more than 300 programs to 41,000 students. Its École des sciences de la gestion has a Department of Strategy, Social and Environmental Responsibility regrouping several teachers working in collaboration with CIRAIG (Montreal Polytechnique).

PROJECT INFORMATION	
Project Title	Environmental and Socioeconomic Life Cycle Assessment of Canadian Milk
Contracting organization	Dairy Farmers of Canada
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Executive Summary

INTRODUCTION

In an effort to clarify the path towards sustainable milk production in Canada, the Dairy Farmers of Canada, in the context of the Dairy Research Cluster, commissioned the Life Cycle Assessment (LCA) of Canadian Milk.

The project's objectives were threefold:

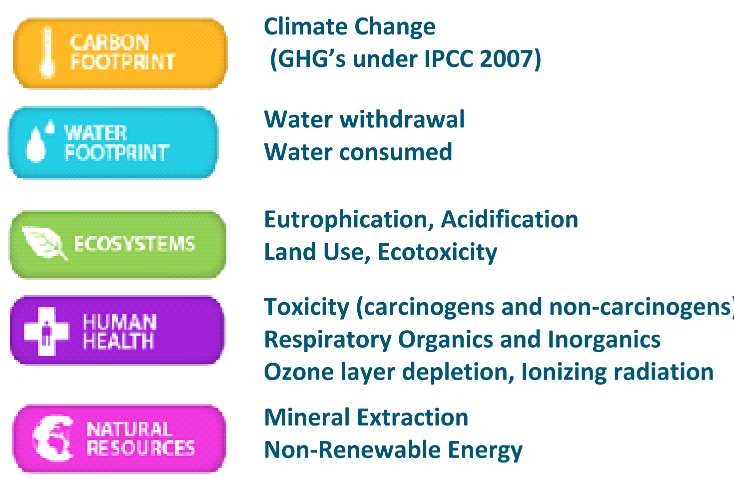
1) To evaluate the environmental and socioeconomic impacts of dairy production in Canada;

2) To identify potential areas of focus for further improvements of the dairy sector's sustainability;

3) To provide the framework and the building blocks to support comparison and benchmarking.

The Life Cycle Assessment

In the last decade, the importance of sustainability and the potential impact associated with products and services has sparked the innovation of methods to better understand, measure and reduce potential impacts caused at different steps along the way. The leading tool developed is also the only tool that takes a comprehensive approach including all life cycle stages of materials involved, and their impact. Life cycle assessment (LCA), within an ISO standard framework, is an internationally recognized approach that evaluates the potential environmental and human health impact associated with products and services throughout their life cycle, from raw material extraction, including transportation, production, use, and end-of-life treatment. Among other uses, LCA can identify opportunities to improve the environmental performance of products at various points in their life cycle, inform decision-making, and support marketing and communication efforts.



Environmental performance is one aspect to consider in regards to sustainability. The product's socio-economic performance counts as well. A Social Life Cycle Assessment (S-LCA) has hence been performed to assess the socioeconomic performance of the Canadian dairy sector. A S-LCA focuses on businesses' behaviour and on the relationships they have with their stakeholders, such as their workers, the local community, their business partners, etc. This tool aims to evaluate the degree of social responsibility of businesses, here the Canadian dairy farms, towards their stakeholders by using a set of socioeconomic indicators related to a list of social issues of concern, going from working conditions and local engagement, to animal welfare and agroenvironmental practices. S-LCA's life cycle perspective also involves evaluating the risk of encountering social risks among the sector's upstream suppliers, which could harm the sector's reputation. S-LCA is a new tool based on the UNEP/SETAC's Guidelines for social life cycle assessment of products published in 2009. This socioeconomic assessment, which is a first in the dairy sector, is based on a unique, innovative and accomplished assessment framework.

METHOD

Environmental LCA

The environmental LCA follows a strict set of rules and guidelines that are detailed below. Potential impacts on the environment were evaluated with a regionalized characterization of impacts whenever possible, and impacts were grouped under five categories, as seen in the diagram above.

The scope of evaluation considered begins with the extraction of all raw materials (called "cradle") required along the life cycle, for each stage included in the scope. For this study, the scope was limited to the main sources of impact, from "cradle to farm gate", plus transportation to processing plant, as pictured in the figure below.

IDF Guidelines & ISO 14040-14044

In 2010, the International Dairy Federation (IDF) released "A common carbon footprint approach for dairy, the IDF guide to standard lifecycle assessment methodology for the dairy sector". The goal of this document was to enable comparable evaluation of carbon footprints that could help benchmark different studies and understand the variable contributions to climate change impact.

The environmental LCA presented here follows the IDF Guidelines on carbon footprints, which in turn follows guidelines of the ISO standards on LCA ISO14040-14044, with a more prescriptive approach to certain methodological choices, such as scope and allocation methods. In compliance with ISO standards, a full report is available, and stakeholders were consulted along the entire duration of the project.

Data Sources

The environmental LCA benefitted from many sources of quality data, while also linking with many collaborators along the way (Table 0-1). The main sources are listed in the table below. Additionally, commercial feed companies contributed information, as well as fertilizer distributors. Provincial regulations and publications were used to determine fertilization rates when information was not available.

As with any study, some information is less accessible or not existing. The major limitations in this study were around manure spreading and fertilization practices. Additionally, quantities of feed given varied greatly in some Provinces and were not available in others, hence feed quantity was recalculated to vary based on milk produced.

Table 0-1 - Main sources of data

Source of Information	Data Provided
Cost of Production Surveys (ON, QC, NB, NS, PEI) **Mail Surveys** (AB, ON)	Feed grown and purchased Manure practices, pesticide use Herd size, milk produced, fat and protein content Energy consumed, water consumed
Articles, mostly: Sheppard et al. (2010) Sheppard et al. (2011)	Diet proportion (%), manure storage practices Fertilizer used in each province, ammonia emissions at farms
Provincial associations (most)	Transportation distances for milk Purchased feed sources Manure spreading tendencies
Statistics Canada (online)	Provincial crop yields, average crop surfaces per farm Herd size, milk production

Social LCA

Social LCA is a new approach that is not yet subject to ISO specific rules. The methodology rather follows the UNEP/SETAC's Guidelines, which in turn were based on ISO 14040-14044. These Guidelines describe the concepts and identify the main steps of implementation to conduct the S-LCA, but do not define any particular assessment methodology. The S-LCA perspective is described below, followed by the presentation of the assessment frameworks developed in this project to assess the socioeconomic performance of the Canadian dairy sector.

The S-LCA perspective

Similar to an Environmental LCA (E-LCA), an S-LCA evaluates the socioeconomic performance of a product at the different stages of its life cycle, from "cradle to grave". But instead of measuring the potential impacts of physical processes, this tool assesses businesses' behaviours to establish their socioeconomic performance with respect to their main stakeholders in regards to different social issues of concern.

The UNEP/SETAC's Guidelines provide the basic framework to conduct such assessment. It identifies for example the groups of stakeholders to include in an S-LCA (Figure 0-1) and proposes a list of issues of concern to document at each stages of the life cycle. As it does not, however, provide a particular assessment framework, a specific one has been developed for this project that is compatible with the guidelines.

Figure 0-1
Stakeholder categories

The assessment frameworks

The product system used in the assessment was similar to the one defined in the E-LCA section, with the difference that the assessment focused on behaviours rather than on processes. The main businesses involved in the system were identified, starting with the dairy farms and their organizations to also include their main upstream suppliers.

More specifically, a detailed analysis – called Specific Analysis – was conducted of Canadian dairy farms and their Boards. The aim of this framework was to provide a detailed analysis of the socioeconomic performance of the dairy sector by assessing the degree of its social responsibility towards its stakeholders. Behaviours were documented using primary data collected through surveys completed by over 300 dairy farmers located in six provinces, as well as by the dairy Boards. More than 20 issues of concern were documented using around 40 socioeconomic indicators (Figure 0-2).

The documented behaviours were assessed using an evaluation scale to determine their level of social responsibility (Table 0–2). Performance Reference Points (PRP), or thresholds, have been identified in each case to determine the socioeconomic performance of all particular behaviours. The description of each indicator and PRP is available in the full report.

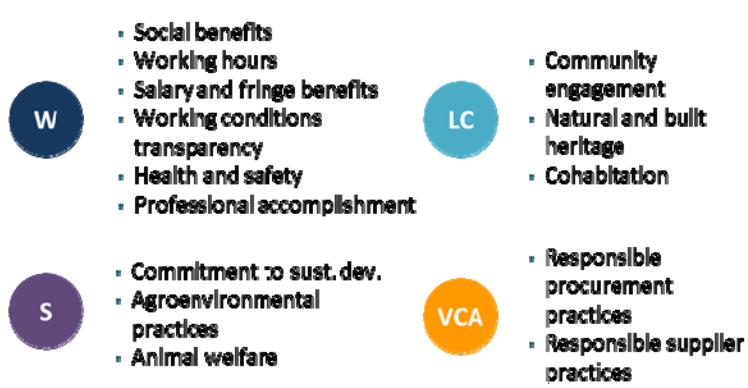


Figure 0-2 - Issues of concern documented at the farm level

A Potential Hotspot Analysis (PHA) has been performed over the Canadian dairy sector's upstream suppliers. A PHA assesses the risk of encountering behaviours going against accepted social norms among the enterprises being part of the system's supply chains. The PHA has been conducted to provide a preliminary overview of the social issues found among the Canadian dairy sector's main supply chains to bring awareness over the socioeconomic risks related to current procurement practices and to point out issues for which deeper analysis is needed.

Table 0-2 - Behavioural responsibility evaluation scale

The assessment of the socioeconomic performance ofCanadian dairy farms and their Boards has been conducted using the following behavioural responsibility evaluation scale:

Risky behaviour	Compliant behaviour	Proactive behaviour	Committed behaviour

A **risky behaviour** is considered as a hazardous practice that can cause significant damages or create serious problems to the concerned stakeholders.

A **compliant behaviour** refers to a normal and expected practice. It corresponds generally to a minimal legal requirement or simply to an absence of initiative or commitment in situations where it is not required.

A **proactive behaviour** translates to an in-between engagement; the business goes beyond legal requirement, but has not yet reached a leading behaviour.

A **committed behaviour** is considered as the most socially responsible practice a leading enterprise could reach. It is a leading behaviour.

Table 0-3 - PHA's risk evaluation scale

Low risk	Moderate risk	High risk

The possibility of encountering **social hotspots** has been assessed by documenting a list of social issues of concern using generic data. PRPs, but also experts' opinions have been used to determine the risk level.

The PHA was performed using generic data, i.e. data available in national and international databases, NGOs' reports, websites, etc. According to data availability, the assessment was conducted either at a business, sectorial or national level using a risk evaluation scale (Table 0–3). The risk of encountering hotspots was identified at each stage of the system according to a list of social issues of concern related to the Guidelines' stakeholder categories.

RESULTS

Environmental Performance

The average profile of 1 kg of milk produced in Canada can be summarized with the numbers below:

Footprint of 1 kg of FPCM

CARBON FOOTPRINT	1.01 kg CO_2e
WATER FOOTPRINT	20 L
LAND USE	1.7 m²

Equivalent impacts (non life-cycle)

6 km driven with a car

a 2 minute shower

0.5 kg of wheat
(1-2 breads)

Potential Impacts over the Life Cycle

In order to understand what contributes to the potential impacts and how these contributions vary, results are detailed by category below.

Climate Change

The spread of greenhouse gas emissions was in line with similar publications. While energy, transportation and buildings and equipment had little impact (8% of the total), the most important emissions were caused by methane and nitrous oxide emissions, occurring, in decreasing order, from enteric fermentation, manure storage and feed fertilization (Figure 0–3).

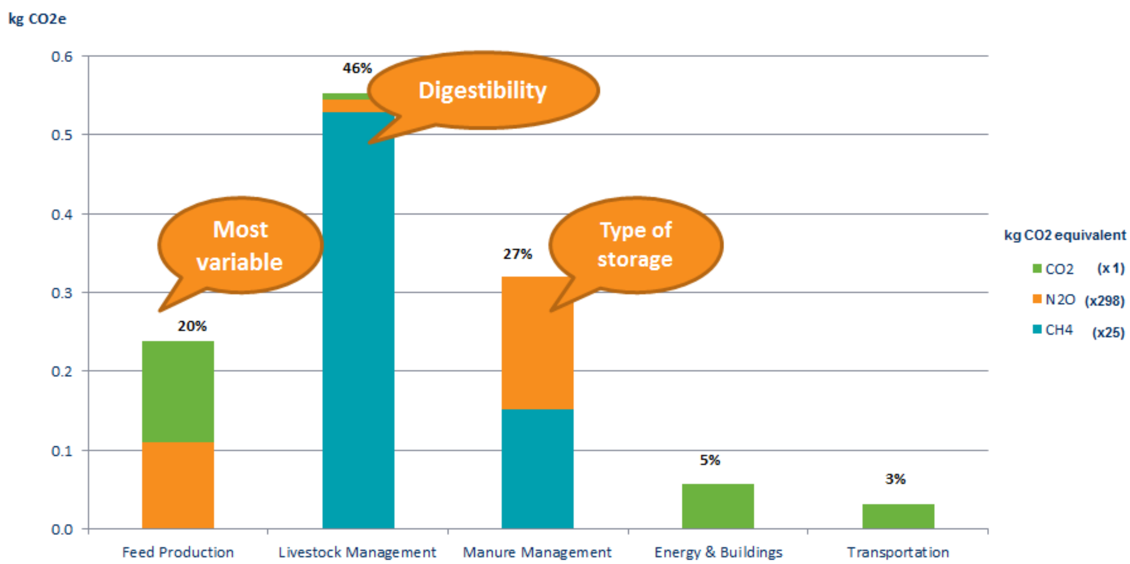
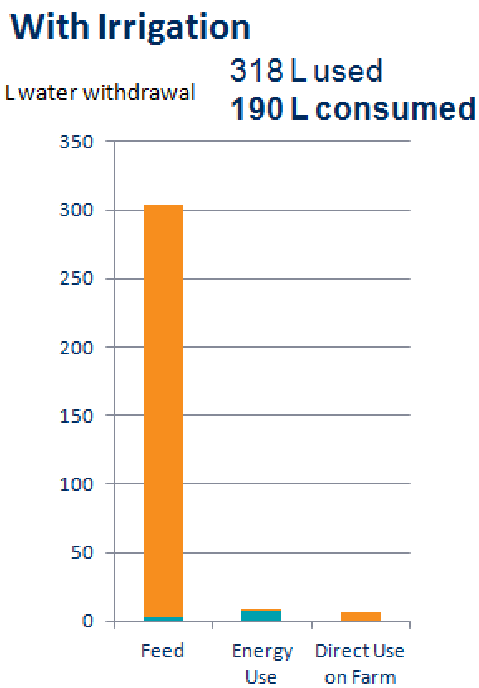


Figure 0-3 - Spread of GHG Emissions

The results overall varied with respect to different types of manure storage, with digestibility, with concentrates for example having a higher digestibility than forage, and last but not least, with the highly variable practices with respect to fertilization in feed production. Manure spreading and incorporation techniques and concentrations, matched with different synthetic fertilizer types and concentrations, as well as spreading techniques, varied greatly and inconsistently, leaving room for a better follow-up and guidance.

Water Consumption

The water footprint of milk production in Canada varies greatly from one farm to another, between 11 L and over 200 L of consumed water with a weighted average of 20 L, however with most farms being at the lower end of this scale. An example of each case is shown in Figure 0–4. Feed produced in regions using irrigation (1.2 %) contributes greatly to the overall footprint. For farms using non-irrigated feed, only a part of water consumption is linked to direct on farm use (drinking and cleaning), while contribution is also linked to water evaporated during energy production, for use at various stages of the life cycle. For this reason, energy efficient practices at the farm also contribute to reducing the water footprint of milk.



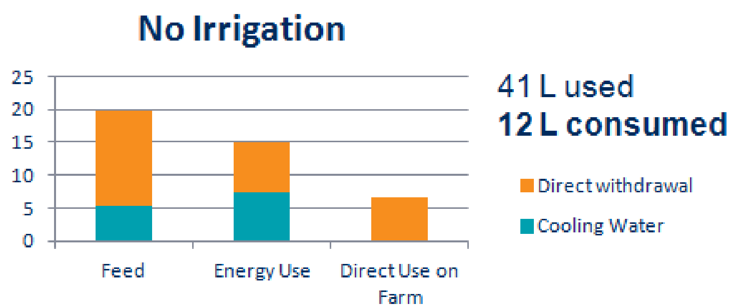


Figure 0-4 - Water withdrawal at different stages, examples with and without irrigation

The footprint of energy also fluctuated importantly between provinces, mostly due to a changing grid mix. Variability also resulted from geographical location, with nitrous oxide emissions from soils being much higher in humid provinces (Eastern Canada and BC) than in the prairies.

Ecosystem Quality

When evaluating potential impacts on ecosystem quality, different categories of environmental indicators were evaluated, with land use, as the main threat, with some potential impact from the use of mineral supplements on ecotoxicity. Impact on biodiversity from ecotoxicity as well as arable land use are both sensitive to geographical location. The latter for example, measuring potential loss in biodiversity, was much more important in areas of dense industrial and agricultural activity (Figure 0–5).

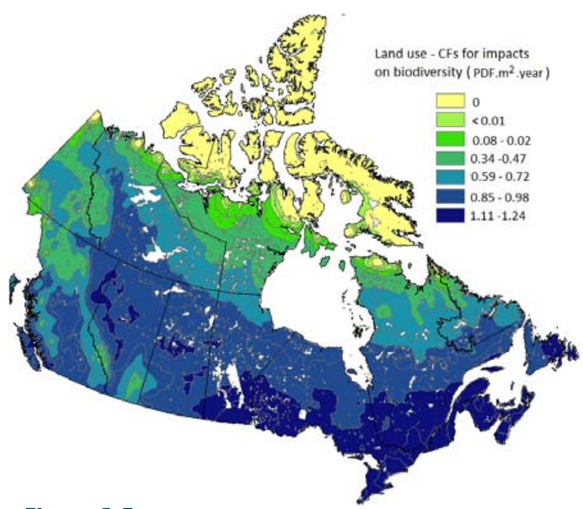


Figure 0-5
Potential impact on biodiversity from land use

Ecotoxicity can occur through a leaching effect, as a result of metals contained in feed. While most of the minerals contained in feed are assumed to be in a closed-loop system where the minerals contained in manure are spread on crops and absorbed by them to be returned to the cow, mineral supplements added in dairy rations are assumed to represent the share of minerals that is lost in the system (through leaching and soil accumulation) and must be compensated. Due to a high uncertainty in the fate of the mineral supplements as well as in the impact model for metals in ecosystems, the potential impact is evaluated in a sensitivity scenario only.

Human Health

Impacts on human health are dominated by the emissions of ammonia from fertilizers, in housing and from manure storage. Impacts also exist along the supply chain in relation to fossil fuel combustion (emissions NO_x, SO_2, hydrocarbons) in electricity production and direct use. Additionally, potential impacts of toxicity also exist in relation to mineral content of manure, when spread on crops not used in feed. Zinc, most notably, is a substance that bio-accumulates over time and can prevent absorption of other essential minerals. The inclusion of mineral supplements is once again only evaluated as a sensitivity analysis.

Resource Depletion

Depletion of non-renewable resources, such as fossil fuels and metals, is also evaluated in an LCA. Feed production is once again responsible for most of the impact (75%), however resource depletion occurs upstream of the farm, in equipment manufacturing and diesel production.

Benchmarking

Looking at the carbon footprint of milk, compared to alternative publications, Canada places among the top, next to New Zealand and along with France and Sweden. While New Zealand operates a particularly extensive pasturing system, France and Sweden also benefit from cooler climates that prevent important methane emissions from manure, and from relatively clean grid mixes. Some variability can result from methodological choices. Meanwhile, the US and the Netherlands find higher footprints, both using more intensive agricultural practices with an important contribution of feed from corn, a high-impact crop. The US has a much higher footprint from manure management, due to liquid storage in warmer climates. With regards to Water Footprinting, a few publications are available that allow for benchmarking. Mainly, a French publication from l'Institut de l'élevage (2012) places the French milk's water footprint at 17 L/kg. A publication by Mekonnen and Hoekstra (2011) evaluates a few more, with the Chinese footprint at 132 L/kg, the Indian footpring at 148 L/kg and the Dutch at 42 L/kg. The variability is entirely a function of irrigation, with large countries composed of different climates demonstrating higher footprints.

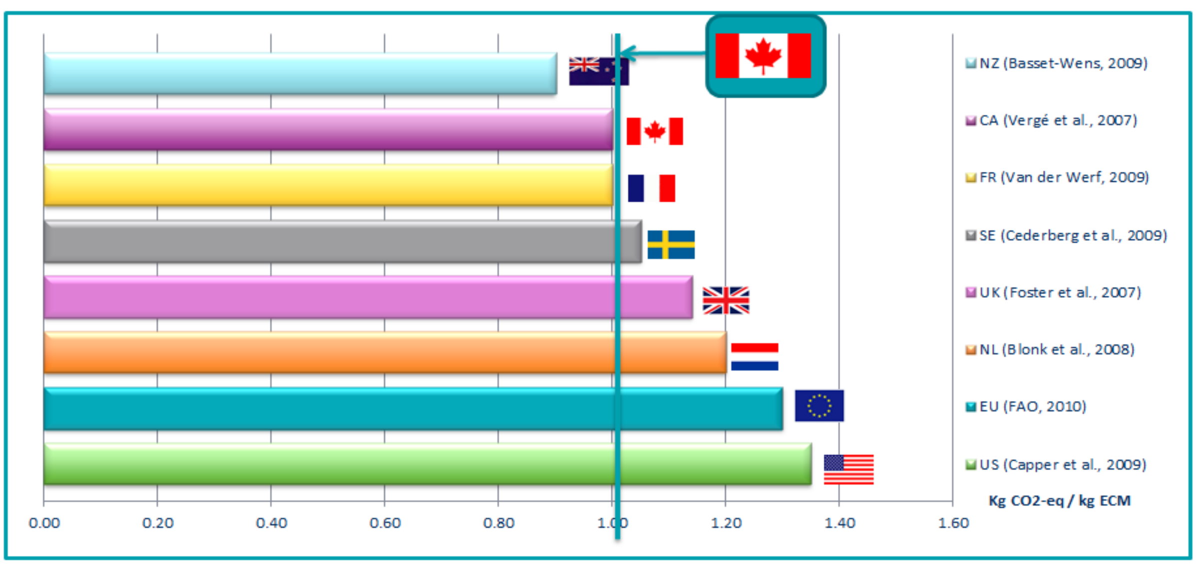


Figure 0-6 - Benchmarking of carbon footprint

Although it would be interesting to compare results with nutritional alternatives, such as soy milk and other animal proteins, doing so on a per kg basis is irrelevant, with a nutritional content so variable. A project beginning in June 2012 will attempt to define the most relevant way to compare the environmental impact of nutritional alternatives to milk. Stay tuned for further developments.

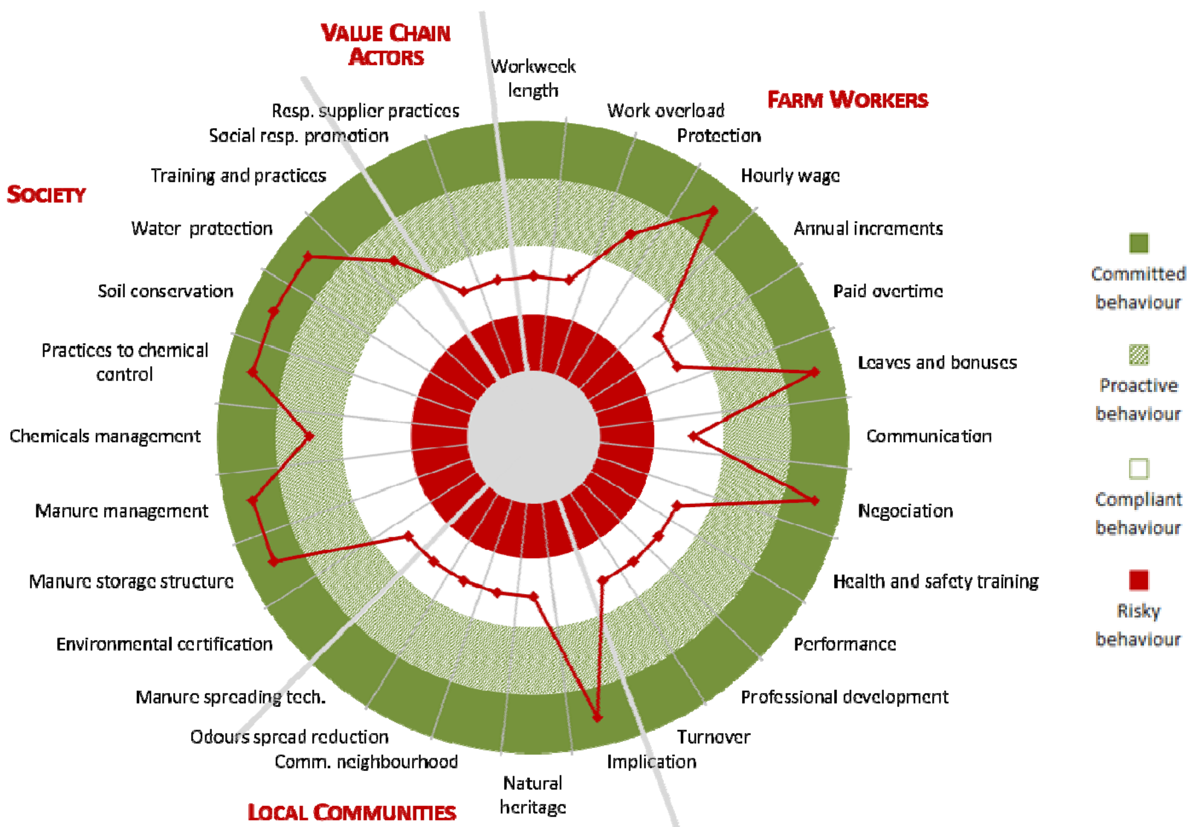
The socioeconomic performance

The socioeconomic performance of the Canadian dairy sector can be portrayed in two ways. By describing the sector's socioeconomic contribution on the one hand and by providing a preliminary overview of the social risks found among the sector's supply chains on the other hand.

The Canadian dairy sector's socioeconomic contribution

The economic contributions of the Canadian dairy sector are well-known. For example, in 2009, the sector's activities have generated over 127,000 direct, indirect and induced jobs, contributed approximately 7.2 B$ to the national GDP and procured almost 1.4 B$ in total tax revenue.

But there is more. Canadian dairy farmers are also corporate citizens whose behaviours – individually and collectively – impact their stakeholders. This S-LCA provided a detailed picture of this socioeconomic performance. Figure 0–7 shows the average socioeconomic performance of Canadian dairy farms towards their stakeholders, i.e. the farm workers, their local communities, the society and their suppliers and business partners (including the consumers).



* Due to data availability, a proactive behaviour was not assessed for these indicators.

Figure 0-7 - The average socioeconomic performance of the Canadian dairy farms

It is made clear from this assessment that Canadian dairy farms have an overall positive performance. It is furthermore obvious with respect to the agroenvironmental practices, whether it concerns water sources protection, manure storage or soil conservation. If this commitment is obvious from an environmental point of view, it is also significant in a socioeconomic perspective, as it also meets the Canadian society's expectation. Dairy farmers' engagement towards their local community is also significant, the vast majority being involved in their communities in many different ways. However, more could be done in terms of cohabitation, with producers adopting practices minimizing odours propagation.

The picture is also contrasted in regards to farm workers. Although dairy farmers provide overall working conditions that go beyond labour standards – to which they are mostly not legally subjected – there is room for improvements regarding various issues, such as professional training and communication of working conditions. The same holds true with respect to their suppliers and business partners, given that a majority of dairy producers do not usually consider their suppliers' performance in regards to social responsibility in their procurement decisions.

The results present only the average performance. For each of these issues, there are producers having more socially responsible practices than others (Table 0–4).

Table 0-4 - Average score and variability of answers at the farm level; the case of local community

LOCAL COMMUNITIES		VARIABILITY	SCORE
Community engagement	Implication within the community		
Natural and built heritage	Preservation of natural and built heritage		
Cohabitation	Communication with the neighbourhood		
	Odours spread reduction		
	Manure spreading technology		

This suggests that there is always room for improvements, now and in the future. For example, with more producers adopting more socially responsible practices, the average socioeconomic performance could be enhanced. Moreover, given that a committed behaviour today can become a minimal expectation in the future, continuous improvement from all producers is also required to improve, but also to preserve the sector's socioeconomic performance

Since Dairy Boards fulfill many tasks on behalf of dairy farmers in areas such as R&D and sponsorship, their behaviours were also assessed for some issues of concern. Table 0.5 portrays their level of social engagement towards the stakeholders with which they interact.

Table 0-5 - Average score and variability of answers at the Boards level

	ISSUES OF CONCERN	VARIABILITY	SCORE
LOCAL COMMUNITIES	Milk donation*		
	School milk*		
	Scholarship*		
	Sponsorship		
SOCIETY	R&D		
	Promotion of sust. development		
	Animal welfare		
VALUE CHAIN ACTORS	Promotion of social responsibility		

** As these actions come under the provincial scope, the DFC's practices have not been taken into consideration.*

** Gray zones are behaviours that were not assessed due to data availability.*

* Grav zones are behaviours that were not assessed

The assessment also demonstrates that the Canadian Dairy Boards are in average committed corporate citizens, especially in regards to local communities, as most of them support milk donation, scholarship and sponsorship to local organizations, even if these actions are not always part of a formal policy or agreement. Last year, Dairy Boards granted directly over 3.4 M$ to their local communities, in addition to milk donation and participation to other initiatives. They are also committed relating to society by funding research in areas such as public health, nutrition and environment. Over 4.5 M$ was directly invested last year in such activities, not including participation to other research clusters.

The assessment also pointed out issues for which dairy Boards could be more committed. This is the case for example with regards to the promotion of sustainable development and social responsibility, since only a minority of Boards hold formal commitments or have partnerships in those fields and grant resources to realize them. The same can be said in regards to the animal welfare issue. While the DFC have set up, in collaboration with the National Farm Animal Care Council, a Code of Practice to support and supervise producers, it has not been yet audited. And if provincial Boards provide trainings and support material on the subject, none have either set up a certification, a set of specifications or an audit system to complement this national initiative.

Overview of the supply chains

Finally, the study also looked at social risk potentially present in the suppliers upstream of the dairy sector, such as manufacturers of machinery, fertilizers, pesticides or pharmaceuticals. The main suppliers being located in Canada or the United States, the prevalence of social hotspots is generally lower than in countries such as China. The fact remains however that some risks seem present in a few links of the supply chains. This is the case in the fertilizer and oil extraction industries for example, where it was possible to document disturbing practices of collusion as well as bank rolling techniques from subsidiary companies of some major players. Potential hotspots were also identified in the North American grain and oilseed sector with regards to working conditions, as they are generally not protected by labour standards. The analysis also brought up public health issues, as well as conflicts of use of natural resources related to many industries, among which the pesticides and pharmaceutical sectors. Some links are also characterized by a lack of competition. Although the Canadian dairy sector has little power to influence these actors located far upstream, in a life cycle perspective, it falls under the responsibility of dairy farmers and their associations to get involved. This assessment can be seen as a starting point in this direction.

Conclusions

Overall, the LCA indicated an existing commitment from dairy producers to the supply chain's sustainability, which characterizes to an overall good performance – both at the environmental and socioeconomic levels. On an international level, Canadian milk places very well, with a relatively low carbon footprint and a water footprint among the best in provinces where there is no irrigation. While there is no available benchmark to compare the sector's level of social engagement, the assessment shows that Canadian dairy farms and their Boards are already socially committed corporate citizens in regards to many social issues.

An existing commitment to agroenvironmental practices, as identified in the S-LCA, suggests that evolving environmental recommendations could help sustain best practices and lower impact. With continuous improvement in mind, target areas were identified. Among them is the possibility of better tracking of fertilization practices at the farm and to improve manure storage. It would be also profitable to provide guidelines on feed, based on impact. In a more socioeconomic perspective, it could be beneficial to promote more actively socially responsible behaviours among farmers, their Boards and eventually, their suppliers, to improve the sector's socioeconomic performance and, ultimately, its overall sustainability. This assessment provides the sector with an innovative, comprehensive and actionable roadmap to move in this direction.

LCA helps put everything in perspective, in a comprehensive and objective manner. It sheds light on where and how to improve. Specifically, this environmental and socioeconomic assessment was conducted to support the Canadian dairy producers, individually or collectively, in their decision making by introducing new parameters to consider in producing milk in an economically efficient, environmentally sustainable and socially responsible way.

The results and conclusions presented here are valid only within the context of this study. Consideration of the boundaries and assumptions is imperative when using the information provided in this document.

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Abbreviations and Acronyms

CH_4	Methane
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
DALY	Disability Adjusted Life Years
FU	Functional unit
GHG	Greenhouse gas
GWP	Global Warming Potential (in general in g or kg of CO_2-eq)
Kg	kilogram = 1,000 grams (g) = 2.2 pounds (lb)
kWh	Kilowatt-hour = 3'600'000 joules (J)
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MJ	Megajoule = 1,000,000 joules
NOx	Nitrogen oxides
PDF*m^2*year	Potentially Disappeared Fraction per Square Meter of land per Year
PHA	Potential Hotspots Analysis
PM2.5	Fine particles
PRP	Performance Reference Point
RER	Europe (in ecoinvent)
SHD	Social Hotspots Database
SIA	Social Impact Assessment
S-LCA	Social life cycle assessment
T	Metric tonne (1,000 kg)
U	Unit process

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Additionally, thanks to the support of DFC, IDF and IDF Canada, the project was allowed to shine on a national and international platform.

Media	Event / Publication	Date
Conference	LCA XI, Chicago, USA	October 7, 2011
Conference	Summilk, Parma, IT	October 19, 2011
Conference	Networking Days – Dairy Research Cluster	November 16, 2011
Conference	IDF Water Footprinting Workshop, Brussels, BE	February 14, 2012
Article	Le Producteur de Lait Québécois	To come (Fall 2012)
Conference	LCA Food, Saint-Malo, FR	September (2012)
Article	The Milk Producer	September 2012

1. Introduction

In the last decade, the importance of sustainability and the potential impact associated with products and services has sparked the innovation of methods to better understand, measure and reduce potential impacts caused at different steps along the way. The leading tool developed is also the only tool that takes a comprehensive approach including all life cycle stages of materials involved, and their impact. Life cycle assessment (LCA), a method defined by the International Organization for Standardization (ISO) 14040-14044 standards, is an internationally recognized approach that evaluates the potential environmental and human health impact associated with products and services throughout their life cycle, from raw material extraction, including transportation, production, use, and end-of-life treatment. Among other uses, LCA can identify opportunities to improve the environmental performance of products at various points in their life cycle, inform decision-making, and support marketing and communication efforts.

The relevancy of life cycle thinking has also been translated to social issues. The social life cycle assessment (S-LCA) focuses on organisations' behaviour and on the relationships they have with their stakeholders, such as their workers, the local community, their business partners, etc. This tool aims to evaluate the degree of social responsibility of organisations, here the Canadian dairy farms, towards their stakeholders by using a set of socioeconomic indicators related to a list of social issues of concern, going from working conditions and local engagement, to animal welfare and agroenvironmental practices. The life cycle perspective also encapsulates the social risks among the sector's upstream suppliers, which could harm the sector's reputation. S-LCA is a new tool based on the UNEP/SETAC's Guidelines for social life cycle assessment of products published in 2009. This socioeconomic assessment, which is a first in the dairy sector, is based on a unique and innovative assessment framework.

There has been increasing concerns from the public and organisations as well as governmental agencies in the last ten years with respect to the emissions of greenhouse gases (GHG). Livestock production in particular has been shamed for the intensity of its contribution to GHG emissions in comparison with other food products, bringing further scrutiny to the bovine industry. In the last few years however, there has been increasing concern surrounding the water footprint of products and the water risks related to a global supply chain. Biodiversity is also becoming increasingly important as part of the sustainability debate (IDF, 2009).

LCA encapsulates all the aforementioned issues as well as the potential impacts on ecosystems and human health impact associated with the life cycle of products and services, beginning with raw material extraction to the end-of-life treatment, including all intermediate steps such as transportation, processing, and use, when relevant. Among different uses, LCA helps identify opportunities to improve the environmental and socioeconomic performance of products at various points in their life cycle, inform decision-making, and support marketing and communication efforts.

In an effort to clarify the path towards sustainable milk production in Canada, the Dairy Farmers of Canada, in the context of the Dairy Research Cluster, commissioned the Life Cycle Assessment (LCA) of Canadian Milk.

The project's objectives were threefold:

1) To evaluate the environmental and socioeconomic impacts of dairy production in Canada;

2) To identify potential areas of focus for further improvements of the dairy sector's sustainability;

3) To provide the framework and the building blocks to support comparison and benchmarking.

Data from over 300 farms was collected along with provincial averages to achieve the average socioeconomic and environmental profile of milk production in Canada. The results of this project are intended for internal use by the Dairy Farmers of Canada to help understand the contribution of practices to the different potential impact on the environment, and take advantage of opportunities for improvement of performance. The LCA is a first step towards a comprehensive strategy towards sustainable development. It was conducted at a macro level to profile average Canadian milk production while taking into account the geographical influence into the results, yet without capturing all possible scenarios existing in Canadian farms. Communication outside the DFC should be conducted with caution and transparency.

This report is divided into 5 chapters that include a Literature Review (chapter 2), the Goal and Scope of the study (chapter 3), an Environmental LCA Results section (chapter 4) and a Social LCA Results section (chapter 5).

2. Literature Review

A review of relevant literature (LCA studies or similar) related to the dairy farm and feed production was performed at the beginning of the project, to orient methodological decision and data collection. This process identifies the different initiatives and the work already performed on a global perspective with regards to environmental and social analysis of the life cycle of milk production.

For this purpose, a systematic review within the various databases and search engine identified relevant publications and initiatives. The research was limited to publications released after 2000. The review also excluded studies that did not take into account the life cycle of major elements related to on-farm activities and its supply chain. LCA is a tool designed for assessing global and systemic benefits and weaknesses of the different initiatives that can be put into practice on a farm or production system. Amongst the different foods products evaluated using LCA, dairy products are the most common subjects of these studies (Basset-Mens, 2008).

Although many LCA studies have been published over the last ten years evaluating dairy products, the great majority of these only take into account greenhouse gases, a limiting aspect in research comparison.

2.1. Initiatives from corporations, governmental agencies and associations

The International Dairy Federation has been raising awareness for several years with its members at its general meetings and through publications. It published guidelines on LCA with focus on carbon footprinting in 2010 (IDF, 2010) following a literature review on the subject (IDF, 2009) and ongoing consultation with participating countries. The review identifies 25 international initiatives, including those of governments and distributors / retailers (e.g. Wal-Mart, Ben & Jerry's, Tesco, Sainsbury, Marks & Spencers) whose objective is to establish mandatory standards. It should be noted that while almost all the initiatives listed consider GHG emissions, some of them simultaneously address other major impact categories according to the holistic vision of LCA. They are based mostly on partial or simplified LCAs.

Apart from these initiatives, many associations of milk producers and governments have already reported the results of LCA's of milk production, including the European Dairy Association, who commissioned a carbon footprint across the EU dairy sector (Sevenster and De Jong, 2008), as well as the Swedish Dairy Association, the Australian Dairy, and the US Dairy Management Inc. In France, an upcoming policy (originally planned for 2011 but delayed) towards environmental labelling of products under the “Grenelle Environnement” has accelerated the implementation of LCA in different consumption products, including food and dairy. An LCA surveyed dairy production on 60 farms in the Britanny region (Roger et al., 2007). Furthermore, the FAO also completed a carbon footprint in 2010 (FAO, 2010) with a global perspective over the entire supply chain. Because of the wide scope of the study however, numerous assumptions and generalisations were needed.

Companies having performed and communicated on LCA’s of their dairy products include Danone in France (Dupré, 2005), Arla in Sweden and Denmark (Larsson, 2005), Fonterra in New-Zealand through a national investigation (Lundie et al., 2009), Aurora Organics in the US in 2007 (Hello et al., 2008), Cadbury in England in 2008 (Cadbury, 2009). In Canada, Liberté has been active in LCA for many years and publishes information on their website (Liberté, 2012). These studies are sometimes limited to a few farms only, which does not imply a small herd, as the Aurora Organics study involved six farms only and a total herd size nearing 12,000 cows.

Meanwhile, comparing LCA studies and results is always a difficult exercise because of the different methodological choices to make, the boundaries of the system evaluated, and the choice of data sources (and quality). This reality has been pushing for more prescriptive guidelines in the different product sectors, usually referred to Product Category Rules, which, with respect to the dairy industry, has translated into the Guidelines published by the IDF.

For the purpose of the current study, it is more relevant to focus on studies performed for governmental agencies and associations, which were driven by similar interests as the current study, looking at a wide variety of farms and practices. A summary table of the literature review is available in Appendix. Conclusions follow.

2.2. Main conclusions from literature review

The literature confirmed LCA as the only approach recognized as being capable of accounting for all environmental impacts linked to dairy production. It is the most scientifically sound and complete tool to calculate environmental impact of dairy production and to report them in a summarized process that can help decision making, regardless of the scale (single farm level or industry level).

When looking at a global assessment of dairy production, regional variations in GHG emissions per kg milk are predominantly driven by differences in farming systems (FAO, 2010). According to this regional comparison, Canada places second in lowest carbon footprint, just behind Latin America. However, the two systems are not comparable as production per cow in Latin America is less than half of the production of Canadian cows.

There is little to no literature surveying the social or socioeconomic aspects of sustainability in dairy. The need to do so has been noted in certain documents, such as in the Life Cycle Initiative programme for the United Nations (Griesshammer *et al.*, 2006) and the IDF review of literature which noted that “*Future research will possibly enable inclusion of social issues in LCA to create a new impact category. The social conditions of workers could be accounted for at farms as well as dairies or retail phase.*” (IDF, 2009).

2.2.1. Impacts

Certain impacts are not well captured in the three different areas of protection (ecosystems, human health, and resources) because of limited characterization methods. These impacts should not be overlooked and can be reported separately, such as is the case with land use and its potential impact on biodiversity.

2.2.2. Functional Unit

Many studies use a volume or mass of milk with a correction factor for fat and protein content, which is necessary to allow for fair comparison between the LCA results of one farm and sector averages. Many studies also refer to a secondary functional unit, using a surface of land used, especially for referencing impact such as acidification eutrophisation. (Haas, 2001; Basset-Mens, 2005; Kanyarushoki *et al.*, 2008). The most recent FAO and DMI studies specifically chose a Fat and Protein Corrected Milk equations that was adopted as the standard by the IDF in their guidelines.

2.2.3. Allocation

To split the impact linked to the production of coproducts, a relation must be quantified between the coproducts. One of the methods often used in literature is economic allocation, based on relative prices of coproducts. Because of regulatory context and market variability globally, economic allocation is not recommended for the dairy sector (Swedish Environmental Management Council, 2006). Many studies, however, have establish the milk and meat allocation based on the biologic energy needs required for the production of each (Cederberg and Mattsson, 2000; Eide, 2002; Basset-Mens *et al.*, 2005; Heller *et al.*, 2008) and this choice of this practice was confirmed by the recommendations of the IDF guidelines (IDF, 2010). The FAO study however chose to allocate milk and meat based on protein content.

2.2.4. Exclusions

The scope of studies varies, generally with respect to the inclusion of steps beyond the farm. In LCA, scope can vary this way, based on the purpose of the study. Meanwhile, in dairy production, studies have long confirmed that most of the impact happens at the farm. The FAO study evaluates the contribution of the farm activities to over life cycle GHG emissions at 93% on average globally, and between 78 and 83% in industrialized countries (FAO, 2010).

Certain specific practices were stated at times in the exclusions. For example, cows can be kept on location beyond the point where their productivity drops in order to help control cash flow. These increases the cost and environmental impact per animal but this is neglected for lack of detailed information.

Land use change is also a topic of concern, as it is very difficult to capture this information along the supply chain. It is typically excluded from studies. The FAO evaluates this contribution to GHG as relatively low. The highest values are estimated for Western and Eastern Europe, where they account for 7 percent and 3 percent respectively of the emissions per kg of FPCM at farm gate.

3. Goal and scope of the study

This chapter describes the goal and scope of the study, along with the methodological framework of the LCA. The study has been conducted according to the requirements of ISO applicable standards (14040/14044) and the *IDF Guide to Standard LCA Methodology for the Dairy Sector*. The specific goal and scope of the S-LCA as well as the methodology used to assess the socioeconomic performance of milk production in Canada (including data collection) are described in section 5.

3.1. Objectives and Intended Application

The scope of interest is defined by the production of milk up until the point of its transformation. This investigation aims to assess the cradle-to-gate global environmental impact of average milk production in Canada, regardless of its intended use. More specifically, the objectives of the study are as follows:

I. To define the profile of environmental and socioeconomic impacts of the Canadian dairy sector over the entire life cycle.

II. To identify potential areas for further focus in improving the dairy sector sustainability.

III. To provide the overall framework and the building blocks to support comparison/benchmark of similar competitive products.

In the first step, this study will also attempt to provide a preliminary assessment of the variations between provinces and areas based on the influence of several key variables in farm practices. The purpose of the study is to serve as a first step towards a comprehensive strategy towards sustainable development. The function of interest is the production of milk in Canada from raw material extraction until it is delivered to businesses.

The results of this environmental and socioeconomic life cycle assessment are meant to be used by DFC for decision making at a macro level but also for communication purposes with all stakeholders (dairy farmers, policy makers, processors, consumers, media, etc.). The LCA results will also serve as a basis for the sustainability agenda.

3.2. General Description of the System Studied

This study evaluates the life cycle environmental impacts of Canadian milk production, from cradle-to-gate, with the gate defined by the dairy processing plant, not including transformation.

3.3. Functional unit

Life cycle assessment relies on a “functional unit” as a reference for evaluating the components within a single system and or among multiple systems on a common basis. It is critical that this parameter be clearly defined and measurable.

The functional unit for this study is:

1 kg of Fat and Protein Corrected Milk (FPCM) from a Canadian farm, to the processing facility

This study includes transportation of the milk at the gate of the processing facility, but excludes the transformation. The correction is made following the equation provided by the IDF, for a conversion to a 4.0% fat and 3.3% true protein content:

FPCM (kg/yr) = Production (kg/yr) x [0.1226 x Fat% + 0.0776 x Protein% + 0.2534]

3.4. Boundaries and assumptions

For the purposes of this analysis, the system was grouped into five principal life cycle stages.

(1) Feed Production: includes manure spreading, pesticide and fertilizer production and spreading, any energy required (diesel) for field manipulations, irrigation water.

(2) Livestock Management: includes bedding, drinking water, milking equipment cleaning products and water, ammonia emissions from housing and methane emissions from enteric fermentation.

(3) Manure Management: limited to emissions of nitrous oxide, methane and ammonia from storage.

(4) Energy and Buildings: includes electricity for dairying, cattle housing and milk parlour equipment and buildings, and gasoline for regular operations.

(5) Transportation: includes only purchased feed transportation, purchased animal transportation and raw milk transportation to processor.

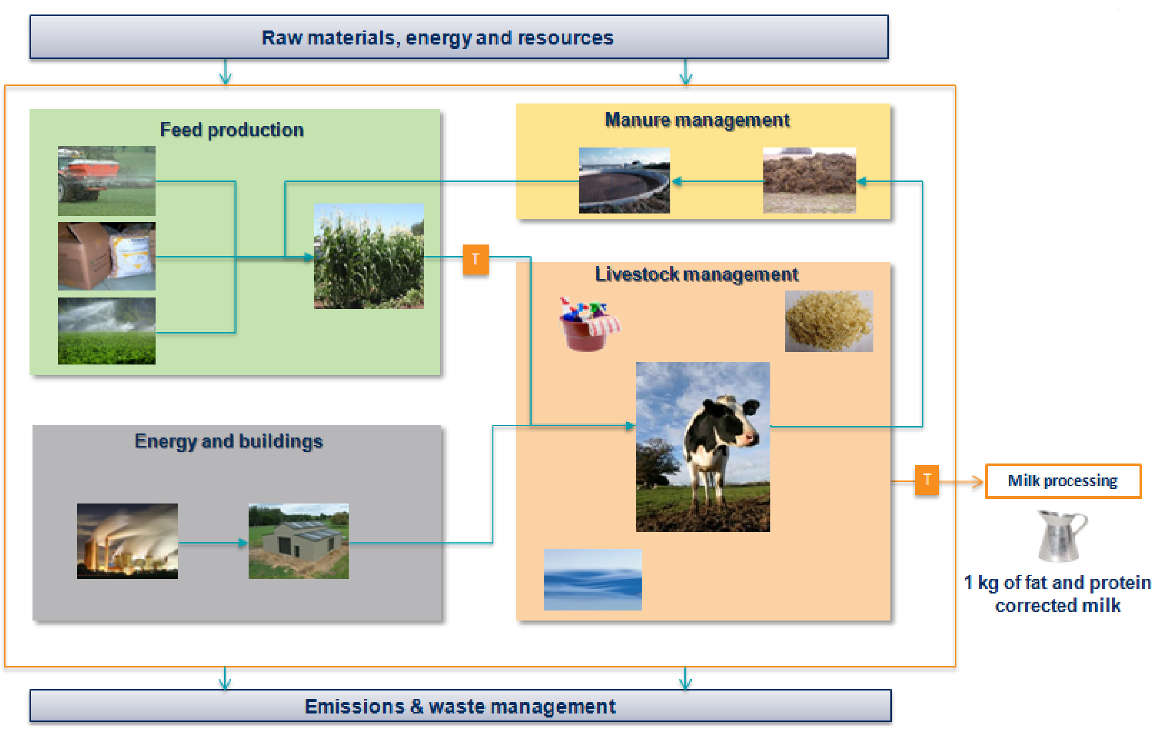


Figure 3-1 - Life Cycle System

Within each of these stages, the LCA considers all identifiable "upstream" inputs to provide as comprehensive a view as is practical of the product system. For example, when considering the environmental impact of transportation, not only are the emissions of the truck considered, but also included are the impact of additional processes and inputs needed to produce the fuel, as well as truck and tire manufacturing. In this way, the production chains of all inputs are traced back to the original extraction of raw materials, within feasible limits.

3.4.1. Temporal and geographic boundaries

This LCA is representative of milk production in Canada at the time the study is conducted (2009-2011). Data and assumptions are intended to reflect current equipment, processes, and market conditions. For direct energy consumption at farm, the electricity grid has been chosen based on the province where the activity takes place. It should be noted, however, that some processes within the system(s) boundaries might take place anywhere or anytime. For example, the processes associated with the supply chain and transportation can take place in North America or elsewhere in the world. In addition, certain processes may generate emissions over a longer period of time than the reference year. This applies to landfilling, which causes emissions (biogas and leachate) over a period of time whose length (several decades to over a century/millennium) depends on the design and operation parameters of the burial cells and how the emissions are modeled in the environment. For our models in this study, emissions are included and equally evaluated regardless of the timing of their occurrence. Based upon availability, the most recent data possible has been used, for both foreground and background data.

3.4.2. Cut-off criteria and exclusions

Processes may be excluded if their contributions to the total system's environmental impact are less than 1% or if credible information is not readily available. All product components and production processes are included when the necessary information is readily available or a reasonable estimate can be made. In cases where important information is unknown, uncertain or highly variable, it is possible to perform sensitivity analyses to evaluate the potential significance of the data gap(s) (see Section 4).

The following processes have been excluded from the study due to expected contribution lower than the cut-off criterion or lack of reliable information:

Other Manure Types

There are certain cases where dairy farms also spread other manure types, such as hog manure, onto the feed crops. Because of the particularity and great variability between farms and instances, this practice was excluded from the scope.

Prescription drugs

Because of the lack of data available on quantities and content of drugs used on farm, as well as the lack of LCA models available on prescription medication, preventing the characterisation of the environmental impacts of prescription drugs given to the livestock, these were excluded from the study. In terms of mass, they represent much less than 1%, while economically, little data is available for medication only, however vetenary, breeding and medicine costs altogether add up to less than 5%, where medicine is assumed to represent a small share of the three (Johnson & Schwartz, 2002).

However, because of medicine's role in eradicating bacteria for example, it is expected that it could have some environmental impacts however local, with ecosystems affected through water and soil emissions from effluents. There is no research available to include this chain of cause and effect to the overall impacts and this hence constitutes a limitation of the study.

Organic Farming

Organic farming is marginal in Canada, with less than 1% of farms being certified. As such, with a sample of less than 5% of all farms, the sample size is simply too small to be representative of this type of agricultural practice. Moreover, the difference in environmental profile on less than 1% of milk production is deemed insignificant. Organic farms could be present in the farms sampled, as contributors to the average Canadian milk production, however no differentiation was made.

Waste

Processes modelled using the database, such as fertilizer production, includes the waste inherent to its model. With respect to waste generated onsite, most of it is related to silage, such as the plastic wrap and strings.

When put in perspective, 1 kg of plastic wrap used on a ball of 400 kg of haylage, with its disposal, considered as landfilling, has a climate change impact equivalent to less than 1% of the impact of the ball of hay, which confirms its negligibility. The same is true with other damage categories.

Milk waste is accounted for, inhenrently, with the inclusion of all impacts generated for its production, while its disposal is added to manure storage for spreading.

Soil Carbon

In accordance with the IDF Guidelines, soil carbon was excluded from the boundaries. Despite the fact that there is an important opportunity for sequestration based on better management of soils, too much uncertainty exists on the few models established. It is not possible to use them on a nation-wide profile of the sector. As summarized by the US milk carbon footprint study (Nutter et al., 2009): "As more detailed, process based, models are incorporated into LCA, the ability to capture an appropriate portion of the carbon in biomass that is incorporated into the soil as a sequestration credit will become feasible."

3.4.3. Main Assumptions

The most important assumptions are summarized in this section.

Steady State system

The main assumption was with respect to the boundaries of the system, where “steady state” had to be assumed related to certain inputs.

For example, a few dairy cows are typically sold and purchased each year, however typically as a means to improve overall performance. For lack of better data and assuming that averaging would eliminate exceptional cases, herd numbers were assumed to remain constant throughout the year.

Forages

Hay, the main source of forage, is typically composed of a mix of grasses, such as timothy, with a legume as a source of protein, such as alfalfa, clover and birdsfoot trefoil. The mix of alfalfa and timothy is often referred to as tame hay. Although the mixes vary greatly, lack of specific data on hay composition in each region and on the behaviour of different forage mixes pointed towards the modelling of an ‘average hay’ which used available data, such as the annual yield of tame hay (Statistics Canada). According to a survey (Sheppard et al, 2011a) legume rich (>25% legume) hay was more common in the prairies (mostly) and Ontario, while BC and the Maritimes traditionally had less than 25% of legumes in hay. Quebec was in the middle, with more legumes in hay destined to silage than to dry hay. Legume content increases crude protein and N intake, however these parameters were assumed to be balanced overall in the diet.

The digestible energy (DE) of forage provides much of the needed energy for dairy cows, however, the DE is known to decrease as plant maturity increases and as fiber increases (Forage Beef, 2010). As such, the variable DE, crude protein and fiber content affects feed efficiency, enteric fermentation, and manure emissions, for which the variability was not captured and accounted for.

Fertilization

Due to the lack of specific data on manure fertilization, in combination with synthetic fertilization (survey data available for Quebec only), fertilization practices were assumed not to exceed recommended levels for each region. While uncertainty on this assumption is high, sensitivity analyses were performed to compare different fertilization scenarios.

Metal in Feed

Feed grown onfarm and supplements purchased contain different metals, some of which have the potential to bioaccumulate (eg: zinc). While metals absorbed by the cow mostly return as manure spread, supplements are almost always added to the cow’s diet, suggesting that metal uptake by plants is partial and the difference is emitted to the soil. Minerals lost in this cycle must then be compensated in the cow’s diet through supplements.

Because of the high uncertainty in this fate model, as well as in the impact assessment method, the impact modelling of these emissions are only evaluated in a sensitivity assessment.

Manure

Based on the data samples, inports (between farms) and exports of manure are deemed negligible, such that all manure produced by the dairy cows is spread onto the crops produced onsite. These crops are not limited to the crops produced for the feed of the dairy cows, but include the total area used for the basic crops (hay, corn, grains and soy).

Weight of cows

Since over 90% of cows (Personal communication with D. Gilbert, AGECO) are Holstein by race, average weights for Holstein cows in Canada were retained. These values were used to calculate the weight of meat produced with culled cows, in accordance to the IDF's guide (IDF, 2010). For the adult cows, median weight was assumed to be 600 kg. Calves sold for meat were assumed to weight 200 kg, which is more representative of milk-fed calves (farmissues.com, 2012), as oppose to heavier grain-fed calves, yet is more representative of the system studied, where feed required to feed calves for meat is excluded.

Source of Feed Purchased

While a percentage of feed is usually purchased, typically from local commercial feed retailers, the feed purchased can come from different locations. While distances travelled were approximated following conversations with provincial associations, no data from origin was precise enough to base modelling from a mix of provinces. As a result, feed consumed in one province is assume to come from the same province, with its yield and its fertilization practices, emission factors of nitrous oxide, etc.

3.5. Allocation procedures

Allocations method used were in accordance to the IDF Guidelines (IDF, 2010).

For byproducts in feed production, such as canola meal and corn distillers grain, an economic allocation was used to allocate impact between the different products. Because of their variable cost and their small contributions (less than 5% of total feed), the default economic allocation model in ecoinvent was kept (not adapted to local values).

For the impact between milk and meat was allocated using an equation developed based on energetic needs (physical allocation).

Allocation Factor = 1 – 5.7717 x (Weight of Live Animals Sold / Weight FPC Milk)

For manure spread on crops not destined for dairy herd, a system expansion was used (also according to the guidelines) where the kg N/ha exported are deemed to replace the most common nitrogen fertilizer (Sheppard et al., 2009), urea.

3.6. Data collection

The quality of LCA results are dependent on the quality of data used in the evaluation. Every effort has been made for this investigation to implement the most credible and representative information available. The life cycle inventory (LCI) is performed using different sources of data. When possible, primary data is collected (measured data from desired target), otherwise secondary data is used. This refers to databases, articles, similar survey from other regions, etc.

3.6.1. Main Sources

A majority of activity data was sourced from on-farm surveys. Other sources includes generic databases and discussion with the provincial federations. The main sources of data are summarized in the table below.

Table 3-1 - Main Sources of Data

Source	Data
Cost of Production Surveys (ON, QC, NB, NS, PEI)	Diet percentages, Manure storage practices
Sheppard et al. (2010) survey on 500 farms	Manure spreading information, energy
Mail-in surveys (AB, ON)	Equipment and energy used in feed production
Sheppard et al. (2011) NH3 emissions from fertilizers	Fertilizer types and concentrations
Ecoinvent models	Transportation sources and distances
Provincial federations (most)	Manure spreading practice tendencies
Statistics Canada	Crop yields, herd size, farm surface

In total, cost of production surveys as well as mail-in surveys collected information from more than 300 farms, in Alberta, Ontario, Quebec, and the Maritimes. A previous survey (Sheppard et al., 2010) supplied additional information on farm practices, covering all provinces. When survey data was not available, assumptions of equivalence were taken when possible, within a same region (eg: Atlantic or Prairies). When no specific site data is available, or contribution to impact is known to be minimal, life cycle inventory databases are used, mainly ecoinvent (SCLCI, 2010). In last resort, when assumptions are necessary and activity data is not available, expert judgements are used for validation.

Models based on ecoinvent database are summarized below, with adaptation described when relevant. For background processes called by main processes, the electrical grid mix used has been adjusted to a North American average.

Table 3-2 - Ecoinvent processes used with adaptations

Processes	Description
Crop production	Model uses ecoinvent data for intensive feed crops, with its equipment and energy (diesel) requirements. **Fertilization, yield and pesticide use is adjusted** to represent provincial data (see next section). Emissions are calculated accordingly.
Buildings & Equipment	Tie-stall housing and free-stall housing (with relevant % of each), as well as milking parlour, used in free-stall housing, including its buildings and machinery, construction energy, material transportation, etc. Although the original model assumed a 50 yr life span, it was reduced to 30 yrs for the housing and 25 for the milking parlour, to account for periodic improvements and renovations.
Livestock management	Dairying uses a model that accounts for cleaning and cleaning water. Energy was removed to prevent double-counting.
Transportation	Quantis developed model for 53 feet long 18 wheelers, using ecoinvent processes for truck manufacturing and diesel consumption, with payload and distance adjusted, refrigeration added for milk transportation.
Electricity	Grid mix adjusted to match provincial mixes, with imports taken into account.

3.6.2. Dairy Production System

Data specific to the system in its whole were necessary, to evaluate the system based on its functional unit, the kg of fat and protein corrected milk, and to allocate the result between meat and milk production.

Milk data was calculated based on the Canadian Dairy Commission data for 2010-2011 (including butterfat and protein content), while herd size for western provinces used CanWest DHI data for 2010. They were more fitting to the milk production data then the slightly variable data pooled from Statistics Canada, for 2010 (used for Eastern provinces).

The allocation factor for milk to meat uses the live weight of animals sold for meat (or used elsewhere but based on the simplified function that they could be sold for meat). This excluded however animals that were replaced by functionally equivalent animals. For animals sold (culled cows and calves), numbers for Eastern provinces were based on cost production data, while numbers for Western provinces were calculated based on replacement animal ratios. The premice for calculation was that each dairy cow (relatively constant number) will have a calve every dairy cycle (14 months), which will either be sold as calves or be kept as replacements. Half the replacements will mature (based on a 2 yr heifer cycle), replacing the cows that will be sold. These numbers are summarized in the table below.

Table 3-3 - Milk and Meat Production

	BC	AB	SK	MB	ON	QC	NB	NS	PEI
Total Canadian Production	8.6%	8.4%	2.9%	4.0%	32.8%	38.0%	1.7%	2.2%	1.3%
hL/farm	12,220	10,798	11,552	8,640	5,925	4,494	5,863	6,761	4,694
kg BF/L	3.88	3.89	3.82	3.87	4.01	4.06	3.97	3.98	4.00
kg Protein/L	3.33	3.32	3.32	3.35	3.35	3.36	3.30	3.30	3.29
kg FPCM/farm	1,245,283	1,100,796	1,167,733	881,118	614,385	469,488	602,968	695,412	483,790
Cows Culled	39	41	37	30	18	11	16	17	24
Calves Sold	79	73	90	64	27	41	41	44	32
Allocation factor	82%	79%	80%	80%	85%	82%	83%	84%	75%

When calculating the average scenario, the individual provincial averages are averaged into one Canadian profile by using the weighted contribution of each province to the overall Canadian production of milk, following the values listed in the table above (first line). Newfoundland, with 0,6% of total Canadian production, is excluded from the model.

3.6.3. Feed Production

While feed is the most important input to the dairy farm system, it is also the most variable between farms, over time and seasons. It consists of a mix of roughages and grains, while some commercial feed is often added to achieve an optimal dietary content. There are notable differences in diets across Canada, based on climate, cost and commodity availability, such as a prevalence of corn in the East and barley in the West.

When possible, feed was calculated based on direct feed produced and purchased according to cost production surveys (Eastern provinces, AGECO, 2011). Otherwise, the mix of dietary intake, in percentage (Sheppard et al., 2009) was used. To extrapolate the proportions of feed types into total weights, an dry matter intake was used (21.7 kg DMI/day, Sheppard et al., 2011a) and adapted to variable milk production efficiencies, considering that approximately 46% of the energy intake is used for lactation. The balance of this DMI, required in maintenance energy for the animal, was kept constant.

Additionally, feed for remplacement animals was included, using the same diet (for lack of better data and since it was less than 25% of total feed), with an average DMI of 10.4 kg DM/kg head used (versus an average of 21.7 for lactating cows (Sheppard et al., 2011a)).

The feed data is available in Appendix B.

Commercial Feed

There are as many different mixes of commercial feed as there are farms. Fortunately, the proportion of commercial feed and protein supplement, in the two largest producing provinces was approximately 10% of the feed only (AGECO, 2011), so that an approximation for each can be used.

Because a great degree of variability exists even within one local producer, an average recipe was calculated by one producer in Quebec (communication Agri-Marché, 2011) and used as the average commercial feed for the Eastern provinces. Another producer's (communication Top Shelf Feeds, 2012) average recipe was modelled as the average commercial feed for the Western provinces.

The information gathered regarding the dairy cow meal in Quebec are presented below in Table 3-4. It was used as an average commercial feed for Eastern provinces.

Western commercial feed, in contrast, used more barley, and canola meal, while corn derivates such as gluten, meal and distiller's grain were reduced or not present.

Data on protein supplements was only available from cost production surveys and could not be extrapolated to all provinces. For this reason, it was treated as commercial feed.

Table 3-4 - Average of four cow rations prepared by Agri-Marché

Ingredients used in the recipes for dairy cows meal (provided by Agri-Marché)	• Wheat shorts (10-15%) • Corn gluten feed (25%) • Limestone (< 2%) • Salt (< 2%) • Magnesium oxide (< 1%) • Corn germ meal (10-15%) • Barley (0-50%) • Distiller's dried grains with solubles (10-15%) • Micro dairy premix base (< 1%) • Selenium premix 600 (< 1%) *Note: The percentages indicated are based on 4 recipes available in January 2012.*
Cost of ingredients (for economic allocation)	• Wheat shorts: $260/tonne (Meunerie St-Frédéric) • Flour: $270/tonne (http://www.ers.usda.gov/Data/Wheat/YBtable33.asp) • Corn gluten feed: < 17% of the price of corn grain (ecoinvent)

Average distances between the ingredient suppliers and the mills where the meal is produced	The reference mill is Agri-Marché's mill located in Saint-Isidore, Quebec, which gets its supplies mostly in Quebec: • Distiller's dried grains with solubles: 260 km • Limestone: 307 km • Corn gluten meal: 442 km • Salt : 187 km • Corn germ meal: 442 km • Barley: 131 km • Wheat shorts: 156 km
Average distance between the mills where the meal is produced and the farms using it	• The reference mill is Agri-Marché's mill located in Saint-Isidore, Quebec: 200 km

Feed Fertilization

Fertilization practices vary greatly across the country, as do farm practice regulations. Dairy farmers typically use a combination of manure, as a first resource, supplemented with synthetic fertilizers. Each farm has a different scenario, with variables surfaces producing different crops. Therefore, spread manure concentrations vary greatly. The proportional spread of manure per farm crops was only surveyed in Quebec, Ontario, New Brunswick and Alberta, hence for the other provinces, approximate scenarios were established based on conversations with provincial organisations, and limits of concentrations possible. Farm surfaces were calculated by AGECO. When resulting manure concentrations exceeded recommended N fertilization rates for the province or a neighbouring province (Atlantic & Prairies), values were adjusted, and when necessary (BC, PEI, NS), manure was taken outside the boundaries (to a different cash crop for example, or a different farm) where it was credited for synthetic fertilizers avoided in its place.

Manure composition (% N, P, K) is known to be quite variable based on feed content and storage equipment, however it was estimated to be constant following a detailed composition chart (CRAAQ, 2003).

When possible, mineral fertilization rates were used based on surveys and statistics. In the different provinces, regulation also dictates how and when manure can be spread on land, but it is typically spread onsite at the dairy farm, except in PEI where crop rotations adapted to the potato context can cause manure spreading on potato crops. In this specific case, fertilization in PEI was modelled as an average of New Brunswick and Nova Scotia

There are occasional cases where manure is sold or transferred to a nearby farm, however these cases are estimated as marginal (in Quebec, this is less than 0.5% of dairy cattle manure, AGECO 2010). There are more cases however, in Quebec, where manure from other farm animals (69% hog manure, 24% chicken manure) is spread on dairy cattle feed crops. This is the case with 29% of the dairy producers surveyed in Quebec, while 19% of them produce the alternative manure onsite, indicating a mix of manure on crops, only 10% actually import manure from another farm. In 71% of these cases, manure is given and not paid for, and transported within a 2 km distance, implying that only extra manure that would otherwise exceed allowable spreading is given. There are only a few cases of manure paid for, most of which were also local, with only 3 cases from almost 100 travelling over 100 km. For this reason, transportation of manure imported was omitted from the model. In terms of quantity, the average import from another farm is of 830 tonnes (for 10% of producers), which rounds down to 83 tonnes over all farms. Compared to an annual production of slurry from dairy cows nearing 1700 tonnes, the share of imported manure from another farm or from the same farm (different animal) is non negligible, yet too variable to be modelled. The same question regarding imports, in Alberta, returned a 93% negative reply. This exclusion of other manure types is a limition of the model, however the average fertilization scenario modelled is assumed to fulfill the equivalent contribution of N, P and K overall.

Table 3-5 - Average provincial scenarios of manure spread on crops

Province	Manure Spreading Basic Scenario
British Columbia	Spread mostly on roughage, with 80% on hay and 20% on corn silage.
Alberta	Great variation, typically little on hay (15%, of liquid only), when corn silage is grown onsite, it typically received about 70% of manure, but about 25% overall, in most cases grain (barley) received the majority (55%) and the balance is applied elsewhere (possibly on canola)
Saskatchewan	No scenario, deemed similar to average prairie region scenario
Manitoba	Typically spread on cultivated land (70-75%), including barley (45%), corn (3%), canola (21%) and soybeans (3%). The balance is broadcasted onto forages.
Ontario	Manure is typically spread on crops closer to the farm, typically hay, and then spread heavier on corn. (70%/30% used here)
Quebec	Spread 52% on hay, 6% on small grains, 17% on corn. The difference is spread on land used for cash crops.
New Brunswick	Spread 60% on hay, 5% on small grains, 22% on corn. The difference is spread on land used for cash crops.
Nova Scotia	Mostly spread locally, with 80% on forages and 20% on corn. (however corn surfaces only correspond to 87% of corn silage consumption and 50% of dry corn consumption)
Prince Edward Island	Manure spreading scenario is more complex because of potato crop rotations. Simplified to match average of Nova Scotia's and New Brunswick's scenarios.

Manure application was limited by the regional recommendations, to prevent the approximations from leading to overfertilization values. Values were found for BC, Manitoba and Quebec, and were extrapolated to regional areas, with soil and atmospheric conditions encouraging this proxy (dry Prairie conditions vs humid conditions in Eastern Canada). Manitoba recommendations were extrapolated to the prairies, while Quebec recommendations were extrapolated to all of Eastern Canada (including Ontario).

Table 3-6 - Nitrogen fertilization recommendations by province

Crops	BC (BCMA, 2010) Kg N/ha	MB (MAFRI, 2012) Kg N/ha	QC (CRAAQ, 2010) Kg N/ha
Grassland and Pasture	250	56	50
Corn Silage/Grain	150	112	145
Oat	(50: other)	81	50
Barley	(50: other)	81	60
Wheat	(50: other)	118	105
Soy	N/A	N/A	15

Phosphate fertilization was calculated based on manure content (% N, P, K) and manure spread (kg/ha). When recommendations were available (based on NBAFA, 2001), if the threshold was not reached by manure only, it was adjusted with synthetic fertilizers based on national sales statistics (CFI, 2007).

Pesticides

Average pesticide use in Canada is variable, yet averages close to 1 kg per hectare. On a national scale, pesticides are composed of herbicides (94%), fungicides (4%) and insecticides (2%) (Eilers et al, 2010). Most provinces mainly use herbicides (80%) with the exception of the Atlantic provinces, where fungicides make up 50% of pesticide consumption. This would be explained by the importance of the potato culture.

For lack of data on specific crop usage, all provinces were assumed to use the same quantities.

In Ontario, herbicides make up between 91% and 100% of pesticides sprayed on corn, soybean, grains, hay and pasture crops. Grain crops are sprayed at 5% with fungicides and 1% with insecticides (OMAFRA, 2010). With this detailed spread of pesticide type per crop, the Ontario model allowed for a good quality scenario that was used for modelling across Canada.

3.6.4. Livestock Management

Bedding

Bedding type was provided by the enhanced cost production survey (QC, NB) and the farm survey in Alberta. Quantities were also provided by the first survey.

In Quebec, both straw and wood chips are used, with an average consumption of 650 kg straw and 228 kg woodchips per dairy cow. In Ontario, the consumption of straw averages 891 kg/head. In the Atlantic provinces (each with a sample of 7 farms, not all of which had answered), displayed individual average far too varied, but averaged at 750 kg of straw with all three samples combined. It is expected that wood chip are also used, but are omitted for lack of data.

In Alberta, 90% of farms used straw, while another 38% used wood chips and 18% used sawdust (some farms used two types). For simplicity (and similarity in dominance of straw yet presence of wood residues), Quebec weight proportions were used. BC was estimated to also use a mix of the two, while Saskatchewan and Manitoba used Ontario consumption as a proxy.

Herd Size

The number of dairy cows per farm was calculated based on Statistics Canada declared cattle numbers and farms per province, averaged over 2009-2011 (because of the spread of data sources over these years).

The % of replacement animals (calculated from 2011 Census of Agriculture) varied between 32% (Quebec) and 38% (Alberta), thereby varying feed efficiency with an increased feed per kg milk where there was a high replacement animal ratio. Bull and calves were reported in the cost production surveys, while for the Western provinces, they were extrapolated based on the average ratio across the Eastern province, per dairy cow head.

Table 3-7 - Average herd size per farm and replacement ratio

	BC	AB	SK	MB	ON	QC	NB	NS	PE
Dairy Cows	131	147	152	125	75	53	75	87	72
Replacement Ratio	36%	38%	33%	35%	37%	32%	33%	33%	35%

Cleaning

After each milking, the hoses of the milking system are typically flushed at high speed and high temperature with cleaning solutions that provide a physical scouring action (Monken and Ingalls, 2002).

While the energy needed to heat the liquids are part of the overall energy requirements, the cleaning agents are modelled in the ecoinvent process for dairying.

Water required for cleaning depends on the size and type of system, but an approximation was used for tie-stall systems and free-stall systems (personal communication with M. Labonté, FPLQ). It was deemed that tie-stall lactoduc systems used 15 – 20 L per day per cow, while free style system used more, estimated at 25 – 30 L/cow.day (middle of each range used).

Drinking Water

While drinking water is not typically measured, and varies greatly based on moisture of feed and outside temperature, many publications offer recommendations. For the purpose of this study, a yearly average of 115 L daily was used per dairy cow (confirmed by Canadian recommended range

(AAFC, 2010a) and M. Labonté, FPLQ). For heifers, an average of 25 L per day was used, similarly for bulls, while 9 L was used for calves.

Enteric Fermentation

Enteric fermentation occurs during the digestion process of cattle and can generate 250 to 500 liters of methane per day per dairy cow. The loss of methane to the atmosphere represents an energetic loss for the cattle, as it means that about 5 to 8% of the feed energy is wasted rather than used for productive purposes (AAFC, 2002). Enteric fermentation depends on the live body weight, the animal activity (stall, pasture or grazing), the quantity of milk produced, the fat content of milk, the digestible energy from the feed and the dry matter intake. These parameters were then used to calculate the methane emission factor due to enteric fermentation. When available, data from a survey compiled by AGECO in 2011 were used in the calculations. Otherwise, data from another survey (Boadi, 2004) or default values suggested by the IPCC (2006) were used.

The detailed emission model is presented in Appendix D.

3.6.5. Energy and Infrastructure

Buildings & Equipment

For lack of specific data, buildings and equipment were modelled based on ecoinvent models (ecoinvent, 2009). Tied-stall housing and free-stall housing use different models, specific to each, and were modelled according to provincial averages. A milking parlour is also included in the case of free-stall housing.

Energy

While some data was collected for diesel, propane and heating oil, their usage was assumed to fall within other categories that were either excluded (heating oil for the home) or included elsewhere (diesel for crop production, propane for corn drying). In turn, only electricity and gasoline were modelled, adjusted to exclude the home use when possible. This was the case for Alberta data, using average household electricity consumption in Alberta (20% of 149 GJ total energy per year for single dwellings, or 8333 kWh (Statistics Canada, 2010)).

3.6.6. Transportation

Although transportation is required for many materials involved in the system, such as for fertilizer, from raw material, to processing plant, to distribution center, to farm, most of the transportation steps are already included in the database models used. Many of these transportation steps are also out of the control of the farmers. For these reasons, the only transportation distances included in this section are the transportation required for purchased feed and for milk delivery to processing facilities. In all other cases, default distances from the ecoinvent database were retained.

Feed Purchased

Transportation quantities for feed purchased in Ontario, Quebec and the Atlantic provinces are based on the enhanced cost production surveys for 2009, tallied by AGECO, using detailed weights of purchased feed. For Western provinces, estimates of purchased feed scenarios were based on conversations with the provincial associations. In Alberta, the quantity of feed produced onsite (mail-in survey) allowed an estimate of quantities of feed purchased, while transportation distances were provided.

The truck used in feed transportation is often a 42 – 53' van (communication AGECO, 2011), in which grains or rations are blown. The Quantis model for 53' vans was therefore used as proxy.

The average transportation distances were based on distances per crop, weighted with respect to the quantity purchased for each crop.

Table 3-8 - Average purchased feed transportation distances by province

Province	Feed Purchased
British Colombia	Grain and corn travel large distances, especially on the island, as does imported hay. Avg: 330 km
Alberta	60% of the forage is home grown, corn and hay can travel important distances. Avg: 163 km
Saskatchewan	Proxy'ed to Alberta
Manitoba	Due to large farms, most of the forage and grains are grown onsite or nearby, while rations and supplements can travel long distances. Avg: 63 km
Ontario	Most of the feed is purchased nearby, rations and supplements proxy'ed on Milk Transportation distances (communication R. Versteeg, 2012) Avg: 158 km
Quebec	Most of the feed is purchased nearby, rations and supplements proxy'ed on Ontario. Avg: 88 km
New Brunswick	Corn and Soy travel greater distances (Quebec), the rest is local. Avg: 71 km
Nova Scotia	Most forages and corn silage grown onsite, corn and soy travel. Avg: 61 km
Prince-Edward Island	Most grown nearby, corn and small grains travel. Avg: 111 km

Milk Transportation

Milk transportation data was provided by each respective provincial organisation, sometimes supported by data, sometimes estimated (SK, MB). In BC, no data was available.

In general, milk citerns will reach full capacity at the end of the route, hence they were modelled as being half full (approx. 10 tons).

Table 3-9 - Average distance travelled by milk

	BC	AB	SK	MB	ON	QC	NB	NS	PEI
Average distance travelled	150	122	221	95	218	100	160	80	50

3.6.7. Manure Management

The fraction of manure handled using specific manure management systems were taken from a survey done with approximately 500 farms across Canada (Sheppard et al, 2011a). As for the fractions of managed manure N losses for cattle due to runoff and leaching during storage of manure, the values were obtained from Agriculture and Agri-Food Canada (Communication Vergé, 2012). The detailed emission model of manure management is presented in section 3.8.

3.7. Data Quality

A data quality assessment aims to identify data requiring improvement. It clarifies limitations in the robustness of the LCA results while facilitating the selection of sensitivity analyses to be performed. The results of the data quality assessment are summarized in table format in Appendix E. Each metric is given a grade between 1 (best grade) and 4 (worst grade). The detailed legend for data grading is also provided in the Appendix.

In order to achieve the goal of this study, it is assumed that the minimum data quality requirement is a grade of 2 for medium and high importance data. A grade of 3 is deemed acceptable for lower importance data. Data with a grade of 4 does not meet the quality standard set for this study and would require improvement.

The data quality assessment shows that most data meet data quality requirements. The exception lies with fertilizer types and amounts applied, which are important yet have a low reliability, based on a combination of assumptions, statistics and expert recommendations . However, there was no better data available in most provinces. As such, this is a clear limitation to the results which is well identified and mentioned in the recommendations.

3.8. Emission Models

Agriculture benefits from a complex ecosystem that transforms soil additions for its use while also releasing emissions to the air, the soil and eventually water. As these are not measured, they must be estimated using emission models. The same is true for enteric digestion and manure storage. The emission models are summarised in the table below, and a full description can be found in Appendix D.

Table 3-10 - Emission models used in the study

Emission type & Source	Model
N2O from crops	IPCC model Tier 2 with Ecodistrict specific emission factors
NH3 from crops	Fertilizer type specific models as per Nemecek (2007) (used in ecoinvent)
Pesticides	Based on Fantke et al., 2011
Phosphorus from crops	As per Nemecek (2007), based on SALCA-P model (Prasuhn, 2006)
Metals in manure	Based on supplementation to the system, analysed for sensitivity
Nitrate from crops	As per Nemecek (2007), based on Richner et al., 2006
Enteric CH4	IPCC Tier 2, while for the Ym, daily CH4 emissions based on Ellis, 2007
Manure CH4	IPCC Tier 2
Manure N2O	IPCC Tier 2
Manure NH3	IPCC Tier 1
Housing NH3	Based on Sheppard et al, 2011b
Carbon Sequestration	None

3.9. Impact Assessment Method

The Life Cycle Impact Assessment (LCIA) aims to translate and to connect each elementary flow quantified in the inventory life cycle into the corresponding categories of impacts on the environment and human health according to fate models, exposure and toxicity of pollutants, or scarcity of resources. Thus, to each substance of the inventory is associated a specific characterization factor *(CFs)* that allows calculating the impact score. The sum of all impact scores of different substances determines the total impact of the system for a given impact category. In a second step, these impact categories (or midpoint categories) can be grouped in a smaller number of environmental damage indicators (or endpoints), which facilitates communication of results and decision making.

Having a specific geographic context, this study considers a multi-scale spatialized life cycle approaches for both inventory and impact assessment levels. Indeed, Canada is divided into distinct regions showing differences in land covers, vegetation patterns, climate and hydrological systems, soil orders and types, etc. Spatial differentiation is important when quantifying the environmental footprint at each life cycle stage of the Canadian milk chain production at the regional level (acidification, eutrophication, smog, etc.) as well as the local level (toxicological or ecotoxicological impacts). However, potential impacts at the global level (ozone depletion, global warming, etc.) are not affected by the emission's location.

For a full environmental LCA of the Canadian dairy sector, a set of comprehensive impact indicators was developed. This allows for a spatial differentiation between emission locations and reduces uncertainty linked to spatial variability. To do so, a characterization framework and a set of basic impact indicators (including a carbon footprint) were assessed based on peer-reviewed and internationally recognized LCIA method IMPACT 2002+ (Jolliet et al. (2003) update by Humbert et al. (2011)).

Moreover, for a specific regionalized assessment that accounts for spatial differentiation, a number of impact indicators addressing environmental problems in the agricultural sector and being highly sensitive to regional characterization, were considered and include: water use, land use, acidification, eutrophication, toxicity and ecotoxicty.

The framework used in this study and the methods underlying these regional-specific impact indicators are based on the IMPACT World+ LCIA method (CIRAIG et al. 2012) and described in the following sections.

3.9.1. Impact assessment framework

The global framework adopted in this study, shown in the figure below, is inspired by the work done for the development of IMPACT World+. Several novelties introduced in IMPACT World+ are considered in this study, including consistent spatialized levels and improved impact categories modeling.

Eighteen impact categories are accounted for in this study. Categories shown in bold chacracters correspond to the ones regionalized. And, while they can be reported and interpreted separately, several of them can be modeled up to the four damage indicators, namely: Climate Change (or carbon footprint), Natural Resources, Human Health, Ecosystem Quality and Water footprint, allowing their respective contribution to be put into perspective. IMPACT 2002+ grouping methodology has been used to aggregate the different midpoint indicators.

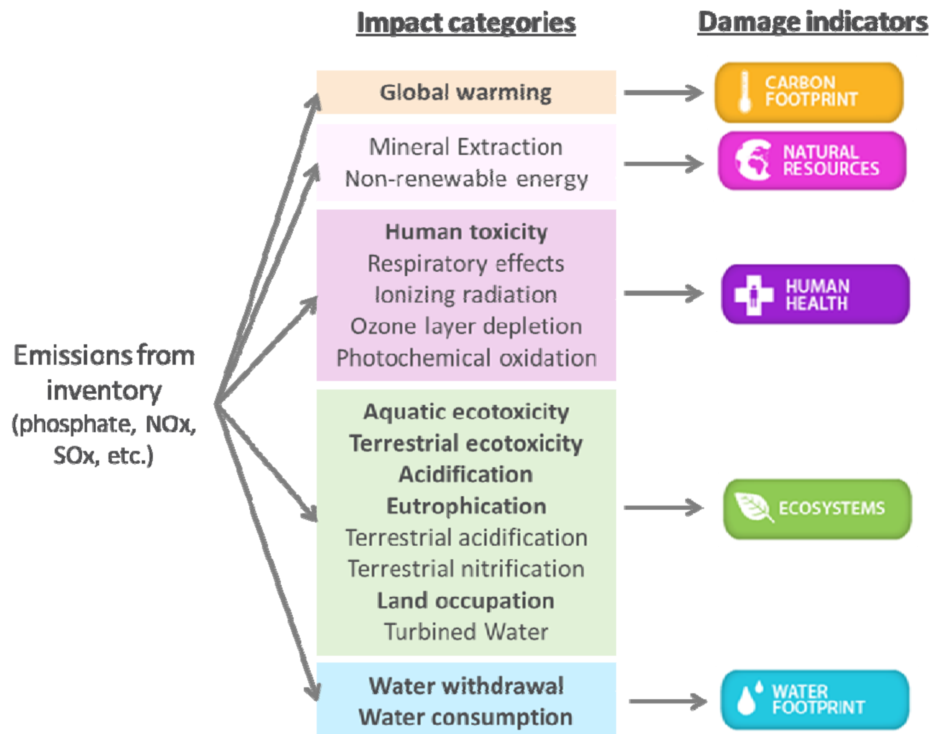


Figure 3-2 - LCIA framework used in this study showing regionalized impact categories in bold characters (CIRAIG et al. 2012)

In this report, LCA results are presented through five indicators that are selected amongst endpoints and midpoints of this framework. These indicators cover all the impact categories from the LCIA framework at the midpoint or endpoint level and are considered the most meaningful for the dairy industry. The following paragraphs present a brief description of each of these indicators.

Climate Change is represented based on the International Panel on Climate Change's 100-year ratings of the Global Warming Potential of various substances (IPCC 2007). Substances known to contribute to global warming are adjusted based on an identified Global Warming Potential, expressed in kilograms of carbon dioxide (CO_2) equivalents. Because the uptake and emission of CO_2 from biological sources can often lead to misinterpretations of results, it is not unusual to omit this biogenic CO_2 from consideration when evaluating Global Warming Potentials. Here, followed is the recommendation of the Publicly Available Standard (PAS) 2050 product carbon footprinting guidance in not considering either the uptake or emission of CO_2 from biological systems. In order to account for the effect from its degradation to CO_2, the GWP from methane of fossil origin is put to 27.75 kg CO_2eq/kgCH_4, and the one of methane from biogenic and unspecified origin is put to 25 kg CO_2eq/kgCH_4.

Human Health impact can be caused by the release of substances that effect humans through acute toxicity, cancer-based toxicity, respiratory effects, increases in UV radiation and other causes. The overall impact of a system on human health is assessed based on the substances ability to cause each of a variety of damages to human health. Potential impacts on human health are measured in units of disability-adjusted life year (DALY).

Ecosystem Quality can be impaired by the release of substances that cause acidification, eutrophication, toxicity to wildlife, land occupation, and a variety of other types of impact. The overall impact of a system on ecosystem quality is assessed based on the substances ability to cause each of a variety of damages to wildlife species. Potential impacts on ecosystem quality are measured in units of potentially disappeared fraction (PDF) of species on a unit surface during one year of occupation (PDF.m^2.year)

Resource Depletion is caused when non-renewable resources are used or when renewable resources are used at a rate greater than they can be renewed. Various materials can be given greater importance based on their abundance and difficulty to obtain. An evaluation of the overall impact of a system on resource depletion is performed by combining non-renewable primary energy use and mineral extraction. Non-renewable primary energy use accounts for the consumption of fossil and nuclear resources and excludes sources of renewable energy at all stages of the life cycle and in all upstream processes. Mineral extraction is an estimate of the increased amount of energy that will be required to obtain additional incremental amounts of substances from the earth due to removal of resources inventoried for each system. Potential impacts on resource depletion are measured in units of megajoules (MJ).

Water footprint accounts for impacts related to water use including water extraction (in m3 of water needed, whether it is evaporated, consumed or released again downstream -- excluding turbined water (i.e. water flowing through hydropower dams). It considers drinking water, irrigation water and water for and in industrialized processes (including cooling water). It considers freshwater and sea water. Furthermore, a water stress index is integrated.

3.9.2. IMPACT World+

Most of the impacts modeled in life cycle impact assessment (LCIA) are regional or local. However, LCIA methodologies currently offer generic characterization factors (*CFs*) that do not account for spatial variability of impacts. Some LCIA methodologies, such as IMPACT 2002+ (Jolliet et al. 2004), ReCiPe (Goedkoop et al. 2008), LIME (Itsubo and Inaba 2003) or LUCAS (Toffoletto et al. 2007), have partially addressed the issue of regionalization as they only cover a specific region of the world. Characterizing life cycle inventories collected within a global economy using only European *CFs*, assuming that all the emissions occur in Europe or at least under European conditions, is not necessarily a better assumption than applying global or generic *CFs*.

IMPACT World+ (CIRAIG et al. 2012) was developed out of the need to offer a regionalized methodology at a global scale, implementing state-of-the art characterization modeling approaches developed since the publication of IMPACT 2002+ (Jolliet et al. 2004) and LUCAS (Toffoletto et al. 2007). It also aims to include uncertainty information encompassing both spatial variability and model uncertainty. This does not only allow applying more environmentally relevant *CFs*, but also to regionally assess any geo-referenced emission. In addition, uncertainty related to spatial variability for an unknown emission location would be evaluated.

The following paragraphs describe the main improvement regarding characterization models that have been developed for local and regional impact categories, each of them based on an appropriate spatial scale. This latter was defined around the most sensitive modeling parameters, such as watersheds for water use impacts, biomes for land use impacts, or based on an archetype approach built upon the sensitive parameters as for example urban/rural archetypes for respiratory impacts (the most sensitive parameter being population density) or soil and water archetypes for metal toxic impacts (the most sensitive parameters being some soil/water properties such as pH etc).

Particular attention has been given to the harmonization of modelling assumptions between different impact pathways. The uncertainty associated with the *CFs* for each of these "fine scale" models has been determined. These fine scale *CFs* have been aggregated at the country, subcontinental, and global scales using the geographical distribution of emissions (or emission proxis) as weighting factors. This resulted in *CFs* at different geographical resolutions, each with its own associated uncertainty and spatial variability. Regionalized *CFs* were calculated for the following environmental problems: respiratory effects, toxic impacts, ionizing radiations, water use, acidification, eutrophication and land use.

The use of such an LCIA *CFs* which will increase both the relevance and the dicriminating power of LCA by allowing to account for uncertainties and spatial variability.

3.9.3. Regionalization

Initial characterization factors have been generated at various spatial scales, from a a finer resolution scale level to broader ones including country, sub-continental and other global geographical scales for local and regional impact categories.

Table 3-11 indicates the level of regionalization at which CFs of the different impact categories accounted for in this study were used. This highlights the necessity of having a spatially-differentiated assessment when quantifying regional and local impacts within LCA.

Table 3-11 - Level of spatial resolution for regionalized impact categories

Impact category	Contributing damage indicator	Damage unit	Initial level of regionalization	References
Water use	Ecosystem quality	PDF.m².yr	Watersheds	Pfister et al. (2009)
Land use	Ecosystem quality	PDF.m².yr	Terrestrial ecoregions	Pfister et al. (2010)
Acidifiation	Ecosystem quality	PDF.m².yr	A 2.5˚ x 2˚ degree grid resolution	Roy et al. (2012a; 2012b)
Eutrophication	Ecosystem quality	PDF.m².yr	A 0.5° x 0.5° degree grid resolution	Helmes et al. (2012)
Ecotoxicity	Ecosystem quality	PDF.m².yr	Watersheds for soil and water emissions	IMPACT 2002 model (Pennington et al.(2005; 2006); Humbert et al. (2009))
Toxicity	Human Health	DALY	A 2.5˚ x 2˚ degree grid resolution for air emissions Watersheds for soil and water emissions	IMPACT 2002 model (Pennington et al.(2005; 2006); Humbert et al. (2009); Manneh et al. (2010)

For a better geographical representation, *CFs* of each impact category were adapted to the geographical context of this study using a finer level of spatial resolution and which considers the location of the dairy farms. A first step consisted of calculating *CFs* at a farm-specific level and then calculating a specific average value for each Canadian province weighted by the farms annual milk production volume for the year of reference.

This was performed using a geographic information system, ArcGIS 9.3 (ESRI 2012), by overlaying all *CFs* data using their initial level of regionalization and then intersecting them with each dairy farm's location to cross-reference with the farms annual milk production volume. This results in characterization factor $(CF_{i,j})$ at a specific-farm level (i) for a given impact category (j).

Assuming that the level of stratification based on the sample of dairy farms (n=13,331[1]) is representative enough of the Canadian provinces (k), an average value $(CF_{j,k})$ weighted by the milk production volume of each farm (MP_i) was calculated for each province (k). The general **equation (Eq. 1)** used for all regional/local impact categories assessed within this study is as follows.

$$CF_{j,k} = \sum_i \frac{CF_{i,j} \times MP_i}{\sum_i MP_i} \qquad \textbf{Eq. 1}$$

A description of the methodology and the characterization model of the regionalized impact categories considered in the assessment, namely water use, land use, acidification, freshwater eutrophication, human toxicity and ecotoxicity is given in Appendix F.

3.9.4. Potential impact from Water Use

Building on the work in progress within the UNEP-SETAC Life Cycle Initiative on water footprinting, a framework has been developed by Quantis which is made of a state-of-the-science compilation of suitable existing methods and tailoring them to comprehensively addressing the major issues related to water use in LCA

The water inventory used in the water impact assessment developed by Quantis is presented below. "Withdrawal" indicates the source/input of the water and "release" indicates the output/fate.

[1] Number of active dairy producers listed by the Canadian Dairy Commission in 2009/10. There postal codes, provided by the Commission, were used to map the distribution of dairy farming activities across the country.

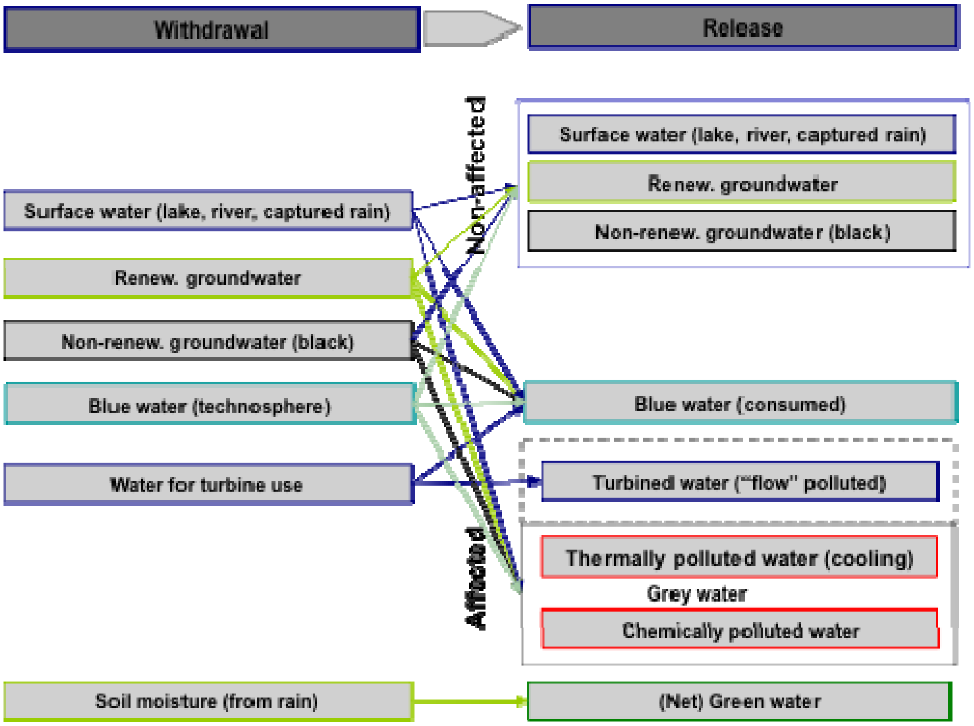


Figure 3-3 - Water inventory assessment

Withdrawal water includes surface water (river, lake, captured rain), renewable groundwater, non-renewable groundwater turbined water and soil moisture. Turbined water is used for power generation. Soil moisture is the water from soil moisture used by plants. An additional withdrawal flow is blue water (from technosphere), that is the water already incorporated into the technosphere products (like bottle of water, tanker, pipelines, etc).

Releases are grouped in two distinct classes: non-affected and affected. By affected, we mean that the water has been chemically (e.g. polluted), thermally (e.g. cooling water) or mechanically (e.g. turbined water) changed, or is consumed, meaning that it is not available any more in the watershed considered because of evaporation or export (e.g. incorporation into products or transferred with an aqueduct).

In the context of a full LCA, chemically polluted water is caracterised through aquatic ecotoxicity and eutrophication, and for this reason it is excluded from the water footprint results. These are targeted at understanding the water withdrawals and releases onsite and upstream, and their potential impact on ecosystem quality, human health and resource depletion.

Water stress assessment or midpoint category

A water stress assessment has been developed using a water stress index (WSI, Figure 3-4) to provide the ability to assess the potential environment impact of water use in a rapid, easy and consistent way. The result is a weighted inventory (or water footprint), in volume-equivalent water use (i.e. m^3_{eq}), that can be mapped. This approach has been published by Ridoutt and Pfister (2010) and Pfister and Hellweg (2009).

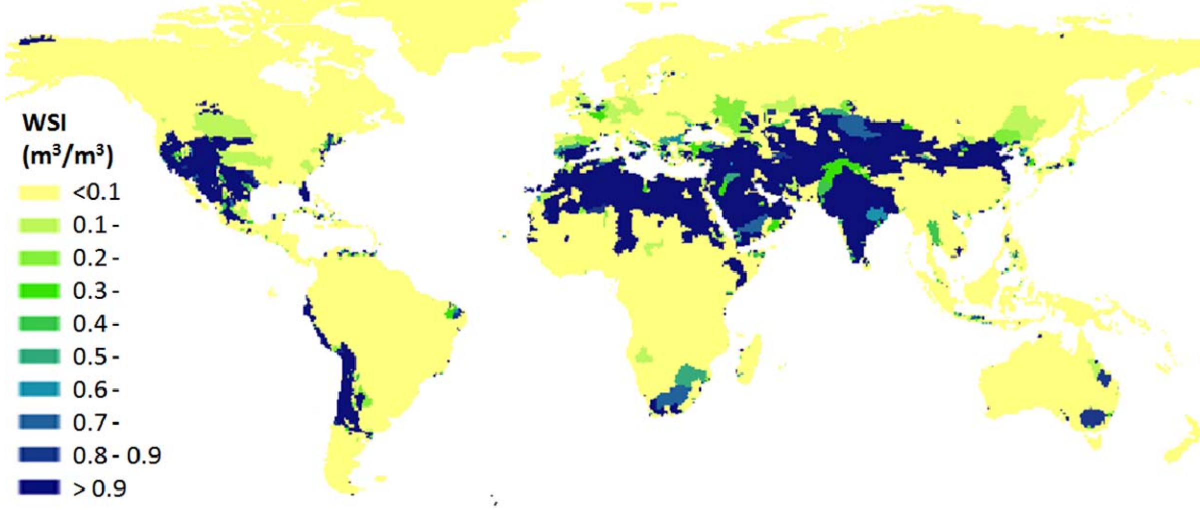


Figure 3-4 - WSI of Pfister (2009) at a watershed level (also available at a country level)

3.9.5. Potential impact from Land Use

Land is a natural resource essential for food production in the agricultural sector. Anthropogenic use of land and substantial changes in land cover constitute a primary source of soil degradation, resulting in an altered ecosystem reducing biodiversity and its ability in performing a range of regulating services and biodiversity.

The assessment in this study goes beyond the traditional inventory-data related indicator, which simply reports the amount in hectare or square meters of land occupied or transformed within a time span (Thomassen et al. 2008; Basset-Mens et al. 2009; Roy et al. 2009).

Framework and impact pathway description

The cause-effect chain proposed in Figure 3-5 is adapted from previous land use impact assessment studies and is structured according to the most relevant impact pathway: Impacts on biodiversity.

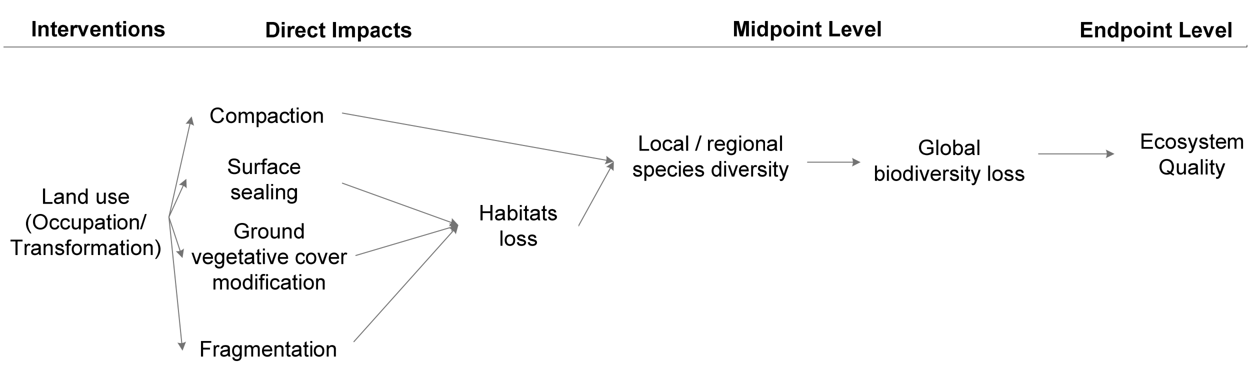


Figure 3-5 - Cause-effect chain considering the main impact pathways for biodiversity and ecosystem services (adapted from Saad (2010) and Lindeijer et al.(2002))

In this study the following pathway is considered; impacts on biodiversity:

- Impacts on biodiversity: land use activities, resulting in alterations of the Earth's land surface, have been widely recognized as major stressors on biodiversity (Sala et al. 2000). Such activities imply a modification of the species distribution and richness through the destruction of natural habitats.

Two environmental interventions are generally considered for land use impacts:

- land occupation: refers to the use of land area for a clear purpose of human activities (eg. agriculture) during a period of time (measured in m^2.year).
- land transformation: also called land use change refers to the change in a land area to meet the requirements of a new type of land occupation (eg. deforestation for agricultural use) (measured in m^2).

Characterization model

The impact assessment method used follows the recommendations of previously published works and guidelines, especially the framework established by the UNEP-SETAC Life Cycle Initiative working group on land use life cycle impact assessment (LULCIA 2011) (phase 1 (Milà i Canals et al. 2007a) and phase 2 (Koellner et al. accepted)). Unlike traditional categories that assess the impacts of emissions, land use impact characterization is not structured according to the conventional steps of fate, exposure and effect, nor is it based on mass and energy balance. As shown in Figure 3-6, the assessment of land use impacts is rather based on the development of ecosystem quality (Q) curve over time for the biodiversity impact pathway.

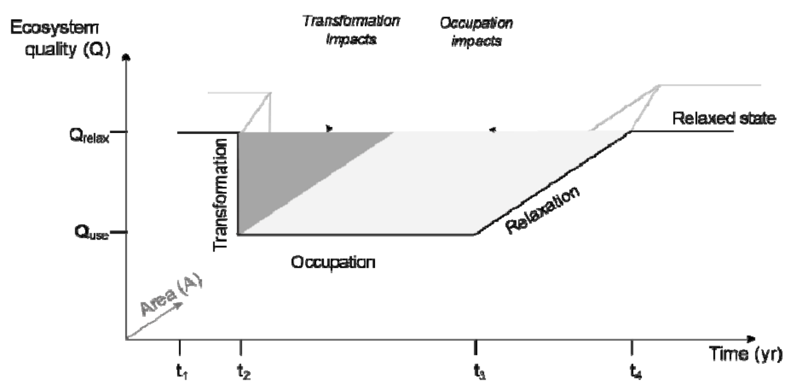


Figure 3-6 - Ecosystem quality curve for land use potential impact assessment (adapted from Milà i Canals et al. (2007), Saad et al. (2011))

The characterization phase consists in the quantification of the impact associated with the environmental intervention, i.e. the occupation process. Land occupation impacts maintain land EQ at a certain level, postponing the relaxation phase by a period equal to the occupation time and preventing EQ from returning to the reference state (Müller-Wenk 1998; Weidema et al. 2001; Lindeijer et al. 2002). Such impacts are calculated as the maintained EQ difference between the use phase (Q_{use}) and baseline state ($Q_{relaxation}$). Their magnitude is approximated by the area of a parallelogram that considers the temporal aspect, expressed in units of change in quality*area*time ($\Delta Q.m^2$.year).

The equation used to quantify potential land use impacts is indicated in Eq. 2. The following Eq. 3 and Eq. 4 are used to quantify land occupation and land transformation impacts respectively.

$$Impact_i = Inventory\,flow_i \times CF_i = A_i \int \Delta(Q_i(t).\,dt) \qquad \textbf{Eq. 2}$$

$$LOI_i = A \times t_{occ} \times CF_{occ,i} \;, \quad \text{where} \quad CF_{occ,i} = Q_{ref,i} - Q_{LU,i} \qquad \textbf{Eq. 3}$$

$$LTI_i = A \times CF_{trans,i} \;, \quad \text{where} \quad CF_{trans,i} = (Q_{ref,i} - Q_{LU,i}) \times \frac{1}{2} \times t_{relax} \qquad \textbf{Eq. 4}$$

LOI_i is the land occupation impact score of the corresponding impact pathway *i*, A is the land surface area (in m²), t_{occ} is the occupation time (from t_2 to t_3, in years) and $CF_{occ,i}$ is the characterization factor for land occupation of the corresponding impact pathway (i), which measures the difference in ecosystem quality (ΔQ) between its use (Q_{LU}) and in comparison with the baseline reference state (Q_{ref}).

Based on the ecosystem quality curve, the land transformation impact score (LTI_i) is quantified similarly by coupling the inventory flow with the characterization factor ($CF_{trans,i}$). The latter is approximated by a triangle accounting for the relaxation time (t_{relax} from t_3 to t_4, in years) before reaching a quasi-natural relaxed state.

Only land occupation was accounted for in this study, assuming that all feed crop production was grown on existing arable land in Canada and no land transformation was involved during the last 20-year time period. This assumption relates to the allocation of land use change impacts and was verified following the recommendations of the UNEP/SETAC Life Cycle initiative working group on land use assessment within LCA (Milà i Canals et al. 2012; Koellner et al. accepted). Using the FAOSTAT database (FAOSTAT 2012), a 5-year average of land area harvested for all crops were compared to the data from the past 20 years. For cereal crops that have shown a significant increase in land area harvested, such as corn, oats and soybean, a change in agricultural and arable land area was further investigated over the same period. Results showed that the area did not increase on a 5-year average during the past 20 years indicating that crop may have expended at the expense of other crops. Thus, not land transformation has occurred.

In addition, although growing season depends on the type of cereal crops grown, it was assumed that they require the use of land area during one year long. This includes all steps needed for soil preparation and the months were no activity occurs due to cold weather.

Spatial coverage and resolution level

Since land use impacts are highly influenced by the condition of the location where the intervention takes place, regionalized *CFs* were developed and used within this study.

For land use impacts on biodiversity, *CFs* from Pfister et al. (2010, 2011) that were initially developed for a global spatial coverage on a 5 arc-minutes resolution are used. Typical land use impacts on biodiversity are expressed in units of potentially disappeared fraction (PDF) of species on a unit surface during one year of occupation (PDF.m^2.year).

Figure 3-7 is a map displaying *CFs* results to address potential land use impacts on biodiversity. High values are observed in areas with high diversity across Canada, such as in the Boreal regions and Mixed wood plains. Lower values are obtained for the arctic regions where species richness is smaller to none.

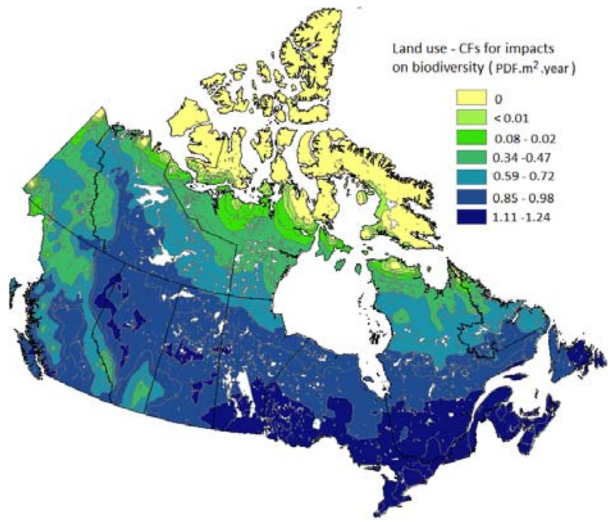


Figure 3-7 - Characterization factors for land use impact assessment on biodiversity (adapted from Pfister et al. (2010))

3.9.6. Potential impact from Acidification

Acidification is the process in which atmospheric deposition related to acidifying emissions can cause changes in soil acidity and consequently harm terrestrial and aquatic flora. An increase of H+ concentration is observed in terrestrial or aquatic environments (Udo de Haes et al. 2002).

A number of acidifying substances are generally known, such as sulphur dioxide (SO_2), sulphates (SO_4), ammonia (NH_3), nitrogen oxydes ($NO_x = NO + NO_2 + NO_3 + HNO_2$) and nitric acid ($HNO_3$). While some other substances can create further acidification (e.g. HCl, HF, H_2S, etc.), emission of SO_2, NO_x and NH_3 are believed to represent 95% of the total emitted acidifying substances (Hauschild and Potting 2003). SO_2 and NO_x are mostly emitted by industries such as electricity production (coal and oil), exploitation and fusion of non-ferrous metals, oil and gas production as well as transports (Jeffries and Ouimet 2004). However, anthropogenic emissions of NH_3 mostly originate from agricultural activities (Portejoie et al. 2002).

There are a number of effects following terrestrial acidification, including dissolution aluminum ions or other heavy metals toxic to plants, nutrient deficiency as well as direct harm related to changes of pH (Hayashi et al. 2004).

Framework and impact pathway description

The considered cause-effect chain describing the impact pathway for acidification impacts is proposed in Figure 3-8. This relies on the framework of emission that is related to impact categories in LCA (Udo de Haes et al. 2002).

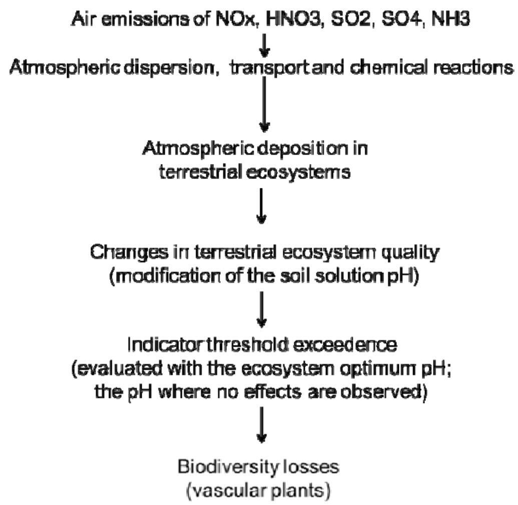


Figure 3-8 - Terrestrial acidification impact pathway (personal communication with Roy (2012))

Characterization model

Relying on the framework addressing impacts related to acidifying emissions, the characterization model includes an atmospheric fate factor (FF), a soil sensitivity factor (SF) and an effect factor (EF).

Damage on ecosystem quality from potential acidification impacts ($AI_{i,p}$) are quantified following Eq. 5, where $m_{i,p}$ corresponds to the mass of the pollutant emission *p* at its emission location *i.*

CFs for acidification impacts on ecosystem quality; expressed in units of PNOF.ha.yr/$kg_{emission\ emitted}$ (or simply ha.yr/$kg_{emission\ emitted}$) and developed by Roy et al. (2012a; 2012b) are used. These factors are given as a function of pollutant *p* and emission location *i* and are developed following Eq. 6.

$$AI_{i,p} = m_{i,p} \times CF_{i,p} \qquad \textbf{Eq. 5}$$

$$CF_{i,p} = \sum_j FF_{i,j,p} \times SF_{i,j,p} \times EF_{i,j} \qquad \textbf{Eq. 6}$$

The atmospheric fate factor (FF, in kg S or $N_{deposited/year}$/ kg S or $N_{emitted/year}$) describes the atmospheric impact pathway from the emission location *i* of the pollutant *p* to the corresponding deposition location in the receiving environment *j*. Deposition is a function of atmospheric climate conditions (i.e. wind, temperature, precipitation, etc.), chemical interactions with the atmosphere and topography.

The receiving environmental sensitivity factor (SF, in (mol/L)*ha.yr/ kg S or $N_{deposited/year}$) represents the pH changes in soil *j* due to a marginal change in deposition. It links changes in H+ concentrations according to a change in deposition of pollutant *p* in receiving environment *j*. Such factors are developed based on mass balance calculations of different soil layers and take into account the weathering rates of ions from independent geophysical properties, weather characteristics (i.e. temperature and precipitation) and soil parameters (i.e. layer depth, soil texture, water content, bulk density, dissolved organic carbon, % of water entering and leaving layer, surface area, runoff, net uptake, mineralogy, CO_2 pressure, base cations and nitrogen uptake efficiency and de-nitrification).

The location specific effect factor (EF, in $(mol/L)^{-1}$) links change in H+ concentration in the receiving environment *j* to change in the "Potentially non occurring fraction" (PNOF) of plant species. It is quantified based on a specific vegetation cover of the biome associated to the receiving environment *j*.

Spatial coverage and resolution level

Terrestrial *CFs* for acidification impacts were originally obtained at a world-wide global scale level where emissions of acidifying substances occurred (seas/oceans emissions originate from ships and aircraft emissions) on a 2˚ X 2.5˚ degree grid resolution, using the GEOS-Chem emissions inventory. For practical reasons, *CFs* from 2˚ latitude by 2.5˚ longitude grid resolution were also aggregated to coarser resolutions, including country and continental spatial level, using a GIS software (ESRI 2012).

CFs originally developed at the finer scale level (i.e. 2˚ X 2.5˚ degree grid resolution) were used in this study and for SO_2, NO_X and NH_3 emissions. Additionnaly, to enable comparison between all impact categories that contribute to the same damage category Ecoystyem Quality, *CFs* originally expressed in units of $PNOF.ha.year/kg_{emitted}$ were converted to $PDF.m^2.year$ This was performed assuming that PNOF ≈ PAF_{EC50} (Van Zelm 2010) and that PDF = ½*PAF (Jolliet et al. 2003). The latter suggests that one half of species affected over their level of chronic EC_{50} (being the half maximal effective concentration) will disappear due to the toxic stress.

Of all *CFs* results characterizing impacts related to acidifying emissions, the ones from NH_3 show higher values. These observations are mainly driven by its high acidification potential in comparison to other substances (Heijungs et al. 1992). In addition, NH_3 emissions showed a local deposition having a longer residence time and thus less transported by air flow. Such emissions are therefore considered having a regional impact rather than a continental one. Therefore, deposition of acidifying substances mainly contributes to causing damage to ecosystems.

Across Canadian regions, most of the Canadian Shield, such as the Boreal areas, is characterized by a receiving environment having a high sensitivity factor (personal communication with Roy (2012)).

3.9.7. Potential impact from Eutrophication

Freshwater eutrophication describes the process of changing species diversity and biomass quantity in water bodies, due to a nutrient enrichment of the aquatic environment (Smith 2003). This generates a growth of biomass, such as an increasing algal growth, which pushes this ecosystem population out of balance: decrease of oxygen levels due to respiration of excess biomass leads to impacts on other aquatic species, further fish kills and disappearance of bottom fauna (Withers and Jarvie, 2008).

In freshwater ecosystems, phosphorus (P) is typically the primary limiting nutrient for primary production, which contributes to eutrophication. Being mainly driven by nutrients into water, eutrophication relates to management of phosphorus and nitrogen emissions in agricultural fields. Potential emissions include emissions from dairy cows, manure management practices as well as application of inorganic fertilizers to feed crops.

Framework and impact pathway description

The latest development in terms of impact assessment method for freshwater eutrophication is considered. Linking the flow of substances generated during the life cycle of milk production at the dairy farm to the associated impacts is performed at the LCIA stage based on a quantitative assessment. Inventory emission flows are translated into potential environmental impacts through the use of characterization factors *CFs* (see Pennington et al. (2004) and Rosenbaum et al. (2007)). The latter consider fate and effect modeling of the substance, also known as stressor.

Characterization model

Based on the method proposed by Helmes et al. (2012), characterization factors for eutrophication impacts on ecosystem quality are given as a function of cumulative fate factors (FF_i) of an emission to freshwater in cell *i* and the effect factor expressing the change in potentially disappeared fraction (PDF) of species in the receiving compartment *j* per unit increase in mass of phosphorus.

Damage on ecosystem quality from potential eutrophication impacts ($EI_{i,p}$) are quantified following Eq. 7 and where $m_{i,p}$ corresponds to the mass of the phosphorus emission *p* at its emission location *i.*

As indicated in Eq. 8, *CFs* are measured in units of PDF.m^2.yr/$kg_{emitted}$, and result from the product of the fate factor (FF_i) with the corresponding effect factor (EF_i).

$$EI_{i,p} = m_{i,p} \times CF_{i,p} \quad \textbf{Eq. 7}$$

$$CF_i = \Sigma_j FF_{i,j} \times EF_j \quad \textbf{Eq. 8}$$

The fate factor (FF_i) represents the overall persistence, measured in days or years, of a substance in the environment, in this case phosphorus, including removal via advection, partitioning and water use.

The ecological effect factor (EF_j) links the mass change of the pollutant in the aquatic ecosystems or other environmental compartments to the ecological damage ecological due to eutrophication, such as decrease in species richness.

Spatial coverage and resolution level

The current approach to assessing freshwater eutrophication impacts beyond a European context is still under continuous development.

Regionalized cumulative fate factors of phosphorus emissions to freshwater developed by Helmes et al. (2012) were used. These were initially derived for a global coverage at 0.5˚x0.5˚ degree grid resolution. They correspond to the sum of the fate factors for the individual cell of emission and of all downstream receptor grid cells. Individual fate factors are expressed in [kg P in freshwater / kg P emitted in freshwater per year].

Although, spatially-differentiated effect factors can also be modeled yet, none has been developed for freshwater eutrophication impacts within a Canadian context. Therefore, a non-regionalized effect factor, taken from IMPACT 2002+ LCIA method (Jolliet et al. (2003) update by Humbert et al. (2011)) was coupled with the fate factors resulting in *CFs.*

Figure 3-9 is a map displaying *CFs* results to address potential impacts from phosphorus emissions to freshwater eutrophication. For practical reason during modeling, *CFs* were converted to characterize phosphate emissions. Low values are found in coastal areas where phosphorus FF is relatively low as it is quickly transported to the water bodies, such as ocean. However, higher values are found in areas upstream of large lakes or reservoirs, where the persistence of phosphorus is high in a high diverse-species aquatic ecosystems (Helmes et al. 2012).

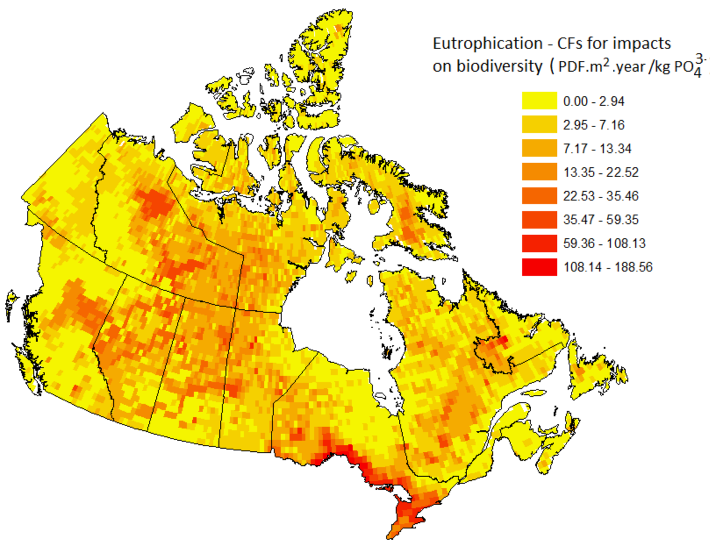


Figure 3-9 - Characterization factors for freshwater eutrophication impact assessment on biodiversity

3.9.8. Potential impact from Toxicity and Ecotoxicity

Human Toxicity measures the potential impacts of toxic releases on human health related to carcinogen and non-carcinogens effects caused by pollutants. The latter mainly relate to application of fertilizers and pesticides, which are emitted into the environment and eventually reaching humans through direct and indirect exposure; air inhalation, drinking water and food consumption (fruits, vegetables, meats, egg, fish, potato, etc.) (Pennington et al. 2005).

Ecotoxicity measures the effects on terrestrial and freshwater (streams and lakes) ecosystems in term of loss in biodiversity caused by toxic emissions emitted into the environment. For terrestrial ecotoxicity (worms, caramboles, etc.), it was estimated that the substances have ecotoxicological effects only by exposure through the aqueous phase in soil.

Other than feed production for dairy cows consumption, major potential impacts sources include electricity production.

Framework and impact pathway description

Both human toxicity and ecotoxicological (terrestrial and aquatic) impacts are assessed based on the multimedia and multi-pathways, fate, exposure and effect model Impact Assessment of Chemical Toxics 2002 (IMPACT 2002) (Pennington et al. 2005; Pennington et al. 2006), which enables estimation of chemical mass (or concentration) in environmental media at a regional and a global scale. It includes multiple exposure pathways that link a chemical concentration in the atmosphere, soil, surface water and vegetation to human intake through inhalation and ingestion.

For the purpose of this study, the spatially-resolved version of IMPACT 2002, adapted by Humbert et al. (2009) for a North American context, namely IMPACT North America model, was used for a regionalized impact assessment. The model provides a geographic differentiation among population exposure of toxic emissions for comparative risk assessment and LCIA within U.S. and Canada. It also considers several zones and regions accounting for air, water, soil, sediment and vegetation media.

Figure 3-10 represents the cause-effect chain describing the general scheme of impact pathways for human toxicity and ecotoxicity on which the IMPACT 2002 model is based. And, the following sections describes the characterization models.

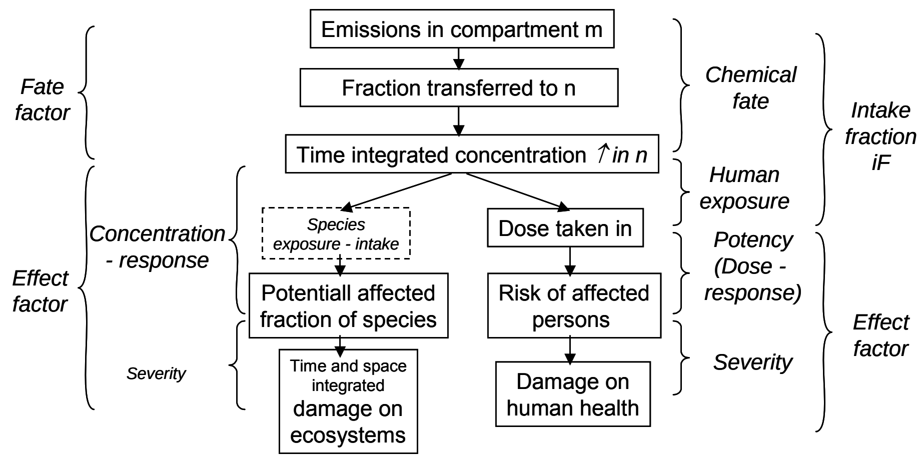


Figure 3-10 - General scheme of the Impact pathway for human toxicity and ecotoxicity (Jolliet et al. 2003)

Characterization model

Starting from the emissions, human toxicity modeling takes into account several factors, including the environmental fate factor of chemicals, a human exposure factor, the chemical potency based on a dose-response factor as well as a severity factor of toxic effects.

The potential damage score (D, in units of DALY) on human toxicity from a pollutant toxic release *p* at the emission location *i* is calculated following Eq. 9. The potential damage score is quantified by coupling the emission quantity emitted (S, in kg emitted/year) and the characterization factor of this specific emission at its emission location *i* ($CF_{i,p}$, in units of DALY/$kg_{emitted}$).

As indicated in Eq. 10, *CF* is the result of the product between the intake fraction (*iF,* in $kg_{intake}/kg_{emitted}$) and the effect factor (*EF,* in DALY/kg_{intake}). More specifically, *iF* corresponds to the combination of the fate factor (*FF*, in $kg_{in\ compartment}/kg_{emitted/year}$) and the human exposure factor (*XF*, in $kg_{intake/year}/kg_{in\ compartment}$). Likewise, EF is the result of the combination between the dose-response chemical potency (*DR*, in cases/ kg_{intake}) and the severity factor of toxic effects (*SF*, in DALY/cases).

$$D_{i,p} = S_{i,p} \times CF_{i,p}$$ **Eq. 9**

$$CF = \text{iF} \times EF = \underbrace{FF \times XF}_{iF} \times \underbrace{DR \times SF}_{EF}$$ **Eq. 10**

Based on a similar framework, ecotoxicity accounts for effects on both, aquatic and terrestrial ecosystems. The modeling is based on two main factors, namely the environmental fate of the chemical, the effect factor expressing how a mass increase of the pollutant affects the species in ecosystems.

As indicated in Eq. 11, the potential damage impact score (D, in units of PDF.m^2.yr) on ecotoxicity is quantified as the product between the emission quantity emitted (S, in kg emitted/year) and the characterization factor (CF, in PDF.m^2.yr/ $kg_{emitted}$).

CFs are developed following Eq. 12 considering the effect factor (*EF*, PDF.m^2/$kg_{in\ compartment}$) and the fate factor (*FF*, $kg_{in\ compartment}$/$kg_{emitted/year}$). These were calculated for emissions into air, water and soil and for both terrestrial and aquatic ecotoxicity.

$$D_{i,p} = S_{i,p} \times CF_{i,p}$$ **Eq. 11**

$$CF = FF \times EF$$ **Eq. 12**

Spatial coverage and resolution level

Using the spatially-resolved model that was adapted and calibrated for a North Americam context (Humbert et al. 2009) brings additional discrimination to the results and adds a new level of accuracy to this impact assessment of toxic release. The IMPACT North America model considers 831 air cells (2° x 2.5° grid resolution) and 523 watersheds in North America.

Therefore, spatially-differentiated characterization factors for all contributing substances and emissions were calculated using appropriate and relevant spatial resolution scale. Working on a Canadian level assessment, a spatial resolution scale based on 538 air cells (2˚ x 2.5˚ degree grid resolution) was used for emissions into air. Another spatial scale based on 172 Canadian watersheds was used for emissions into water and soil.

3.10. Scenarios and sensitivity analyses

In order to understand the incidence that key assumptions and data gaps have on the results, alternate scenarios are modelled and sensitivity analyses are performed. While sensitivity analysis in LCA typically tests for the effect of variability in key parameters, the context of the study already assesses variability across different averages. In certain cases, improvements on sensitive parameters are possible, yet their significance in practical terms (at the farm) also means a range of parallel effects on other (sensitive or not) parameters, so that modelling is not possible or very complex. An example of this would be an increase in dairy production linked to an increase in feed. The overall balance is a sensitive one to many aspects that is not so easily modelled. However, comparison of different existing scenarios (such as two provincial averages) can allow a certain degree of comparison towards answering the question on the parameter of interest. These will rather be discussed in the results and discussion section.

While the allocation ratio and methane from manure storage were tested for sensitivity to average data selected (sensitivity of methodology), most analyses focused on tested parameters that were based on decision making for practices at the farm level.

Simple scenarios were chosen to evaluate the scale of mitigation of practice changes at different areas in the milk production process. These also focused on hot spots, as identified in literature review and preliminary assessments. These “what if” scenarios are the following:

- Comparison of use of different synthetic fertilizers.
- Comparison of variable animal replacement ratio.
- Comparison of feed options to increase digestibility.
- Comparison of Liquid versus Solid manure management.
- Comparison of Liquid manure management With or Without natural crust.

Moreover, standard sensitivity analysis were also performed to assess the influence of certain parameters such as in transportation, and for the calculation of an allocation ratio.

3.11. Calculation tool

SimaPro 7.3.3 (www.pre.nl) will be used to assist the LCA modeling, link the reference flows with the life cycle inventory database, and compute the complete life cycle inventory of the systems. The final life cycle inventory result will be calculated by combining foreground data (intermediate products and elementary flows) with generic datasets providing cradle-to-gate background elementary flows to create a complete inventory of the two systems.

3.12. Uncertainty analysis

There are two types of uncertainty related to the LCA model:

- Inventory data uncertainty, assessed with a Monte-Carlo simulation.
- Characterization models uncertainty, which translate inventory into environmental impacts.

3.12.1. Inventory data uncertainty analysis - Monte-Carlo

An analysis of the uncertainty due to the variability of inventory data will be performed. SimaPro 7.3.3 software includes a module for Monte-Carlo simulation, which allows assessment of the variability embedded in inventory data spread over final results. This is achieved using a pedigree matrix that evaluates the representativeness of the temporal, geographical, and technological aspects of a parameter as well as the data sample size. This results in an estimate of the uncertainty for each data. Results of the uncertainty analysis then become probabilistic, with an analysis performed for 1000 iteration steps.

3.12.2. Characterization models uncertainty analysis

In addition to the inventory data uncertainty described above, there are two types of uncertainty related to the LCIA method. The first is in the characterization of the LCI results into mid-point indicators, and the second is in the subsequent characterization of those mid-point scores into end-point indicators. The uncertainty ranges associated with characterization factors at both levels vary from one mid-point or end-point indicator to another. Indeed, the accuracy of characterization factors depends on the ongoing research progress in the many scientific fields behind life cycle impact modeling, as well as on the integration of current findings within operational LCIA methods.

The minimal uncertainty on score results for some indicators, according to Humbert et al. (2009), can be summarized as follows:

- Climate change: 10%
- Human health (toxicity): 1 order of magnitude (factor 10)
- Human health (respiratory inorganics): 30%
- Ecosystem quality (toxicity): 1 order of magnitude (factor 10)
- Ecosystem quality (acidification/eutrophication): 30%
- Resources depletion: 10%

It should be noted that no LCIA-related uncertainty is carried over into the Water use indicator since the scientific consensus on this sensitive topic, as well as the grouping methodology, is still under revision in order to better assess these ranges of uncertainty.

4. Environmental LCA Results & Discussion

Presented in this section are the results from the environmental LCA of Canadian milk for each of the impact categories evaluated. Information provided in this section should be used only within the context of the boundaries and assumptions of this study and in consideration of this study's limitations, as described in sections 3.4 and 4.7, respectively. The sections below also present results for each system by stage of the life cycle when relevant. Variability across provinces is demonstrated through an error bar (or variability bar) on each column. This information is presented only to further explain the difference in overall trends seen in the different farm practices and regional context.

4.1. Environmental Footprint Profile

A footprint profile of the average kilogram of milk produced in Canada can be summarized with the numbers below. These represent only footprinting information that can be found in public communications, and do not include all aspects evaluated in this study.

To make these values more tangible, it is helpful to consider the results shown here in terms of aspects of daily life that are easier to visualize or understand. Benchmarking was also applied in relation to overall national impacts, such as the inventory of GHG emissions for all of Canada.

Table 4-1 - Simplified Environmental Footprint

Simplified Environmental Footprint		Equivalent (in non-life cycle terms)	Impact of Canadian Milk Production (8 Billion kg)
CARBON FOOTPRINT	1.01 kg CO_2e	6 km driven with a car	Less than 2% of Canada's carbon footprint
WATER FOOTPRINT	20 L	a 2 minute shower	Less than 1% of Canada's water consumption
LAND USE	1.7 m^2	0.5 kg of wheat (1-2 loaves of bread)	2% of Canada's agricultural land

4.2. Life Cycle Impact Contribution

In order to understand which types of activity contribute to the potential impacts and how these contributions vary across country, results are detailed by category below. When discussing variability, it is the result of provincial averages compared and analysed. It is typically based on different practices, and also linked to the regionalisation of impact characterisation.

4.2.1. Climate Change

The spread of greenhouse gas emissions is in line with similar publications. The main contributor in greenhouse gases consists of methane, followed by nitrous oxide and with carbon dioxide only in third place. This last gas, related to energy, transportation and infrastructure, has little impact (18%, including equipement and energy required in feed production). The most important emissions are caused by methane and nitrous oxide emissions occurring from enteric fermentation, manure storage and feed production.

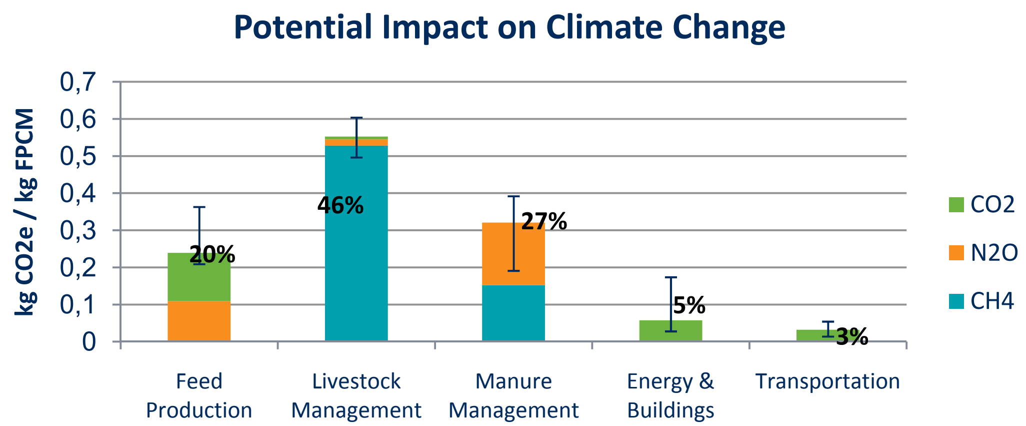


Figure 4-1 - Climate Change Impact Distribution, with provincial averages variability (error bars)

Variability with respect to the size of emissions is highest (range from 0.025 to 0.17 kg CO2e/kg FPCM) for energy emissions, due to the variability of the electrical grid mix between provinces (from 14 g CO2e/kWh to 293 g CO2e/kWh).

Variability is likely underestimated in Feed Production, based on the assumption that fertilization recommendations are always followed. Manure spreading and incorporation techniques and concentrations, matched with different synthetic fertilizer types and concentrations, as well as spreading techniques, varied greatly and inconsistently, leaving room for a better follow-up and guidance.

With fertilization, nitrous oxide emission factors also vary based on geography, a characterization mostly linked to climate moisture (Rochette et al., 2008). Feed production emissions are lowest in Alberta and Saskatchewan, because of dry climate, while they are highest in BC, due to a moist climate and much higher N recommendations for hay (section 3.6.3), (200 to 300 kg N/ha compared to less than 150 kg N/ha elsewhere), followed by the atlantic provinces, also because of moist climates, moderate yields and lower milk production per animal.

Fluctuations in emissions from livestock management are linked to changing replacement animal ratios (since their feed, digestion and manure is also included in the milk production system), as well as digestibility of feed, with concentrates having a higher digestibility than forage.

For the second biggest contribution to GHG's, different types of manure storage account for varying contributions of methane and nitrous oxide. While liquid storage results in important methane emissions that are sensitive to heat and reservoir type (dug-out lagoon or tanks, with crust, cap, or no cover), solid storage is more prone to emissions of nitrous oxide. This is detailed further in section 4.3.3.

4.2.2. Water Consumption

The water footprint is defined by the water consumed over the life cycle stages of the product, either by evapotranspiration or through inclusion in the produt. The water withdrawal (or water used), therefore, is a sum of the water consumed and the water returned to the system.

The water footprint of milk production in Canada varies greatly from one region to the next, between 11 L and 336 L of consumed water, however with most farms being at the lower end of this scale. According to Statistic Canada's irrigation data on feed produced (Statistics Canada, 2011), irritated farms in British Colombia top the footprint with 336 L consumed (546 L withdrawal) with irrigated farms in Alberta and Sasktchewan following, with 189 and 185 L consumed respectively. However, it is important to note that the irrigated farms only represent 10.6%, 2.84% and 0.74% of these three provinces respectively. An example of the spread in water use for the irrigated and non-irrigated scenarios is shown in Figure 4-2. Feed produced on irrigated surfaces contribute greatly to the overall footprint, shifting the weighted Canadian average to 20 L/kg FPCM. For farms using non-irrigated feed, less than 30% of the water consumption is linked to direct on farm use (drinking and cleaning water), while a greater contribution is linked to water evaporated during energy production, for use at various stages of the life cycle. For this reason, it is interesting to note that energy efficient measures also contribute to reducing the water footprint.

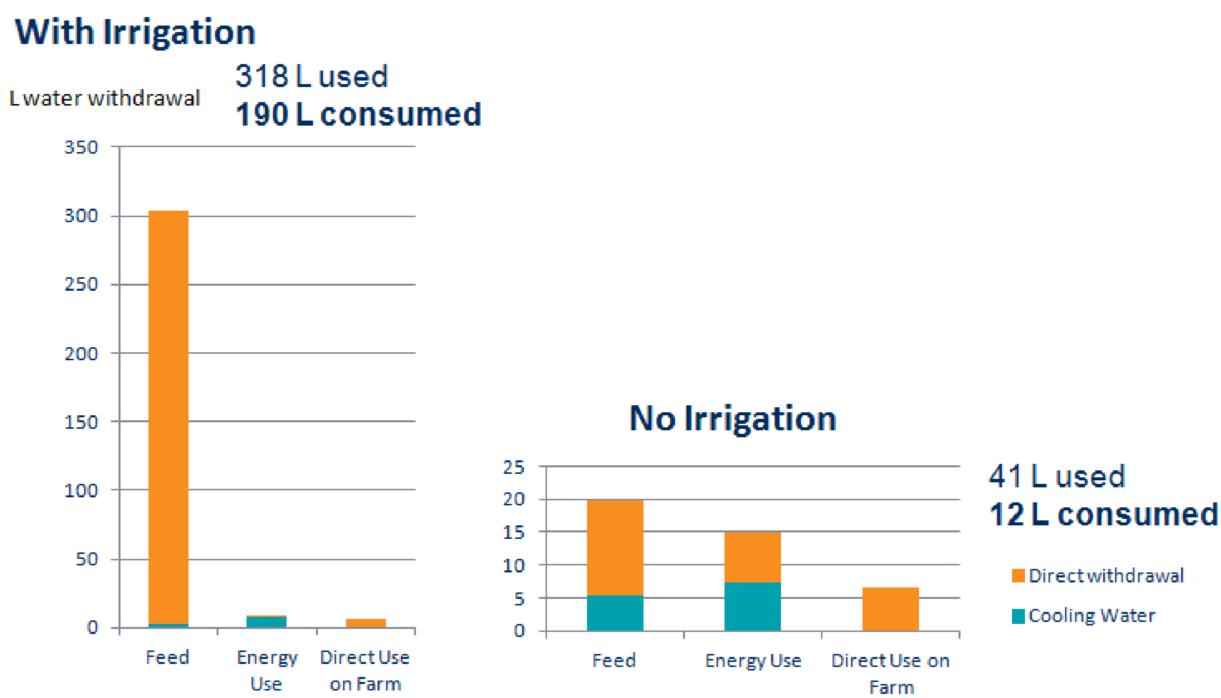


Figure 4-2 - Water withdrawal at different stages, based on two "average" scenarios, with and without irrigation.

The water consumption was also analysed in a water stress assessment. The water stress index (WSI) is defined as the ratio of total annual freshwater withdrawal to hydrological availability and takes into consideration water availability fluctuations throughout the year. With a value between 0 and 1, an index of 1 indicates a greatly stressed watershed. Because of the low scarcity on water in most sub-watersheds in Canada (Pfister, 2009), the overall stress assessment (a product of the water stress index and the water footprint) was very low, with a weighted Canadian average stress footprint of 1.1 L-eq/kg FPCM.

It should be noted that the equivalent water stress footprint reaches as low as 0.15 L-eq/kg FPCM in New Brunswick while its highest provincial average is at 4.4 L-eq/kg FPCM in Saskatchewan. For irrigated farms specifically, in Saskatchewan, this value is at 34 L-eq/kg FPCM.

In a further assessment step, the study evaluated the potential endpoint impacts of the water withdrawal and consumption on ecosystem quality, human health and resource depletion. The highest contribution came from irrigation water, highest in British Colombia, yet the overall contribution to potential impacts on ecosystem quality was still much lower than other contributors in the same category (2% of total impact on ecosystem quality), coming from different sources such as land use.

4.2.3. Ecosystem Quality

When assessing potential effects on ecosystem quality, different categories of impacts were evaluated, including ecotoxicity (terrestrial and aquatic), acidification, eutrophication, water use and land use. Each one of these categories were characterized using regionalized models, such that impact variability across Canada were a result of variable farm practices as well as changing geophysical conditions.

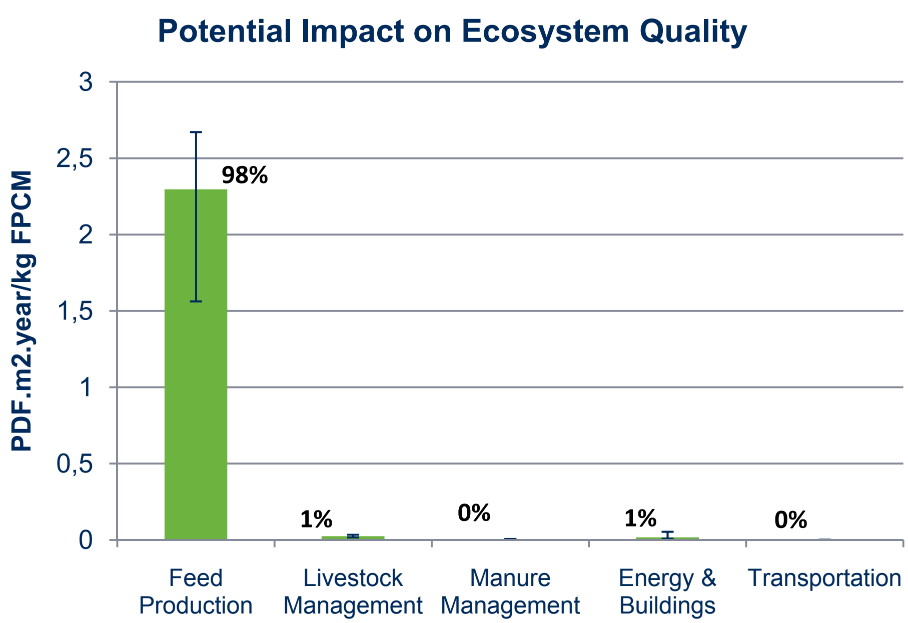


Figure 4-3 - Ecosystem Quality Impact Distribution, with provincial variability

The main type of potential impacts on ecosystem quality is linked to land use (95% of impact), with a potential impact on biodiversity, as well as some potential impact (3%) from acidification, due to ammonia emissions, ecotoxicity, from energy production, later consumed in different stages of the supply chain, and finally water use (1%). The impact of land use on biodiversity and metals on ecotoxicity are also very sensitive to geographical location. The potential for biodiversity lost from land use, for example, , is much more important in areas of dense industrial and agricultural activity. This is due to the existing fragility of ecosystem biodiversity in these areas.

Although variability of results between provinces was mostly linked to the sensitivity to biodiversity lost from land use, there is also inherent variability linked with feed crop choices and crop yields, causing a variability in the land footprint (m^2) itself.

The contribution of metals found in mineral supplements in the diet (such as copper, cobalt and zinc) were excluded from the base scenario. Together, these three metals could otherwise contribute an equivalent impact to ecosystems than the one caused by land use, based on a sensitivity analysis. However, in the case of metal emissions to the environment, the contribution of to the overall impact is known to be overestimated in the impact assessment model. This is because the model assumes that metals are in their dissolved ionic form (thus easily available), which is not always an accurate representation of the speciation of the metal emitted in the environment. Furthermore, the fate of metals contained in mineral supplements is uncertain. While there is an uptake by the feed production following the spreading of manure, the fact that mineral supplements are continuously given suggests that the feed does not take up everything and the difference is lost or emitted in the soil.

In terms of practices, the main sources of impact were linked to feed production. Potential loss of biodiversity was higher in areas sensitive to it (Figure 4–4), as well as in provinces with lower crop yields, as more land is required.

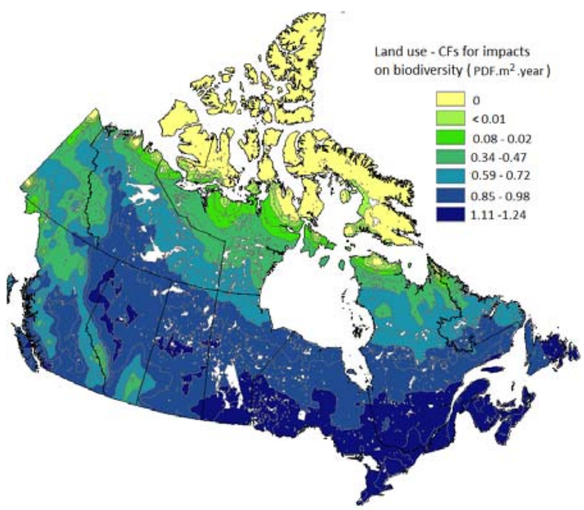


Figure 4-4 - Map of potential loss of the biodiversity from land use

4.2.4. Human Health

The potential effects on human health were assessed using six different categories of impact, namely respiratory inorganics and organics, toxicity, carcinogens, inozing radiation, and ozone layer depletion. Toxicity was further modelled using regionalized characterisation.

It is the respiratory inorganics potential impact that is most significant, with a 97% contribution to the Human health indicator. Most of this impact is characterized by ammonia emissions (71%), as a result of fertilizers, housing and from manure storage. The balance of impacting substances (26%) falls also in the category of respiratory inorganics, in relation to fossil fuel combustion (emissions of particulates, NO_x, SO_2, and hydrocarbons) in electricity production and direct use, occurring at different stages along the supply chain. While mineral supplements were excluded from the main scenario analysis, they can be assumed to accumulate in soils (see explanation in 4.2.3). The potential toxicity model is linked with an important uncertainty, however an estimate provides a contribution of 7% more impact to human health, from the mineral (metal) content of manure, when spread on crops. Zinc, most notably, is a substance that bio-accumulates over time and excess zinc consumption (through crops) can interfere with the absorption of other essential minerals (ODS, 2011).

The sum of potential impacts on human health reaches almost 1 x 10e-6 DALY/kg FPCM (disability adjusted life years). While it is relatively impossible to evaluate the overall significance of this value, it can be compared to the impact on human health of smoking 0.05 cigarette, or a living time reduction of 33 seconds. This conversion appears precise however it is important to remind the reader that it is an approximate comparison to potential impacts that are modelled, not measured.

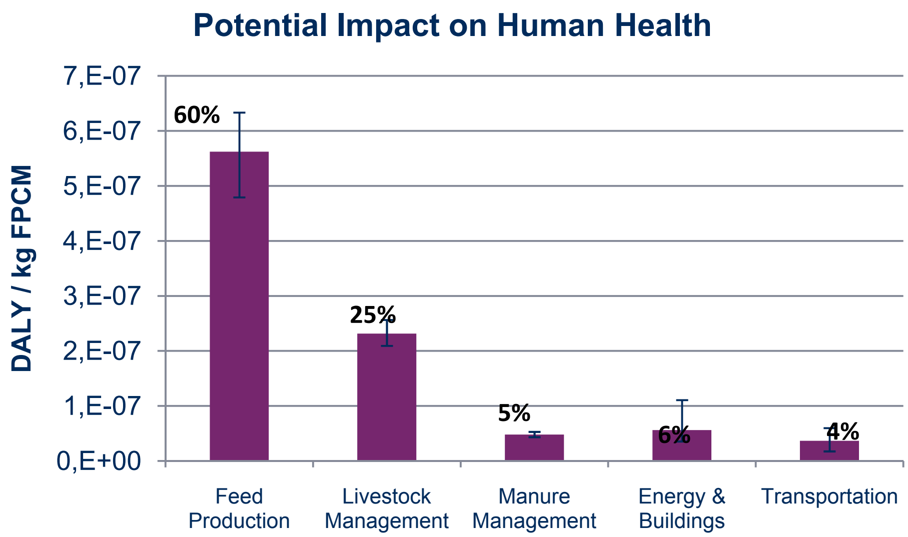


Figure 4-5 - Human Health Impact Distribution, with provincial variability

Variability between provinces was not so important, since most of the impact was linked to non-regionalized characterization (respiratory inorganics category). Some variability is inherently linked to the choice of fertilizers however, as emission factors of ammonia vary based on type.

Table 4-2 - Ammonia emission factors from use of different fertilizers

	Kg NH3/kg N applied (as per Nemecek, 2007)
Anhydrous ammonia	0.02429
Ammonium Nitrate	0.07286
Calcium Ammonium Nitrate	0.03642
Diammonium Phosphate	0.1336
Manure	0.255
Urea	0.279

4.2.5. Resource Depletion

On average, for Canadian milk production, the potential impact towards non-renewable resource depletion is caused mainly (91%) by the overall life cycle consumption of fossil fuels (62% oil, 16% natural gas, 13% coal), with the balance linked to the consumption of uranium in nuclear energy production. The energy consumption happens over three main stages of the life cycle, mainly the feed production (and upstream steps), the energy at the dairy farm (and upstream production of electricity) and the transportation.

Variations by province linked to farm practices are related to crop farming, with the consumption of diesel and the choice of fertilizers affecting the balance. More variation is linked to the energy use and its production, because of the great variability in provincial electrical grid mixes. Finally, variable distances of milk transportation has a relatively small effect on the overall bill of energy. In terms of equivalence, this total life cycle consumption of 4.75 MJ/kg FPCM is equal to 0.11 L of oil (petrol).

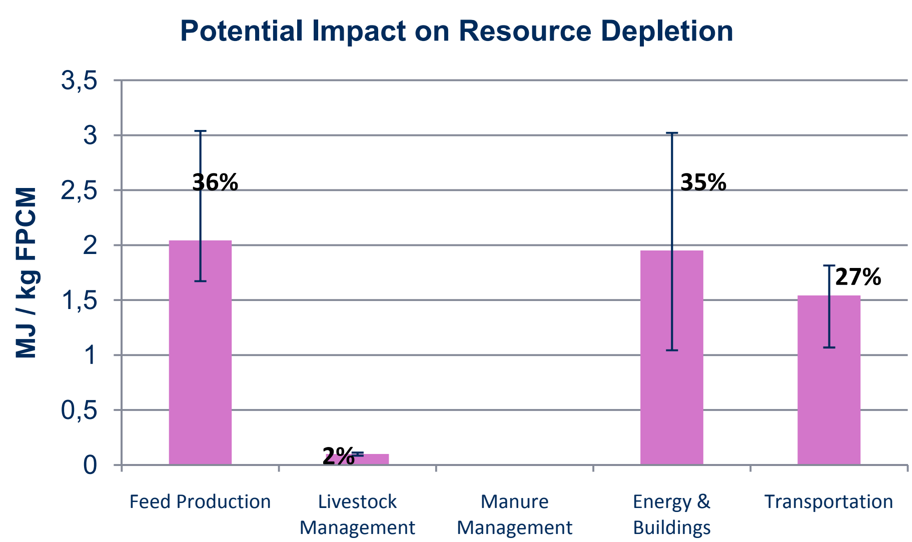


Figure 4-6 - Resource Depletion Impact Distribution, with provincial variability

4.3. Hot Spot Assessment

In this section, the main contributing life cycle stages were analysed further to understand the burdens at each stage of the life cycle.

4.3.1. Feed Production

Feed Production was the third most important lifecycle stage for greenhouse gases, yet the most important stage for all other potential damage categories.

Different crops have varying contributions to the overall impacts, mainly based on fertilization (quantity and type), yields (land use) and energy requirements, as illustrated in Table 4-3. Corn grain, for example, had proportionally more impact on climate change, as did small grains, while soybeans had less. This was due in great respect to fertilization concentrations needed. Dry corn also requires more energy, including onsite and drying, which accounts for a more important consumption of non-renewable resources. While hay is the most important constituent of the diet (46% by weight) it has relatively less impact (<46%) on all damage categories.

With potential impacts on ecosystem quality, it was a direct link to average crop yield. Corn silage, for example, benefitted from the highest yield per hectare (approximately 13 tons of dry matter per hectare) while soybeans were in the lower range, with a yield around 2 tons of dry matter per hectare, which accounted for the largest divergeance from weight distribution to impact distribution (8% to 22%).

Table 4-3 - Contribution of feed to impact categories

Contribution	Hay	Corn Silage	Dry Corn	Small Grains	Soybeans	Rations East	Rations West
Average Diet (by weight)	**46%**	**20%**	**11%**	**10%**	**8%**	**6%**	**3%**
Climate change	33%	10%	17%	15%	4%	13%	7%
Ecosystem quality	61%	4%	10%	0%	22%	2%	1%
Human health	38%	19%	13%	15%	9%	3%	2%
Resources	26%	7%	20%	15%	5%	18%	9%

4.3.2. Livestock Management

Greenhouse gas emissions from livestock management were, as previously mentioned, dominated by methane emissions resulting from enteric fermentation. Variability across Canada was based on milk production efficiency (kg/head) and digestibility. Digestibility was calculated as a function of the share of forage versus concentrates in the diet, with concentrates having a higher digestible energy.

Overall, the emissions of methane per dairy cow are found to average 125.9 kg CH4/kg FPCM, with a range between 124.3 and 126.3 kg CH4/kg FPCM. This value is consistent with Canadian scientific literature at 126 kg CH4/kg FPCM (Ominski et al., 2007).

For potential impacts on human health, it was ammonia emissions in housing that presented a threat to the respiratory system. With respect to ecosystem quality, the potential impacts lie upstream, in energy production, with potential emissions affecting ecotoxicity. This result, as mentioned in Section 4.2.3, is linked to a high uncertainty.

4.3.3. Manure Management

Variability across provinces for potential impact on human health and ecosystem quality is low, and mostly caused by a variation on average milk efficiency per animal.

Variability in the emissions of greenhouse gases however is strongly linked to the choice of manure management type (solid vs liquid) and storage tank, for the liquid management.

With regards to manure management, average practices vary from province to province. While there is more liquid storage (75%) in the prairies, most liquid lagoons are found in Ontario, which profiles it as having the largest emissions for this stage (0.4 kg CO2eq/kg FPCM). With an important share of solid storage as well as the highest milk yield per cow, BC displays the lowest emissions (0.2 kg CO2eq/kg FPCM).

The table below compares the different profiles of GHGs for manure management with respect to the production of 1 kg FPCM.

Table 4-4 - Profile of GHGs from different manure management practices in Canada

	Averaged Manag't	Solid Storage	Solid on Pasture	Liquid with Crust	Liquid with Cover	Liquid with no cover	Liquid Lagoon
% of Manure	Canadian average :	34%	13%	37%	5%	8%	3%
Kg CO2e/ kg FCPM	0.32	0.17	0.30	0.31	0.34	0.35	0.96
% CH4	47%	15%	4%	40%	52%	61%	86%
% N2O	53%	85%	96%	60%	48%	39%	14%

4.3.4. Buildings & Energy

As mentioned in section 4.1, a great variability is found in the greenhouse gas emissions from electricity production in the different provinces. The same is the case for the other categories of impact. However, the variability is not detailed here, as it is not linked to a practice that milk producers can act on.

On average, electricity contributes between 40% and 80% of the environmental impacts from its production. Gasoline production and consumption contributes between 10% (to ecosystem quality) and 54% (resource depletion) of impact. The remaining contributions are less than 5%, from the production and demolition of buildings and dairying equipment. Free-stalls and tie-stalls had a similar profile, as the core of the buildings are similar, requiring more or less the same building components. Because of the addition of milking parlours to free-stall management, buildings were more impacting for this type of farm.

4.3.5. Transportation

Three sources of transportation were modelled, with milk transportation, transported purchased feed and transported purchased farm animals. However, this last item proved to be insignificant (less than 1%), which is understandable by its low frequency. For example, while an average between 500 to 1250 tons of milk are transported every year from the farm over approximately 150 km, less than 5 tons in animals are transported on average over similar distances.

With respect to feed, the weight ratio of dry feed to kg FPCM ranges typically between 1.2 and 1.4, however the proportion of purchased feed ranges anywhere between 10 and 45% (provincial averages), on variable average distances that fluctuate between 60 and 340 km, such that, overall, it represents 15% of overall transportation to and from the farm.

Milk transportation, in turn, represents 85% of total transportation.

4.4. Scenario and Sensitivity Analyses

While sensitivity analysis in LCA typically tests for the effect of variability in key parameters, the context of the study already assesses variability with the most impact across different averages.

While the allocation ratio and methane from manure storage were tested for sensitivity to average data selected (sensitivity of methodology), most analyses focused on tested parameters that were based on decision making for practices at the farm level.

It must be stressed that while countless mitigation scenarios exist to help reduce the impact of milk production in some way or other, many practices have inherent parallel impacts, which are often tradeoffs, that render modelling very difficult at life cycle approach to macroscopic modelling. For example, while increasing crop yields would help reduce different aspects of the environmental impact, this is typically achieved by increasing fertilizer application, which will in turn contribute to the environmental impact in other ways. The relation between the two is not one that is easily modelled, and the objective of the scenario analyses detailed below was strickly to help understand the scale of reduction possible in the case of simple changes.

4.4.1. Sensitivity to Methodology - Allocation Ratio

The allocation ratio has a direct impact on the footprint of milk. Allocation method was calculated according to IDF (2010), based on a physicochemical ratio of energy ingested for meat production versus milk production.

This ratio was calculated, when data was available, using the average number of cows and calves sold versus milk sold. An average weight had to be assumed, using 200 kg for calves and 600 kg for culled cows. In the allocation calculation, it is the weight of calves that is most arbitrary, with a value of 200 kg.

Two parameters were tested. While the basic scenario assumed calve weights of 200 kg, excluding the feed of grain fed calves, a similar system with grain fed calves, with an average of 250 kg per calve was calculated. Additional feed production was based on an average feed for calves of 4 kg dry matter/hd.day. While the additional feed only contributed 1.2% more to the overall impact (before allocation), the additional weight in the allocation factor contributed to a reduction up to 0.05 kg CO2/kg in the overall footprint, or by 4.4%.

It is interesting and useful to note that while this test was done on the weight of calves, similarly, this 20% in overall weight increase (based on a cow/calve sold ratio of 1 to 2) could have been achieved by increasing the average weight of culled dairy cows from 600 to 675 kg, and calves from 200 to 265 kg.

Table 4-5 - Sensitivity of calve weight in allocation factor

	Base Scenario (200 kg)	Mid range (250 kg)	Heavy range (300 kg)
Allocation ratio	82.2%	80.2%	78.2%
Allocated carbon footprint	1.01	0.98	0.96

4.4.2. Sensitivity to Methodology - Manure Storage Temperature

The IPCC Tier 2 methodology for calculating CH4 emissions from manure management using emission factors that are based on an average annual temperature. For Canada, this temperature is always at 10°C or below, therefore pointing to the use of the small emission factors. However, when comparing methane emissions in this stage with the equivalent for the US context, there is a large discrepancy, which is caused by the use in the same modelling of a higher average annual temperature. In fact, in Eastern Canada, temperatures can be very warm during the summer, causing equally important methane emissions. To test for the sensisitivity of this use of a low average annual temperature, an average temperature of 15°c was tested.

The overall difference in the carbon footprint was however only 0.06 kg CO2eq (or 6%) higher for the average Canadian scenario.

4.4.3. Sensitivity to Methodology – Inclusion of Mineral Supplements

The fate of metals contained in mineral supplements is not well known. As discussed in 3.6.3, it is assumed that minerals in manure, from digested feed, are not fully captured by crops, which explains the need for mineral supplements. The difference is therefore assumed to be emitted to soils. In the impact assessment method, ecotoxicity and human toxicity modelling from metals is based on the assumption that metals are fully dissolved, in their ionic form, and for this reason the impact is known to be largely over estimated. If included in the model, it is both Ecosystem Quality and Human Health impacts that are affected.

Ecosystem Quality is increased by 60% to 3.5 PDF*m2*yr, while Human Health impact is increased by 7% to 1.01E-6 DALY.

4.4.4. Scenario Analysis - Synthetic Fertilizer Application

To supply the need of nitrogen fertilization, a mix of synthetic and natural (manure) fertilization is typically used, one that is not well documented. For the purpose of comparison, a test is made supplying the complete requirements with synthetic fertilizer (no manure), using the three main fertilizers used. These consist of urea, ammonium nitrate, and anhydrous ammonia, with a variable degree of popularity based on provinces and regulation (Sheppard et al., 2010). Their volatility and reaction with air to release NO_2 and NH_3 varies, which is tested here for overall impact on climate change and human health.

Because of the high uncertainty and variability in fertilization scenarios, these scenario analyses were modelled using a simplified assumption by which all fertilization needs are fulfilled (substituting all the manure). The comparison is between the different options and the overall total of impact is not quantified to avoid comparison with the basic scenario.

Figure 4-7 - Scenario Analysis - Choice of synthetic fertilizer - Climate Change Impact

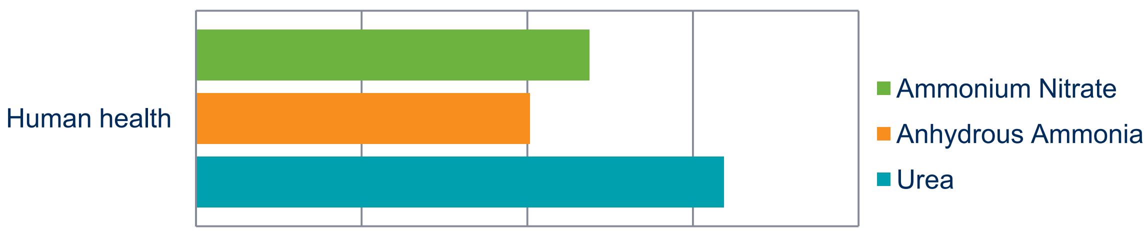


Figure 4-8 - Scenario Analysis - Choice of synthetic fertilizer - Human Health Impact

Anhydrous ammonia, on an equal concentration of N, would release 37% less ammonia, thereby increasing its efficiency (more N retained in the soil) and reducing the need for further fertilization.

4.4.5. Scenario Analysis - Animal replacement ratio

The animal replacement ratio refers to the percentage of dairy cows that are culled annually, to be replaced with bred heifers. Dairy cows are said to be replaced typically after two or three years of lactation (rate of replacement between 33 to 50%, with an average of 38%). This rate, in turn, affects the number of replacement animals at the farm, thus affecting inputs and outputs, including feed production, enteric fermentation emissions, and manure production. Scenarios were tested for ratios of 25% and 33% (3 to 4 years of lactation).

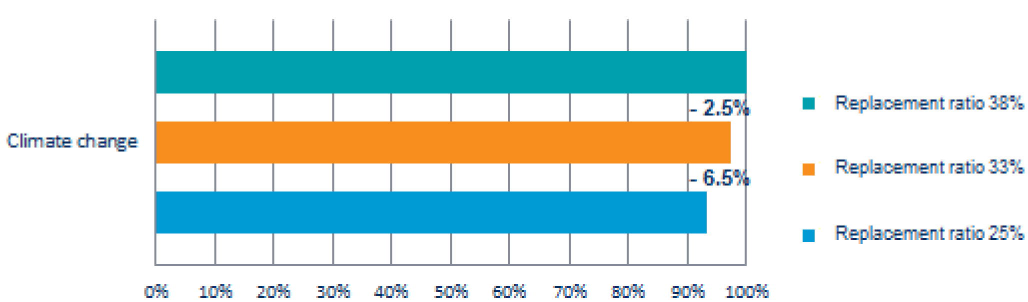


Figure 4-9 - Scenario Analysis - Animal Replacement Ratio

Overall, it was found that a reduction in animal replacement ratio from the average of 38% to 33% would see a reduction in the overall environmental footprint of 2.5%, while a further reduction of ratio to 25% would see an overall reduction in footprint by 6.5%.

4.4.6. Scenario Analysis - Enteric Fermentation

Various studies (Moate et al., 2011; Beauchemin et al., 2007) have suggested that including more fat supplements in the cattle diet could reduce methane emissions due to enteric fermentation. A sensitivity analysis was performed to test the potential reduction by increasing the percentage of high concentrate feed and the digestibility of the high concentrate feed in the model. As a result, when the fat content increased by 10%, the methane emissions decreased by 4 to 5%. It must be noted that there is a limit to the quantity of fat that can be fed to cattle to avoid digestive disturbances. The potential increase in the feeding costs must also be considered.

Overall, by simply adding fat to the diet (orange bar on graphic), a reduction of the overall carbon footprint of 4% is achieved. Increasing the concentrates in the diet also helps decrease the emissions of methane from enteric fermentation, however conclusions cannot be drawn on the overall footprint as a change in feed will also change the footprint of the feed production and potentially the manure storage.

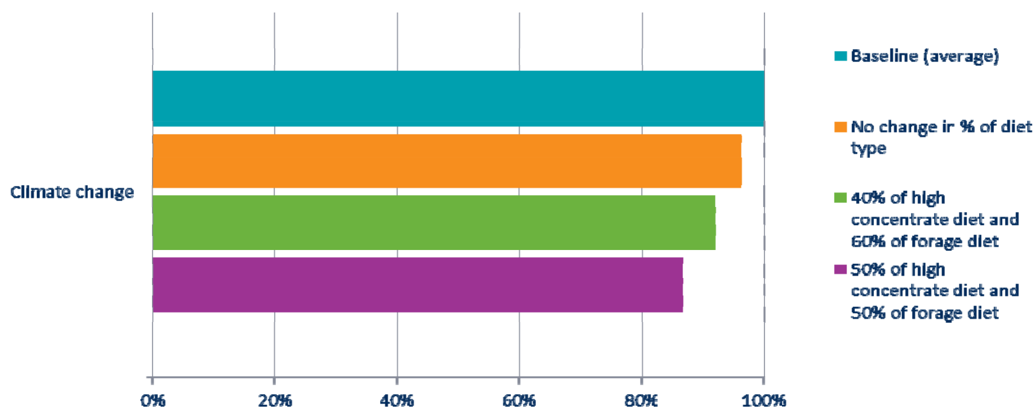


Figure 4-10 - Scenario Analysis - Enteric Fermentation - Climate Change Impact

4.4.7. Scenario Analysis - Manure Management

Solid vs. Liquid

Liquid manure management leads to more anaerobic conditions than solid manure management and thus more methane are emitted from liquid storage systems (Langmead, 2003). Since in most provinces, liquid manure management accounts for more than 45% of the manure management systems, a sensitivity analysis was done to observe the potential reduction of the impact on climate change when 100% of the manure was stored in solid manure management systems. In this scenario, the impact on climate change decreased by 9%. If the opposite was achieved, and all manured was stored in liquid form, an increase of the footprint by 8% could be expected.

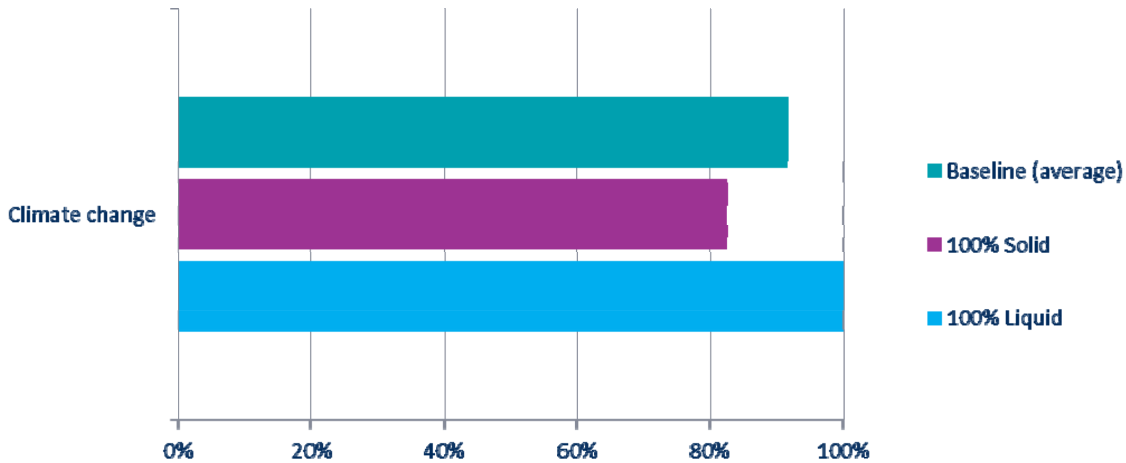


Figure 4-11 - Scenario Analysis - Manure Management Type - Climate Change Impact

Changing the storage structure and spreading mechanism from liquid to solid requires significant investments, but it is definitively something that could be considered when the current structure is near its end-of-life. This change affects mostly climate change only, with a change in potential impact on human health possible from ammonia emissions (not modelled here by storage type).

Liquid Manure Management

According to the IPCC Guidelines (2006), a manure management system with a natural crust cover on top has the lowest methane conversion factor, but has the highest N_2O emission factor. On the other hand, an uncovered anaerobic lagoon has the highest methane conversion factor (see Table 4-4 for more information), but the lowest N_2O emission factor.

The following sensitivity analysis compared the average Canadian scenario with two changes in liquid manure management – where one (purple) has all liquid management convert to a natural crust system, and the other where all liquid manure is stored in dug-out lagoons. It is possible to see a 20% difference on the overall impact to climate change between these two scenarios. The reduction from the base scenario to the all-crust-cover scenario is only reduced by 4%, however this is because only 12% of farms use a lagoon.

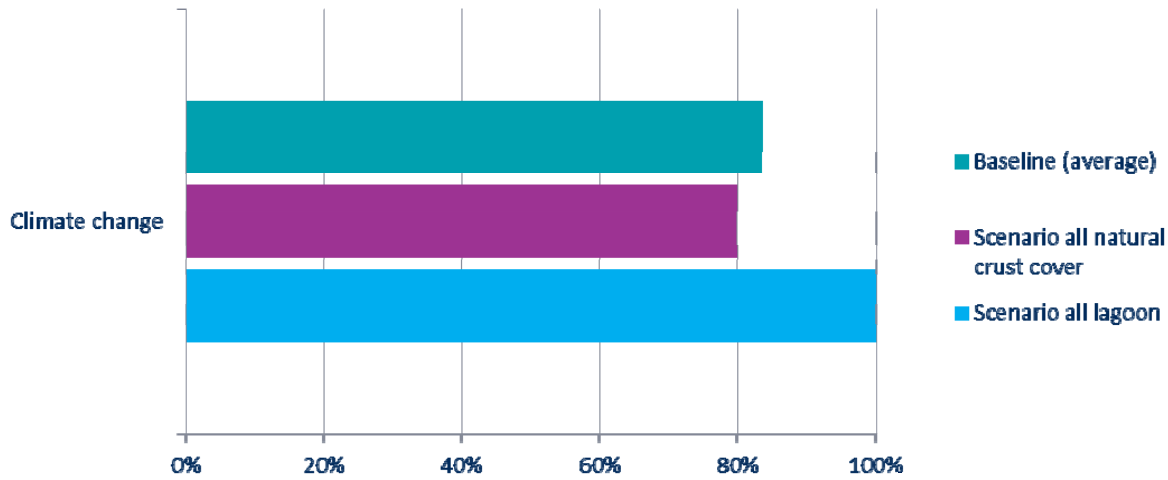


Figure 4-12 - Scenario Analysis - Liquid Manure Storage Type - Climate Change Impact

4.5. Uncertainty Analysis

The uncertainty is calculated using a Monte Carlo analysis, with data parameters characterized following a pedigree matrix, to assess uncertainty over temporal, greographical and technological representativity as well as quality of the data source and size of sample.

The carbon footprint of milk has a 95% confidence interval with a range from 1.20 to 1.24 kg CO2e/kg FPCM, before allocation. This value gives a high confidence of the result, by which, including the allocation ratio between milk and meat of 82%, we get a range between 0.99 and 1.03 kg CO2e/kg FPCM. Uncertainty, however, was not characterized on the emissions factors used, because their value is not known. As such, the uncertainty value expressed here is underestimated overall yet there is no simple way of estimating the full uncertainty.

Uncertainty on the overall potential impact on ecosystem quality was highest, with a range of almost 1.3 PDF.m2.year/kg FPCM over a value of 2.3 PDF, representing 56% of the value, while potential impact on human health had a 95% confidence interval that varied over 7% of the footprint. The same interval spread over 34% of the impact result for resource depletion, and 12% for the water footprint (no-irrigation scenario).

If uncertainty was highest in the ecosystem quality category of impact, it is because the most important sources of uncertainty are related to feed production, which is a more important hotspot category for this type of impact than for climate change, for example. Uncertainty was linked to quantity of feed consumed (produced), yield as well as quantities of natural and synthetic fertilizers used. This uncertainty is mostly inherent to the quality of data available regarding feed production. With regards to yield, the variability is linked to climactic conditions from year to year. With feed quantities fed to animals, the variability is related to quantity per animal, as there the precision of data is not so fine. However, with respect to fertilizers, there is a lack of tracking of what is actually spread at the farm. This is the area that could most benefit from improvement.

4.6. Comparison to Other Studies

Although the results of any LCA are valid and meaningful only within the context of the study's boundaries, assumptions, and limitations, it is important to nevertheless compare outcomes to those of LCAs performed elsewhere, and understand the difference in performance. While the values may not be directly comparable, the assessment can act to some extent illuminate the influence of system conditions to results, and guide future work. Several studies are identified here for these purposes.

Looking at the carbon footprint of milk, compared to alternative publications, Canada places among the top, with New Zealand leading the pack. Some variability can result from methodological choices, however New Zealand benefits from a mild climate and a geography that allows for pasturing year-long. Meanwhile, the US and the Netherlands find higher footprints, both using more intensive agricultural practices with an important contribution of feed from corn, a high-impact crop. Most importantly, the US produces an important percentage of its milk in Southern states such as California where liquid manure management combined with high temperatures boosts the methane emissions from manure manage much higher than in Canada.

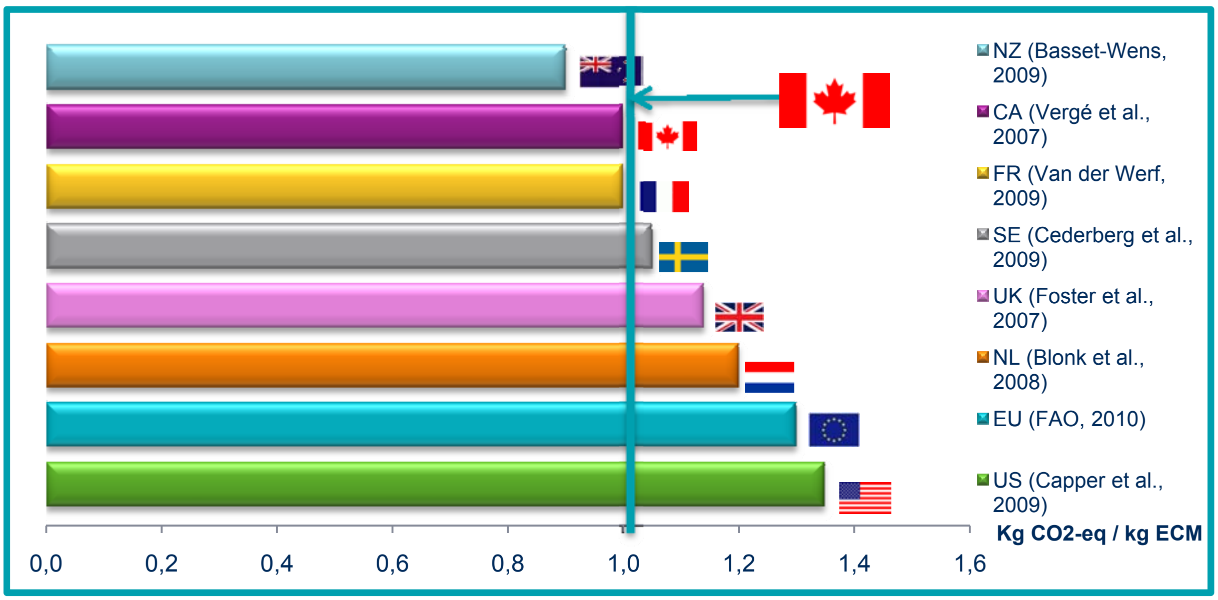


Figure 4-13 - Benchmarking of carbon footprint

With regards to Water Footprinting, a few publications are available that allow for benchmarking. Mainly, a French publication from l'Institut de l'élevage (2012) places the French milk's water footprint at 17 L/kg. A publication by Mekonnen and Hoekstra (2011) evaluates a few more, with the Chinese footprint at 132 L/kg, the Indian footpring at 148 L/kg and the Dutch at 42 L/kg. The variability is entirely a function of irrigation, with large countries composed of different climates such as Canada demonstrating higher footprints.

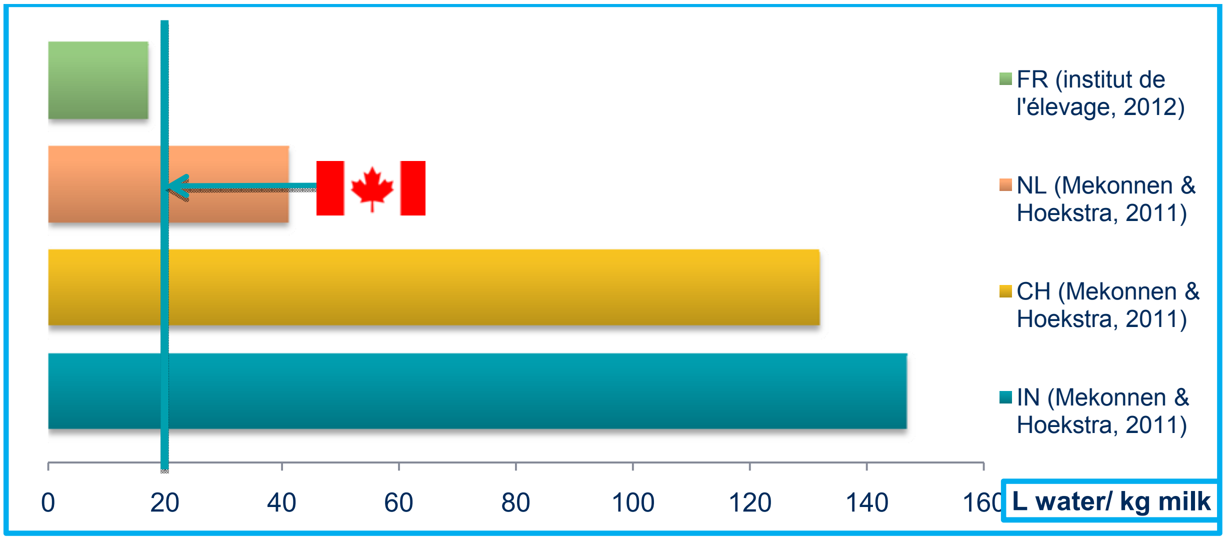


Figure 4-14 - Benchmarking of water footprint

Although it would be interesting to compare results with nutritional alternatives, such as soy milk and other animal proteins, doing so on a per kg basis is irrelevant, which a nutritional content so variable. A project beginning in June 2012 will attempt to define the most relevant way to compare the environmental impact of nutritional alternatives to milk.

4.7. Study Limitations

The work presented here is a detailed assessment intended to provide reliable macroscopic insight with a high level of efficiency. There are, therefore, several limitations to the certainty of outcomes from the project, namely the following:

- This study evaluated a specific range of impact categories. Conclusions should not be drawn regarding types of environmental impacts that have not been directly addressed here.
- Hay (dry and silage) is the most significant source of feed for cows. However, hay production varies greatly, not only in the grass type itself (tame hay, alfalfa, clover, etc) but in its management (permanent or semi-permanent pasture, or in crop rotation) and fertilization. As such, it brings an important uncertainty on emissions from crop production.
- The potential of soil degradation and the use of crop rotation are not easily captured in life cycle assessment, as most studies evaluated a system in a one-year production time frame. It is however a topic of great interest that goes hand in hand with best practices in soil fertilization. Underlying system assumptions must be based on sustainable soil practices.
- Practices of manure spreading are not well documented and vary greatly between farms. The same is true of synthetic fertilizers. Meanwhile, these are important sources of emissions to air, soil and water impacting ecosystem quality, human health, climate change and resource depletion. There are therefore significant limitations to using approximate scenarios that would greatly benefit from better tracking of these practices.

- IPCC Tier 2 model for land management does not differentiate between the different types of land management, period of spreading and spreading technique. Accounting for these could help capture reductions in emissions and help identify best practices.
- Quantities of feed per animal were not known for most provinces. It was calculated based on DMI recommendations. It is known however (Capper et al., 2009) that feed efficiency (kg/kg milk) is very variable, which in turn would ad an additional layer of variability on the assessment.
- Feed rations and protein supplements are not well documented in grey literature and are known to vary greatly, in their content and their use. An average is difficult to define and inhenrently comes with limitations.
- Mineral supplements to dairy cows contain metals that accumulate in soils from manure spreading (minus a partial uptake by plants). Impact models in LCA model these with a great over estimation of the impacts, which is why they were only assessed in an sensitivity analysis. A potential issue is hence idenfied yet the interpretation of the scale is very limited.
- The enteric fermentation model is an approximation of methane emissions and does not differentiate between different types of feed. There are many limiting factors in this model that affect the methane emissions results, such as the methane conversion factor, the digestible energy of the diet and the body weight of the cattle. As such, they only provide a scale of emissions useful for comparisons with other sources of GHG emissions.
- The methane conversion factor (Y_m) can significantly drive the total methane emissions. In this study, the Y_m was calculated using one of the many equations developed by Ellis (2007). This equation is based on the dry matter intake and provided results below and above the 6.5% suggested by the IPCC (2006). More accurate models are found, however they require information on the chemical composition of the diet which was are relevant on a farm-to-farm basis but were not available for this study.
- The dry matter intake was previously calculated from the body weight of the cattle and the digestible energy (DE%) of the diet. In this study, the means of the digestible energy (DE%) ranges provided for each feed class by the IPCC (2006) were used, but more precise DE% data would be preferable since a 1% change in the DE% can cause a variation of up to 4% for Y_m. According to the IPCC (2006), a 10% error in the average diet DE% can cause a variation in the range of 12 to 20% in the methane emissions. Also, on a farm-per-farm basis, more specific data on the body weight of the cattle would be necessary to refine the calculation of the dry matter intake. It is important to note that the model used does not take into account the decrease in DE% when more feed is consumed daily. The feed intake of high producing cattle is therefore underestimated.
- When using the IPCC Tier 2 model for manure management model, many default values have been included in the calculations since there were no country or region specific values available in the data collected or in the literature. The IPCC (2006) reports a ±20% uncertainty range in the emissions factors when the Tier 2 method is applied. To refine the model used in this study, values that represent more specifically the manure management conditions of each region should be found for the following parameters: ash content of manure (ASH), maximum methane producing capacity (B_o), methane conversion factor (MCF), emission factor for direct N_2O emissions (EF_3), emission factor for N_2O emissions due to volatilization (EF_4) and emission factor for N_2O emissions due to leaching and runoff (EF_5). The temperature, moisture conditions, aeration, VS content, duration of storage, and other aspects of treatment are to be considered in the measurements of these parameters (IPCC, 2006).

- Although the data collected took into consideration that manure could be managed with various types of manure management systems within a single farm, the model does not represent the fact that the same manure could go through different management systems.
- Achieving consistency in data collection and interpretation across Canada was a challenge. For this reason, high data resolution was sometimes omitted in preference of consistent data.

4.8. Best Practices and Leads

While assessing best practices was not easily achievable based on provincial average comparisons, review of literature and results analysis allowed for the identification of paths towards best practices.

Table 4-6 - Leads towards best practices

Practice or Activity area	Description
Different choice of fertilizers	Manure, when looking at emissions from spreading only (impacts of storage are linked to the animal product), represents the least impacting choice of fertilizer, assuming equal efficiency. Injected anhydrous ammonia is also a very efficient choice with less impact. From the most common sources of synthetic fertilesers, ammonium nitrate production is responsible for more CO_2 emissions, while urea is responsible for more emissions of ammonia on the field.
Manure spreading technique	Important emissions of N_2O and NH_3 occur following manure spreading, thereby reducing the efficiency of manure as a nitrogen fertilizer. Shifting autumn manure application to spring and incorporating all manure within one day of application could help reduce these emissions by 17% (VanderZaag et al., 2011)
More efficient forage	Alternatives to corn silage could help replace fertilization and water requirements. It has been shown that barley silage has a similar dietary content, requires less fertilization and water, while it also significantly increases milk fat and protein (Tudisco et al., 2010)
Energy efficiency	Energy efficiency improvements have much more impact on greenhouse gas emissions in provinces with fossil fuel based grid mixes than in provinces with mostly hydroelectricity (20 times more reduction impact in Alberta than in Quebec). In Alberta, a reduction in 30% electricity consumption would result in a reductions of 5% of the carbon footprint. Use of more efficiency dairying equipment (such as a heat exchanger) can help reduce this contribution to energy consumption at the farm (25%).
Participation in a EFP (Environmental Farm Plan)	Environmental Farm Plan help manage fertilization, among others. The 2006 FEMS (farm environmental management survey) identified that there is a significantly higher proportion of livestock producers in Quebec and Ontario participating in the EFP program than in other provinces (over 60% of livestock farms, versus 23% in Western Canada (AAFC, 2012)), likely due to provincial legislation that targets nutrient and manure management issues.

5. S-LCA of Milk Production In Canada

This chapter presents the Social life cycle assessment (S-LCA) of milk production in Canada. The aim of this S-LCA is to assess the socioeconomic performance of the organizations involved in the life cycle of milk produced in Canada. More specifically, the study focuses on the following objectives:

- Identify the relevant specific groups of stakeholders;
- Identify and document a set of specific socioeconomic performance indicators with particular emphasis on milk production at farm level;
- Assess the socioeconomic impacts generated on stakeholder groups and;
- Analyse and interpret the results in order to provide some recommendations towards improvement of practices among the Canadian milk production sector from a social responsibility perspective.

This chapter starts with a brief overview of the S-LCA technique describing its rationale and its main analytical components (section 5.1). Section 5.2 portrays the **product system** upon which this assessment has been performed. The two analytical frameworks used to assess the socioeconomic impacts resulting from the Canadian milk production sector are described in sections 5.3 and 5.4. They are the **Specific assessment** applied to the dairy farms and their business partners included in their sphere of influence and the **Potential hotspots analysis** applied to the organisations falling outside their sphere of influence. Results are presented in section 5.5.

5.1. Social Life Cycle Assessment

S-LCA is a "technique that aims to assess the social and socioeconomic aspects of products and their potential positive and negative impacts along their life cycle" (UNEP/SETAC 2009; 37). By extension, S-LCA tool is also applicable to a service, a sector or an organization. The main features of this tool are its broad scope, which encompasses a product's whole life cycle, and its assessment method, which relies on benchmarks to assess the relative social performance of the organisations (private, public, or non-profit) involved in the product's life cycle. These features differentiate this technique from the Corporate Social Responsibility (CSR) reporting tools such as the Global Reporting Initiative (GRI), which aims to measure and disclose the organizational performance towards the goal of sustainable development, but without using a life cycle perspective.

The S-LCA methodology relies on the recently developed 'Guidelines for Social Life Cycle Assessment of Products' (hereafter the Guidelines). Published in 2009 by the United Nations Environment Programme (UNEP) in collaboration with the Society of Environmental Toxicology and Chemistry (SETAC), these Guidelines provide the general framework needed to conduct such an assessment.

The Guidelines propose a classification of the main socially significant themes to assess, as well as a categorization of the main stakeholder categories potentially affected by the socioeconomic impacts induced by the activities and behaviours of the organisations involved in the product's life cycle. Six main impact categories are listed in the Guidelines, each being related to a number of impact subcategories, or specific issues of concern, which are "socially significant themes or attributes" to assess (UNEP/SETAC 2009; 44). These impact categories are **human rights**, **working conditions**,

health and safety, **governance**, **cultural heritage** and **socioeconomic repercussions**. As for the stakeholder categories, the Guidelines list the following five groups: **workers**, **local communities**, **society**, **consumers** and **value chain actors** (Table 5–1).

Table 5-1 - Stakeholder categories and Impact subcategories listed in the Guidelines

Stakeholder categories	Impact subcategories (impact categories[1])
Workers	Freedom of association and collective bargaining (HR) Child labour (HR) Fair salary (WC) Working hours (WC) Forced labour (HR) Equal opportunities/Discrimination (GV) Health and Safety (HS) Social Benefits/Social Security (WC)
Consumers	Health & Safety (HS) Feedback Mechanism (GV) Consumer Privacy (HR) Transparency (GV) End of life responsibility (GV)
Local communities	Access to material resources (HR) Access to immaterial resources (HR) Delocalization and Migration (HR) Cultural Heritage (HC) Safe & healthy living conditions (HS) Respect of indigenous rights (HC) Community engagement (SR) Local employment (SR) Secure living conditions (HR)
Society	Public commitments to sustainability issues (GV) Contribution to economic development (SR) Prevention & mitigation of armed conflicts (GV) Technology development (SR) Corruption (GV)
Value chain actors	Fair competition (GV) Promoting social responsibility (GV) Supplier relationships (GV) Respect of intellectual property rights (GV)

[1] HR – Human Rights; WC - Conditions de travail; HS – Health and Safety; CH – Cultural Heritage; GV – Governance; SR – Socioeconomic Repercussions.

Source: UNEP/SETAC 2009, 49 and adapted by Group AGECO.

In addition to this general framework, the Guidelines also specify the steps to follow and the requirements to fulfill in order to conduct a rigorous and transparent assessment. However, the Guidelines are a work-in-progress towards the elaboration of a comprehensive assessment framework. Adaptations are admittedly needed in order to perform a S-LCA (UNEP/SETAC 2009; 82). For instance, the Guidelines do not define any particular assessment methodology. It was hence necessary to develop an ‘assessment framework’, compatible with the Guidelines, to perform the S-LCA of milk production in Canada. The following sections thus describe this framework and present the methodological underpinnings on which it is based. When needed, the adjustments made to the general framework provided by the Guidelines are discussed.

5.2. The Scope of the S-LCA

The first step of a S-LCA aims to describe the intended application and the reasons for carrying the study (goal) and to define its depth and breadth (scope). As highlighted in the Guidelines, “the ultimate objective for conducting a S-LCA is to promote improvement of social conditions and of the overall socioeconomic performance of a product throughout its life cycle for all of its stakeholders” (UNEP/SETAC 2009; 50). This is also the project’s main objective: assessing the socioeconomic performance of the Canadian milk production sector and identifying potential social hotspots to provide some recommendations in order to improve the system’s overall socioeconomic performance towards its stakeholders.

As for an E-LCA, this implies identifying the functional unit, the product system and its boundaries (UNEP/SETAC 2009; 51-57). The UNEP/SETAC Guidelines do not provide any particular direction on how the scope of a S-LCA should be adapted to fit the one of an E-LCA when both assessments are conducted together. It is however acknowledged that given the S-LCA’s specificities, the scope might not necessarily be the same or totally integrated.

In the course of milk production study, the scope of the S-LCA has been defined according to the one described in the E-LCA chapter (section 3). This choice was made for methodological consistency, to facilitate the interpretation of the results and allow discussing potential trade-offs between the system’s overall socioeconomic and environmental performance.

The first element to consider in this regard is the choice of the function and **functional unit**. As stated in the Guidelines, the “specification of the functional unit and the reference flows is essential to build and model the product system” (UNEP/SETAC 2009; 53). This S-LCA refers to the same functional unit as the one described in section 3: ‘1 kg of fat and protein corrected milk’. The product system differs however slightly between a S-LCA and an E-LCA. First in its constituting parts: since a S-LCA is primarily focusing on the behaviour of the organisations involved in the product’s life cycle, a S-LCA product system is made of those organisations, organized in value chains, rather than by the processes they perform as in an E-LCA. Secondly, in its scope: for a matter of simplification and access to data, the scope of a S-LCA product system is usually circumscribed to include only the most important and relevant value chains and organisations, where the product system in E-LCA is more exhaustive and usually extended until no more exchanges are made between processes inside the technosphere.

Hence, the definition of a S-LCA product system first requires identifying the organisations involved in each value chain included in the product’s life cycle. In a S-LCA perspective, a value chain can be defined as a set of businesses located whether upstream or downstream of an organisation, providing the inputs and services needed for the production and the marketing of the product under assessment. Then, depending on the objectives of the project, criteria are set to delimit the scope and the range of the system under study.

The above considerations have been taken into account to specify the product system used to perform the S-LCA of the milk production in Canada. Based on the information provided by the **milk Cost of Production database**[2], it was possible to define the main value chains involved in milk production according to the inputs and services they provide to the dairy farms[3]. Table 5-2 lists the items accounting for more than 1.5% of the total expenditures of dairy farms located in Quebec, Ontario and the Atlantic provinces.

Table 5-2 - Average percentages on total costs of the main expenditure items[1]

Inputs	Average % on total cost [2]
Animal feed (grains, concentrates, premixes, etc.)	21.9%
Interest fees and taxes	13.1%
Agricultural machinery acquisition[2]	7.8%
Buildings construction[2] repairs and maintenance	6.7%
Veterinary expenses (including drugs and services)	4.5%
Milk transportation	4.4%
Salaries	3.8%
Joint marketing plan management fees	3.1%
Fuel and diesel	2.4%
Electricity	2.2%
Fertilizers	2.0%
Cows replacement	2.1%
Insemination (Bovine semen + services)	2.0%
Seeds	1.8%
Field equipment maintenance	1.6%

1 Average cost of dairy farms located in Quebec, Ontario and the Atlantic provinces (Western provinces not included).

2 Measured as the depreciation cost of the item.

Source: **AGECO**, 2011.

2 The milk CoP database is a sample of farms (stratified by region and size and randomly selected to represent the population) used by provincial Dairy Boards and CDC to establish each year the cost of production of 1 hl of milk. The P5 database (Quebec, Ontario, Maritimes) is supervised by AGECO.

3 Whilst being part of the socioeconomic system in which operates the milk production sector and its business partners, the institutional, sectorial, social and political organizations or associations operating with and around the economic actors involved in milk production are excluded from this system.

Given the vast array of inputs and services involved, decisions were made to further circumscribe the scope of the system. First, inputs related to farm buildings are excluded from the system, because this group of expenses is related to various kinds of tools, materials and services of low individual significance. Cow replacement is also excluded, given that these animals are generally traded among dairy farmers. Items only related to services, such as salaries, joint marketing plan management fees and field equipment maintenance expenditures, and those not directly associated to milk production, as interest fees and taxes, are also excluded. Although milk transportation is a service, it is left within the system since it is part of its scope. Finally it was decided to exclude 'electricity' from the system and to include 'pesticides' although it accounts only for 0.4% of the average total cost. These choices are justified by the fact that electricity is a relatively minor and non-agricultural input from which suppliers are globally disconnected from the agricultural sector (Parent et al. 2012), whereas pesticides are an economically and socially sensitive product primarily used in agricultural production. According to these choices, the following inputs and services are therefore included in the S-LCA system:

- Animal feed.
- Farm inputs (fertilizers, seeds, pesticides).
- Milk transportation.
- Veterinary services (drugs and bovine semen).
- Agricultural machinery.
- Fuel and diesel.

Each of these inputs and services are provided to dairy farms via a specific supply chain composed of a number of steps (from extraction of raw material to final distribution). Each step involves a vast number of businesses producing products or providing services. In order to simplify the system, cut-off criteria have also been used to limit the length and complexity of each of these value chains:

- For each value chain, **only one to two representative inputs or services** have been considered at each step, according to their relative importance at this step.
- The range of each value chain has been extended as long as it was possible **to trace back a main input or service** used in the production of the previous product or service.

Figure 5-1 shows the product system selected for the S-LCA study. First tier suppliers, i.e. businesses or value chain actors directly interacting with dairy farmers for advice or commercial purposes related to the selected inputs, are shown next to the left of dairy farms. They include advisers or representatives, such as feed and farm inputs dealers, affiliated or not to specific companies involved in the production or the handling of some inputs. Upstream are listed the selected inputs sold to dairy farmers (or used to supply the services) and the main auxiliary inputs needed to produce them. Taken together, these inputs, auxiliary inputs and the companies producing and handling them, shape the product system considered to perform the S-LCA of milk production in Canada.

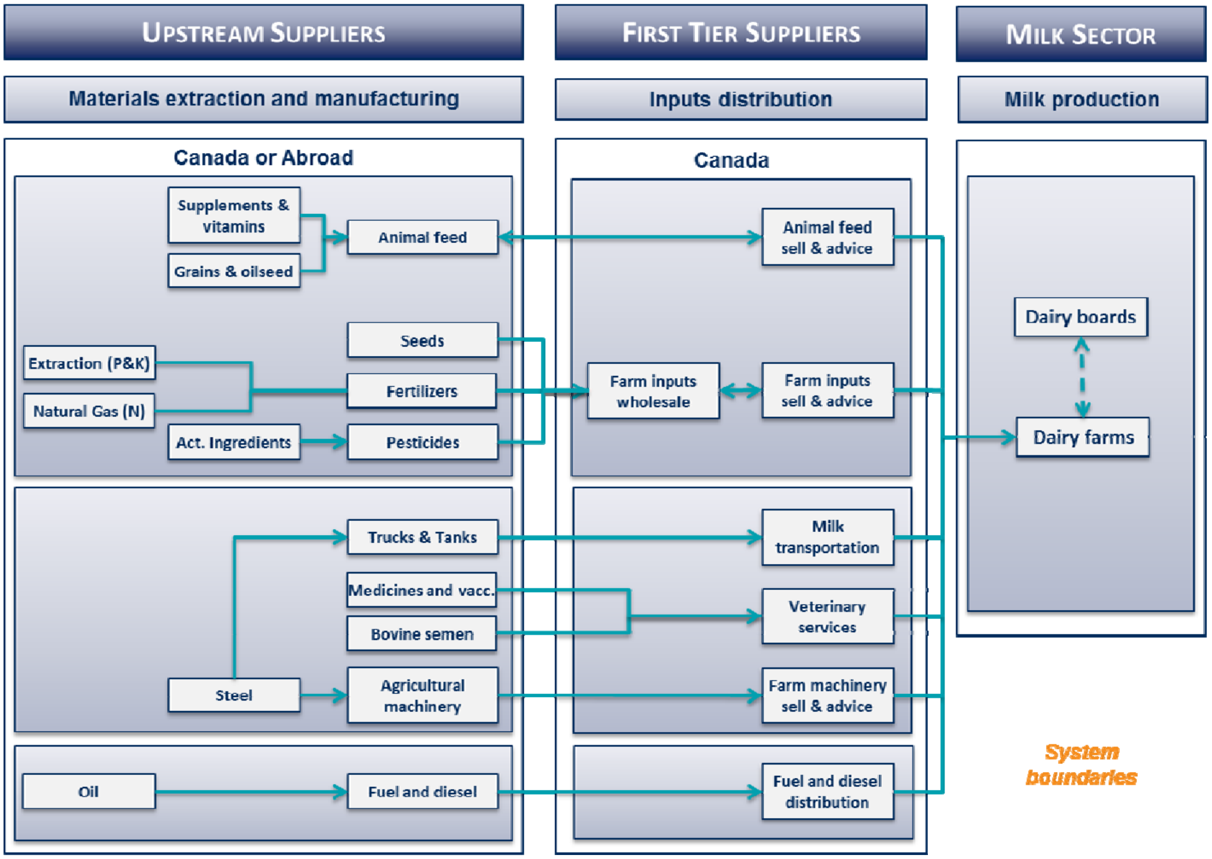


Figure 5-1 - Product system of the Canadian milk production

Although the aim of a S-LCA is to provide, for a given product, a profile of the socioeconomic performance of the organisations involved in its entire life cycle, the assessment's degree of details can vary across the system. It is not always readily possible, necessary or even relevant, to assess in details the behaviour of all the organisations throughout the life cycle of a product. While practical constraints such as data limitations, short delays or budget restrictions can impede in-depth analysis, the assessment's focus is generally determined by the intended applications of the S-LCA results by the commissioner (Parent et al. 2012).

In the case of this study, the objective of the S-LCA is to give a socioeconomic profile of the product system with an emphasis on the Canadian milk production sector. Therefore, the socioeconomic performance of the Canadian dairy farms and their sectorial organizations are assessed through a **Specific analysis** – which provides a high level of details on their degree of social responsibility based on the compilation of primary data collected on-site. For the rest of the product system, a **Potential Hotspots Analysis** (PHA) is performed – which offers an overview on the possibility of encountering risky behaviours among the supply companies/sectors based on the compilation of generic data collected from international and national databases, websites, human rights reports, etc.

Figure 5-2 shows how each assessment framework applies over the product system. Most of first-tier suppliers are not covered by any of the two assessment frameworks. This is primarily due to the project's focus on the milk production sector, on which most resources have been granted. Indeed, significant resources would have been needed to conduct a Specific Analysis over these suppliers all across Canada. This situation is also explained by the fact that these first tier suppliers are characterised by their small size, vast number, disperse localisation, etc. which made the use of the Potential Hotspots Analysis methodology unsuitable. In order to get a preliminary overview of the social risks related to the agricultural inputs sellers' behaviours, the Wholesale & distribution sector was used as a proxy.

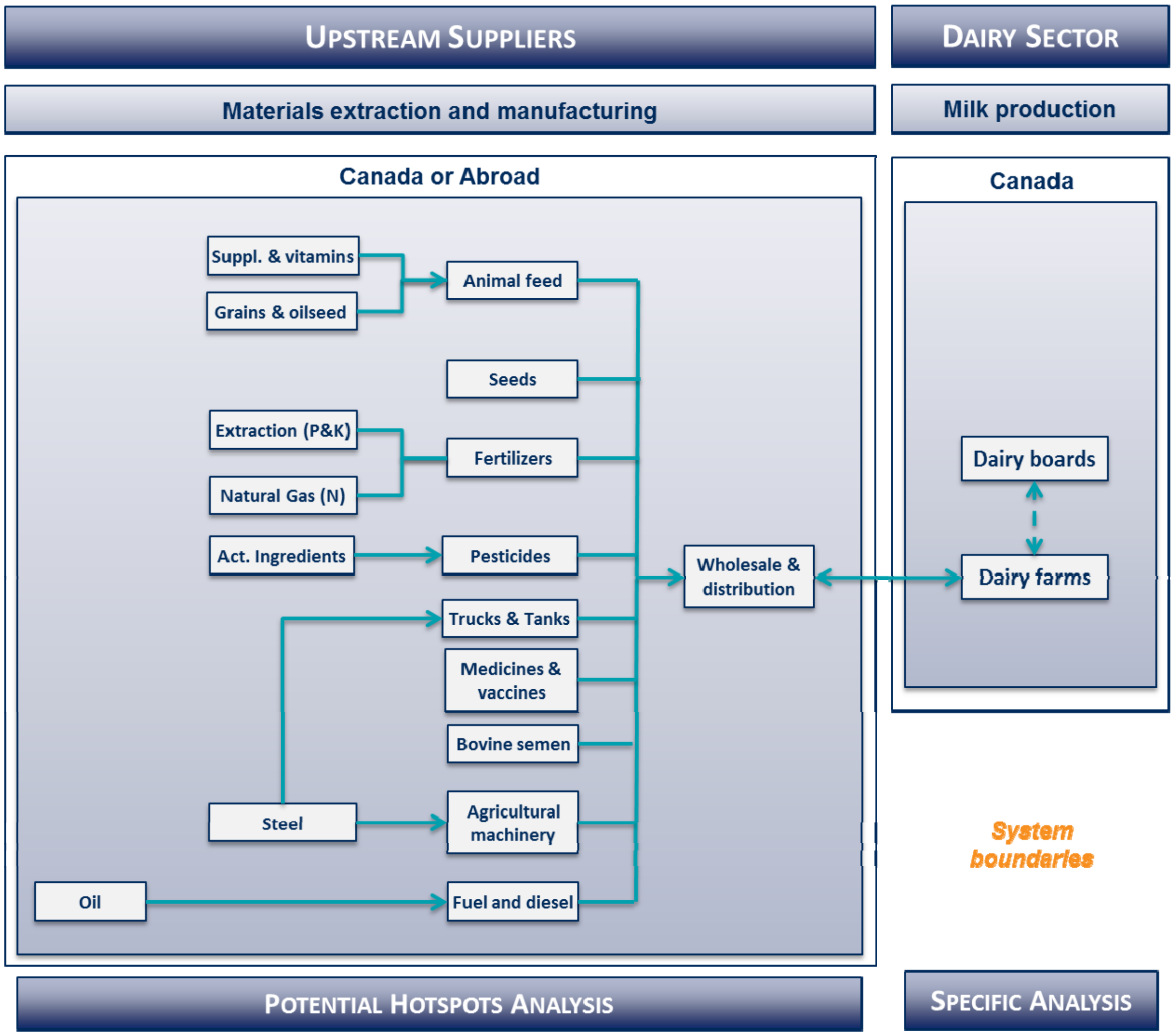


Figure 5-2 - Coverage of each assessment framework over the product system

The Specific Analysis methodology is presented in section 5.3 and the Potential Hotspots Analysis one is described in section 5.4.

5.3. The Specific Analysis

The aim of the Specific Analysis is to provide a detailed analysis of the socioeconomic performance of a particular company / organization / sector by assessing its degree of social responsibility toward its stakeholders.

Given the focus of this project, the Specific Analysis approach is used to assess the socioeconomic performance of the milk production sector in general and of the dairy farms and dairy organizations in particular.

Given the structure of the Canadian milk production sector, which involves about 13,000 dairy farms across Canada which are provincially and nationally organized, the assessment addresses more specifically the socioeconomic performance of the sector at three different levels – since the behaviours and practices encountered at each level do not necessarily affect the stakeholders in the same way or do not relate to the same issues of concern. The three assessment levels are the following:

- **Dairy farms level**: the dairy farms are at the center of the assessment. Their behaviour and practices affect mostly the farm workers, the local communities where they are located and their suppliers.
- **Dairy Boards level**: all across Canada, dairy farms are organized in provincial dairy Boards performing the administrative, marketing and communicative tasks assigned by the dairy farmers. By fulfilling these tasks, those organizations induce impacts on different stakeholders.
- **Sector level**: milk production takes place in a legal and institutional framework that shapes most of the sector's characteristics, which have in turn significant implications on the entire sector's stakeholders. Whereas this particular framework is not necessarily specific to the milk production sector, or dairy producers directly accountable for it, its implications still have to be assessed as producers have together the ability to act upon it.

It is important to stress that the S-LCA approach in general and the Specific Analysis in particular, **exclusively addresses the relationships between a business/organization and its stakeholders**, the former being the one inducing the socioeconomic impacts – whether positive or negative – on the surrounding groups of individuals. Accordingly, the impacts experienced by the dairy farmers or the dairy Boards resulting from their own behaviour are not addressed by this framework. The assessment framework assesses rather the degree to which the Canadian dairy farmers and dairy Boards behave in a socially responsible manner towards their stakeholders.

The groups of stakeholders affected by the dairy farmers and their Boards are identified in section 5.3.1, followed by a description of the specific social issues of concern associated to their activities in section 5.3.2.

The assessment framework draws from the UNEP/SETAC's Guidelines introduced in section 5.1. It has however been adjusted and enhanced in order to take into account the specificities of the Canadian milk production sector.

5.3.1. Stakeholder Categories

Formally, stakeholders are "those groups and individuals that can affect, or are affected by, the accomplishment of organizational purpose" (Freeman R., 1984 cited by UNEP/SETAC 2009, p. 47). As pointed out in section 5.1, the UNEP/SETAC's Guidelines propose a list of five main stakeholder categories potentially impacted by the life cycle of a product. These are the **workers**, the **local communities**, the **society**, the **consumers** and the **value chain actors**. However, depending on the study's boundaries and the sector's particularities, it is possible to add, to exclude, to differentiate or simply to define more precisely the proposed categories to get a clearer description, at each step of the value chain, of the stakeholders involved (UNEP/SETAC 2009 p. 46).

Given the scope of this study and the focus of the Specific Analysis, such adaptation of the basic stakeholder categories was necessary. The 'consumers' category (seen as the 'people who drink' milk) was hence excluded from the framework since dairy farms' activities – and of their upstream suppliers – affect them only indirectly, mostly in regards to consumers' health and safety. The issues of concern potentially affecting consumers have instead been assessed in relation with the 'Value chain actors' category, given that raw milk is the main input used by dairy processors to elaborate the dairy products sold to consumers (section 5.3.2).

The other four stakeholder categories cover adequately the different groups of individuals potentially impacted by milk production activities, as shown by the review of the existing literature (Appendix H). Based on the results of several focus groups conducted in the first stages of the study (Appendix I), each stakeholder category has been defined in more details (Table 5-3). Given that the Specific Analysis was exclusively conducted on the dairy farms and their Boards, the categories have been adapted only to the individuals impacted by dairy activities.

Table 5-3 - Definition of the stakeholder categories impacted by milk production activities of the Canadian dairy farms and their Boards

Stakeholder categories	Definition
Workers	This category covers exclusively the farm workers that are not relatives of the producer (husband, wife, children, etc.). As business owners, the producer and his family members are not considered as 'workers' even if they work on the farm. This category has been further differentiated into four subcategories of workers frequently working on farms: a) **Regular workers**: farm workers working at least 25 hours per week, at least 40 weeks per year on the farm (irrespective of their particular occupation); b) **Temporary foreign workers**: foreign workers hired to work on a farm for a temporary period of time through the Seasonal Agricultural Worker Program (SAWP) or the Agricultural Stream of the NOC C and D Pilot Project; c) **Young workers**: school age individuals working on farm (family included); d) **Occasional workers**: local or foreign workers hired temporarily through the services of an employment agency.
Local communities	Regardless of their geographic location, this category covers the individuals or groups of individuals directly affected by the milk production activities, i.e. neighbours, local and regional groups, surrounding populations, etc.
Society	This category refers to acknowledged social values uphold in a particular society by organizations such as provincial, national or international interest groups, government agencies or the civil society as a whole.
Value chain actors	This category refers to dairy farms' inputs and services suppliers (Figure 5-1), but also indirectly to consumers, given that the Canadian milk production sector's efforts to provide dairy processors with a high quality milk have an impact on 'final' consumers.

5.3.2. Issues of Concern (Impact Subcategories)

Impact subcategories are the "socially relevant characteristic or attribute to be assessed" in a S-LCA (UNEP/SETAC 2009, p. 71). Based on international agreements (conventions, treaties etc.), the Guidelines already propose a list of internationally recognized impact subcategories, each being related to a specific stakeholder category (section 5.1). While most of the listed impact subcategories are relevant to consider in a Canadian context, some of them, such as 'delocalization and migration' or 'prevention of armed conflicts', are not necessarily relevant.

In order to encompass comprehensively the issues of concern related to milk production in Canada, and has allowed by the Guidelines, the list of subcategories was adjusted, upon justification. It was done on the basis of a review of the existing literature, experts' opinion and the results of three focus groups conducted among sector's stakeholders (Appendixes H and I).

Table 5-4 presents the impact subcategories chosen for the study. Each one is explicitly defined to ensure a common understanding of the social issue it covers. These definitions do not necessarily follow the ones proposed in the methodological sheets published by the Life Cycle Initiative (LCI 2010), because they do not adequately describe the issues under assessment in this specific case.

A scale of assessment level is also specified, as some issues of concern relate primarily to dairy farms activities, while some others rather relate to their provincial Boards, or even to the milk sector as a whole. One issue of concern can be related to more than one level of assessment as well. The impact assessment methodology is presented in section 5.3.3.

Table 5-4 - Impact subcategories according to the corresponding stakeholder categories

STAKEHOLDER CATEGORIES	SELECTED IMPACT SUBCATEGORIES	DEFINITION	ASSESSMENT LEVEL		
			Dairy farms	Dairy Boards	Dairy sector
Workers	Working hours	Working hours are a major proxy of proper working conditions. Even if agricultural production is characterised by long working days and that most farm workers are not covered by labour standards, too many working hours per week can affect workers' welfare.	X		
	Benefits	Government sets minimal norms regarding benefits and social securities. An employer can however offer improved conditions to its employees and their families.	X		
	Salary and contribution to fringe benefits	Salary is a central component of working conditions. It should not be inferior to minimum wage, when required by law. If possible, it should be competitive compared to the sectorial average wages and be inflation-adjusted to protect workers' purchasing power. Other monetized benefits can also be provided to workers in addition to/or complement of salary, such as bonuses for statutory holidays and premiums for overtime.	X		
	Working conditions transparency	A good communication between the employer and its employees concerning working conditions is essential to build a fair relationship between the two parties.	X		
	Freedom of association and collective bargaining	The growing numbers of non-family related workers on farms causes unionization to become an economic as well as a social issue in the agricultural sector. While challenging, this new issue needs to be addressed by provincial regulations to allow farm workers to assert their rights.			X
	Health and safety	Farm workers should benefit of safe and secure conditions at their workplace and have access to all the necessary resources to prevent incidents that could compromise their physical or psychological health.	X		
	Professional accomplishment	Employees should benefit of a stimulating and rewarding workplace that allows personal and professional development.	X		
	Integration and/or discrimination (*for temporary foreign workers*)	There should be no significant and unfair discrepancies between the working conditions offered to temporary foreign workers and to regular farm workers.			X
	Young workers employment	Working conditions of school age workers should respect legal requirements and contribute positively to their development.			X

STAKEHOLDER CATEGORIES	SELECTED IMPACT SUBCATEGORIES	DEFINITION	ASSESSMENT LEVEL		
			Dairy farms	Dairy Boards	Dairy sector
Local communities	Community engagement	Through its implication and involvement in its community, a producer can foster local development and contribute to create a harmonious environment with the community.	X	X	
	Natural and built Heritage	Farms can contribute to the beauty of countryside through initiatives aiming at enhancing and protecting the natural and built heritage.	X		
	Cohabitation (i.e. life quality)	Although nuisances such as noises, smells and dusts inevitably arise from normal agricultural activities, farmers can minimise their impacts on local life quality by using different production methods and by informing the neighbourhood before the most disturbing activities.	X		
Society	Commitment to sustainability issues	Producers as well as their organizations can commit themselves in regards to sustainability by holding formal certifications.	X	X	
	Agroenvironmental practices	Milk production can have a significant impact on the environment, depending on how producers manage the manure, use chemicals and work their land. By adopting good agroenvironmental practices, they can minimize this impact.	X		
	Contribution to economic development	This subcategory assesses to what extent dairy activities contribute to the economic development of the country by generating revenue and creating jobs.			X
	Technology development	This subcategory assesses whether the Boards participate in joint research and development for efficient and environmental sound technologies.		X	
	Animal welfare	As a growing number of consumers are becoming sensitive to the way animal are treated and require more humane treatments, animal welfare is becoming one major concern in the agro-food sector, especially at the production level.	X	X	
Value chain actors	Responsible procurement practices	Purchasing decisions can be based on social and environmental considerations or criteria to ensure socially responsible procurement practices.	X		
	Responsible supplier practices	As a supplier, dairy producers can adopt voluntary norms and certifications in order to supply the dairy industry with a competitive yet high quality product.	X		
	Promotion of social responsibility	This subcategory assesses to what extent dairy Boards are committed and involved in initiatives and partnerships aimed at promoting social responsibility.		X	
	Fair competition	Competitive markets in which a vast number of sellers and buyers interact freely constitute usually a safeguard to protect market actors as well as consumers against abusive market practices and non-competitive prices. This subcategory assesses to what extent the Canadian milk sector is characterized by a fair competition.			X

5.3.3. Impact Assessment Methodology

The impact assessment phase of a S-LCA involves translating inventory data into measured impacts by aggregating inventory indicators within subcategories and comparing them against a so-called 'Performance Reference Point' (PRP) – or benchmark. However, as the Guidelines point out, "impact assessment methodologies are under development and S-LCA is an open field for future research" (UNEP/SETAC 2009, p. 69). For instance, unlike the E-LCA methodology, there is no characterization model allowing the translation of inventory indicators into socioeconomic impacts using quantitative models. And the aggregation of social and economic inventory data is not readily possible in a S-LCA, as it might result into meaningless final scores.

Although the Guidelines do not provide any particular indications or suggestions regarding the impact assessment methodology to use in a S-LCA, this issue is extensively discussed in the socioeconomic impact evaluation literature (Burdge, 2004; Burdge and Vanclay, 2004; Chadwick, 2002; Becker and Vanclay, 2003). Our assessment methodology is thus relying on this literature, but also on our expertise in this field[4].

Most social assessment methods, including the S-LCA methodology, rely on socioeconomic indicators to measure and assess the social and economic impacts induced on stakeholders by a particular activity. But as pointed out in the Guidelines, "several inventory indicators and units of measurement/reporting types may be used to assess each of the subcategories. Inventory indicators and units of measurement may vary depending of the context of the study" (UNEP/SETAC 2009, p. 44). Indeed, there is no formal or universally acknowledged set of indicators to which one can refer to assess the socioeconomic performance of a particular product or company. To carry out a particular assessment, a specific set of indicators has thus to be developed according to the project's objectives and data availability.

Based on the multiple assessment frameworks suggested in the literature – many of which having been conceived to be used in an agricultural context – but also on expert' judgments, a list of indicators has hence been developed to assess the socioeconomic performance of the Canadian milk production sector. The methodological criteria to which we referred to define these indicators are discussed in Appendix H.

These indicators are listed in the following tables. Table 5-6 presents the indicators used to assess the socioeconomic performance of dairy farmers. They are classified according to the stakeholder categories and the related impact subcategories. To ensure that the assessment framework is both clear and transparent, each indicator is detailed using a standardized approach. First, a brief description of what each indicator measures is given. Then, the PRPs – or benchmarks – against which the performance is assessed is specified (UNEP/SETAC 2009, p. 69).

[4] AGECO has within its team experts on the dairy field. The dairy industry has been analysed by AGECO from different point of views over the years and at different industry levels (farm level, processing activities, domestic and international dairy policies, etc.): supply system management, financial situation of Canadian dairy farms, dairy farms production costs, and labour problematic at the farm and processor levels are some of the subjects that have been studied. New opportunities in marketing settings and dairy products marketing were also studied. AGECO has also animated a few years ago a reflection session within the project Premium Milk Innovation. Therefore, AGECO is familiarized with each actor and as well as with the stakes of the Canadian dairy industry at a national and international level.

PRPs are acknowledged social standards, norms or practices used as thresholds to discriminate, among the observed practices or behaviours, those that are socially responsible from those that are minimally expected from the organisation. One indicator can be related to several PRPs, such as a national or international minimal legal standard, a "Best available practice", an average performance of a company or a group of businesses, etc. Given the Canadian milk production sector's particularities, the PRPs have mostly been selected according to minimal legal requirements, sectorial standards and average performance, as well as best expected practices based on our own expertise of the sector. The choice of each PRP is justified for each indicator.

Table 5-5 presents the evaluation scales used to assess the performance of dairy farms. These four-level scales specify how each indicator can be declined practically, given the PRP used. More specifically, these evaluation scales allow assessing, for a given issue of concern, the level of social responsibility of a dairy farmer. For example, in the case of the issue of concern 'cohabitation', the method assesses if the producer has adopted responsible practices, such as the use of windbreaks, which contribute to improve the local community' life quality and to avoid conflicts with the neighbourhood, here by reducing odours spread around the farm. The same scale is used with all behaviours to ensure a standardized interpretation of the results[5].

Table 5-5 - Specific Analysis' behaviour evaluation scale

■	□	▨	■
Risky behaviour	Compliant behaviour	Proactive behaviour	Committed behaviour

A **risky behaviour** is considered as a hazardous practice that can cause significant damages or create serious problems to the concerned stakeholders. Given that most hazardous practices are forbidden by law, they are generally related to illegal behaviours. Yet, in some cases, it is possible to consider a particular behaviour as risky even if it is not illegal insofar as it can potentially have serious and negative implications for the individual or group of individuals it concerns, compared to its potential benefits. This is for example the case with the "working hours" subcategory as there is generally no legal limit to workweek length or legal standard relating to work overload in the agricultural sector. Allowing a number of working hours beyond a certain threshold can however have negative implications for the workers' health and safety – irrespective of the fact that they agree to work them.

A **compliant behaviour** refers to a normal and expected practice. It generally corresponds to a minimal legal requirement or simply to an absence of initiative or commitment in situations where it is not required. In other words, a compliant behaviour means that the organisation, while not acting in a socially irresponsible way, is not especially socially responsible either.

[5] This particular approach has two main advantages. The first one is that it focuses on what is actually observed and assessed, i.e. a farm's behaviour. The second one is that by assessing the level of social responsibility of a particular behaviour, this method provides a more consistent idea of its global consequences compared to the traditional and binary notion of «impacts" and «benefits", since a more responsible behaviour both involves increased benefits and lessened negative impacts for a given stakeholder (and vice-versa). Of course, our assessment method assesses only observed behaviours (midpoint) and not their actual consequences (endpoint).

The two other levels refer to behaviours that go beyond compliant or minimal expectations to tend toward more socially responsible behaviours. Depending on the issue and the PRP identified, a **committed behaviour** is hence considered as the most socially responsible practice a leading organisation could reach, while a **proactive behaviour** translates an in-between engagement; the business goes beyond legal requirement, but has not yet reached a leading behaviour.

Of course, this classification is relative, as the PRPs used to determine whether a particular behaviour is more or less socially responsible can evolve in time and place. In other words, a today committed behaviour could become a minimal expectation in the future, or could be considered as a desired behaviour in another region.

This evaluation scale is also dependent on data availability. In order to assess a particular behaviour according to this four-level scale, it is necessary to have access to detailed information both to establish the PRPs and to assess the behaviour itself. The data collection process conducted in this project is described in section 5.3.4. At this point it is however important to indicate that in the absence of sufficiently detailed information, the evaluation scale can be operated by using only two or three levels as shown in Table 5-6. For example, since it was not possible to document the contraventions received by milk producers for their potential violations of environmental regulations, risky behaviours were not assessed, the minimal score being a 'compliant behaviour'. Similarly, no relevant PRP was found to determine what a 'desired behaviour' is in regards to 'workweek length'. For that reason only risky and compliant behaviours were assessed using an ILO standard.

Table 5-6 - Impact subcategories and the corresponding socioeconomic indicators per stakeholder categories documented at the dairy farm level

FARM WORKERS			
Working hours			
Workweek length	Description	The average workweek length (hours/week) of regular workers in comparison to the ILO' standard of 48 hours/week	
	PRP	ILO' standard (C-01, art. 2) : 48 hours	
	Justification / commentary	Even if farm workers are generally excluded from most provincial labour standard' provisions – Including the cap of hours of work per week – too many working hours can compromise workers' health and life quality. The ILO' standard of 48 hours per week is in this regard a widely accepted limit to workweek length. No provincial labour standard goes beyond that threshold either.	
	Evaluation scale	■	The average workweek length of regular workers exceeds 48 hours per week
		□	The average workweek length of regular workers does not exceed 48 hours per week
		▨	---
		■	---
Work overload	Description	Number of weeks during which workers worked more than 48 hours	
	PRP	a) Expected practices b) ILO' standard (C-01, art. 2) : 48 hours	
	Justification / commentary	Field work usually goes from May to October. During this period, intensive harvesting work is expected during which workers can work more than 48 hours per week. However, this situation should not extend on more than 13 weeks (more than 3 months) during this period.	
	Evaluation scale	■	Work overload situation (i.e. 48 hours per week) exceeds 13 weeks (3 months) per year
		□	Work overload situation does not exceed a period of 13 weeks per year
		▨	---
		■	---

FARM WORKERS (continued)			
Benefits			
Scope of the protection	Description	Number of social benefits provided to employees	
	PRP	AGECO (2010): List of social benefits the most commonly provided to farm workers (wage insurance; health insurance; life insurance; pension plan contribution; paid sick days; unemployed insurance; in kind).	
	Justification / commentary	Each benefit is count individually even if they are provided in a collective insurance scheme	
	Evaluation scale	■	---
		□	The producer provides only the minimal legal requirements to its employees
		▨	The producer provides enhanced social benefits to its employees and their family in at least one of the listed categories.
		■	The producer provides enhanced social benefits to its employees and their family in more than one of the listed categories.
Salary and contribution to fringe benefits			
Average hourly wage of workers	Description	Comparison between the average hourly wage of regular workers and 1) the province's minimal salary and 2) the provincial median hourly wage rate in the agricultural sector	
	PRP	a) Provincial labour standards ($/hour, 2011): **BC**; 10,25 / **AL**; 9,40 / **SA**; 9.50 / **MA**; 10.00 / **ON**; 10.25 / **QC** (2010); 9.50 / **NS**; 10.00 / **NB**; 9.50 / **IPE**; 9.60 / **NFL**; 10.00 b) Statistic Canada (table 282-0072) ($/hour, 2011): **BC**; 13.00 / **AL**; 16.00 / **SA**; 16.00 / **MA**; 14.69 / **ON**; 12.00 / **QC** (2010); 11.00 / **NS**; 12.00 / **NB**; 12.50 / **IPE**; 12.00 / **NFL**; 12.00	
	Justification / commentary	Provincial labour standards define socially accepted working conditions that should be minimally guaranteed to employees. Even if farm workers are frequently excluded from most provisions, they still are relevant benchmarks to consider. The provincial median hourly wage in the agricultural sector is another relevant benchmark to compare the salary paid to dairy farm workers (regardless the other premiums or benefits paid or provided).	
	Evaluation scale	■	The average hourly wage of regular workers **<** the provincial legal minimum wage rate
		□	The average hourly wage of regular workers is **=** to the provincial legal minimum wage rate
		▨	The average hourly wage of regular workers is **>** the provincial legal minimum wage rate, but **≤** the provincial median hourly wage
		■	The average hourly wage of regular workers is **>** the provincial median hourly wage rate in the agricultural sector

FARM WORKERS (continued)			
Salary and contribution to fringe benefits (continued)			
Annual increments	Description	Comparison between the average salary increments and the Canadian inflation rate target of 2%	
	PRP	Bank of Canada	
	Justification / commentary	Notwithstanding the worker's performance or skills acquisition, the salary can be adjusted to cope with inflation in order to preserve its purchasing power. The inflation rate usually fluctuates around the 2% target sets by the Bank of Canada.	
	Evaluation scale	■ (red)	The average salary does not increase on an annual basis
		□ (white)	The average salary increases annually at a pace inferior or equal to the inflationary rate target of 2%
		▨ (hatched green)	---
		■ (green)	The average salary increases annually at a pace greater than the Canadian inflation rate target of 2%
Leaves and bonuses for statutory holidays	Description	Employers can offer additional leaves or bonuses to their employees in case they have to work during statutory holidays	
	PRP	Provincial labour standards	
	Justification / commentary	Provincial labour standards define socially accepted working conditions that should be minimally guaranteed to employees. Even if farm workers are frequently excluded from most provisions, they still are relevant benchmarks to consider.	
	Evaluation scale	■ (red)	---
		□ (white)	Producers do not offer leaves or bonus payments for statutory holidays to their regular workers
		▨ (hatched green)	---
		■ (green)	Producers offer leaves or bonus payments for statutory holidays to their regular workers
Paid overtime	Description	Even if they are not legally committed to, producers can pay workers when overtime is done as well as offer them a premium.	
	PRP	Provincial labour standards	
	Justification / commentary	Provincial labour standards define socially accepted working conditions that should be minimally guaranteed to employees. Even if farm workers are frequently excluded from most provisions, they still are relevant benchmarks to consider.	
	Evaluation scale	■ (red)	---
		□ (white)	Employees do not get overtime paid
		▨ (hatched green)	Employees get overtime paid without receiving an overtime premium
		■ (green)	Employees get overtime paid and receive an overtime premium

FARM WORKERS (continued)			
Working conditions transparency			
Communication of working conditions	Description	Employees should receive and have access to a written copy of their contract	
	PRP	Best expected practices	
	Justification / commentary	In order to avoid conflicts and to ensure a right understanding of working conditions, a formal and written contract should be given and signed by each employee.	
	Evaluation scale	🟥	---
		⬜	Employees do not receive nor have access to a formal copy of their employment contract
		▨	---
		🟩	Employees receive and have access to a formal copy of their employment contract
Negotiation of working conditions	Description	Employees should have the opportunity to discuss their working conditions with their employer	
	PRP	Best expected practices	
	Justification / commentary	A dialogue between the producer and its employees can contribute to make sure that working conditions are satisfactory to both parties.	
	Evaluation scale	🟥	---
		⬜	Working conditions are based on a non-negotiable offer submitted to workers
		▨	---
		🟩	Working conditions are based on a negotiable offer submitted to workers
Health and safety			
Health and safety training	Description	Whether employees have received a health and safety training	
	PRP	Best expected practices	
	Justification / commentary	Although most farm workers are covered by the provincial occupational health and safety legislation, employers can tool up their employees with additional skills and resources.	
	Evaluation scale	🟥	---
		⬜	Employees have neither received a health and safety training nor the farm has a formal procedure in case of injury
		▨	Either employees have received a health and safety training OR the farm has a formal procedure in case of injury
		🟩	Employees have received a health and safety training AND the farm has a formal procedure in case of injury

FARM WORKERS (continued)			
Professional accomplishment			
Performance	Description	Whether the producer offers bonuses to its employees according to their performance	
	PRP	Best expected practices	
	Justification / commentary	Employees' performance and skills acquisition can be recognized by offering them a bonus when deserved.	
	Evaluation scale	🟥	---
		⬜	The producer does not provide to its employees any bonus based on performance nor an end-of-year bonus
		▨	---
		🟩	The producer does provide to its employees a bonus based on performance and/or an end-of-year bonus when deserved
Professional development	Description	Whether the producer provides his employees with professional trainings to enhance their professional skills and knowledge.	
	PRP	Best expected practices	
	Justification / commentary	Continuous formation gives employees the opportunity to develop and improve their professional skills and knowledge.	
	Evaluation scale	🟥	---
		⬜	The producer does not allow his employees to participate to training activities (other than health and safety trainings)
		▨	---
		🟩	The producer allows its employees to participate to training activities
Turnover rate	Description	Retention rate of farm workers	
	PRP	Best expected practices	
	Justification / commentary	A high turnover rate – or a low retention rate – is symptomatic of poor working conditions, but more importantly a lack of recognition and valorisation for employees.	
	Evaluation scale	🟥	The organization usually retains its regular workers for less than 1 year
		⬜	The organization usually retains its regular workers for more than 1 year
		▨	---
		🟩	---

LOCAL COMMUNITY

Community engagement

Implication within the community	Description	Assess whether the producer is involved in a local organization, hosts trainees, allows free visits on his farm or makes donations to local non-profit organizations	
	PRP	Best expected practices	
	Justification / commentary	These four examples are the frequently observed forms of engagement in the agricultural sector.	
	Evaluation scale	■	---
		□	The farmer is not involved in a local organization, does not host trainees, nor allows free visits on his farm, or make any donations to local non-profit organizations
		▨	The farmer participates in at least one of the previously listed activities
		■	The farmer participates in at least two of the previously listed activities

Natural and Built heritage

Preservation of natural and built heritage	Description	The farmer is involved in an initiative aiming to preserve the heritage and natural agricultural landscape	
	PRP	Best expected practices	
	Justification / commentary	The countryside's natural and built heritage is increasingly valued and producers can engage themselves in initiatives to preserve and develop it.	
	Evaluation scale	■	---
		□	Producer is not involved in any initiative aiming to preserve the heritage and natural agricultural landscape
		▨	---
		■	Producer is involved in an initiative aiming to preserve the heritage and natural agricultural landscape

Cohabitation (i.e life quality)

Communication with the neighbourhood	Description	The farmer informs its neighbours before manure application	
	PRP	Best expected practices	
	Justification / commentary	Informing the neighbourhood before manure application can reduce the risk of conflict with the surrounding community.	
	Evaluation scale	■	---
		□	Producer does not inform its neighbours before manure application
		▨	---
		■	Producer do informs its neighbours before manure application

LOCAL COMMUNITY (continued)			
Cohabitation (i.e life quality) (continued)			
Manure spreading technology	Description	The type of manure spreading technology used on the farm	
	PRP	Best expected practices	
	Justification / commentary	Some manure spreading technology can significantly minimize the unpleasant smells during and after the application.	
	Evaluation scale	■	---
		□	The manure spreading technology used (solid manure; high spreading; lateral spreading; sprinklers; irrigation guns) does not contribute to minimizing odours spread
		▨	---
		■	The manure spreading technology used (low spreading, conventional low boom, dribble bars, injection) contributes to minimizing odours spread
Odours spread reduction	Description	Whether the producer has adopted techniques to reduce odours spread around his farm	
	PRP	Best expected practices	
	Justification / commentary	Windbreaks can prevent and reduce spread of odours near field crops and/or livestock facilities.	
	Evaluation scale	■	---
		□	Producer has not set up windbreaks near crop fields, nor has protected his buildings with nature or managed screens in order to prevent the spread of odours
		▨	Producer has set up one of the two installations
		■	Producer has set up both installations
SOCIETY			
Commitment to sustainability issues			
Environmental certification	Description	The enterprise holds a formal certification / specification aiming at minimizing environmental damage (ISO 14 001, organic certification, etc.)	
	PRP	Best expected practices	
	Justification / commentary	Producers can go beyond goodwill and engage themselves into formal and binding processes aiming at minimizing environmental damage induced by their activities.	
	Evaluation scale	■	---
		□	The dairy farm does not hold any certification / accreditation or specification requiring minimizing environmental damage
		▨	---
		■	The dairy farm holds a certification / accreditation or specification requiring minimizing environmental damage

<table>
<tr><th colspan="4">SOCIETY (continued)</th></tr>
<tr><th colspan="4">Agroenvironmental practices</th></tr>
<tr><td rowspan="7">Manure storage structure</td><td>Description</td><td colspan="2">Whether the farm is equipped with a manure storage structure</td></tr>
<tr><td>PRP</td><td colspan="2">Best expected practices</td></tr>
<tr><td>Justification / commentary</td><td colspan="2">An efficient storage structure can contribute to reduce manure spilling and facilitate manure management, hence reducing potential environmental damage.</td></tr>
<tr><td rowspan="4">Evaluation scale</td><td>■</td><td>---</td></tr>
<tr><td>□</td><td>The producer does not have any particular manure storage structure (manure pit, cement slab, lagoon/cement pond, Lagoon/earth, slurry store/metal)</td></tr>
<tr><td>▨</td><td>---</td></tr>
<tr><td>■</td><td>The producer holds a manure storage structure</td></tr>
<tr><td rowspan="7">Manure management</td><td>Description</td><td colspan="2">Assess the procedures performed by the producer to manage the manure and its application</td></tr>
<tr><td>PRP</td><td colspan="2">Best expected practices</td></tr>
<tr><td>Justification / commentary</td><td colspan="2">Regular analysis of his soil, forage and manure, as well as efficiently planned spreading applications can reduce the risk of causing environmental damage</td></tr>
<tr><td rowspan="4">Evaluation scale</td><td>■</td><td>---</td></tr>
<tr><td>□</td><td>The producer neither uses a spreading manure register, conduct soil/manure/forage analysis nor possess a fertilization plan for his farm</td></tr>
<tr><td>▨</td><td>The producer performs at least one, but not all, of the previously listed practices</td></tr>
<tr><td>■</td><td>The producer performs all the previously listed practices</td></tr>
<tr><td rowspan="7">Chemicals control</td><td>Description</td><td colspan="2">Asses the procedures implemented by the producer to manage the chemicals and their application</td></tr>
<tr><td>PRP</td><td colspan="2">Best expected practices</td></tr>
<tr><td>Justification / commentary</td><td colspan="2">By reducing as much as possible the use of chemicals on his farm, a producer limits the potential environmental risks associated to those products.</td></tr>
<tr><td rowspan="4">Evaluation scale</td><td>■</td><td>---</td></tr>
<tr><td>□</td><td>The producer' practices (i.e. register of spreading operations, application strategies and criteria of application) do not significantly contribute to minimizing the use of pesticides</td></tr>
<tr><td>▨</td><td>The producer' practices partly contribute to minimizing the use of pesticides</td></tr>
<tr><td>■</td><td>The producer' practices can significantly contribute to minimizing the use of pesticides</td></tr>
</table>

SOCIETY (continued)			
Agroenvironmental practices (continued)			
Alternative practices to chemicals control	Description	The techniques implemented by the producer to minimize the use of chemicals on his farm	
	PRP	Best expected practices	
	Justification / commentary	By reducing as much as possible the use of chemicals on his farm, a producer limits the potential environmental risks associated to those products.	
	Evaluation scale	■ (red)	---
		□	The producer does not use any particular alternative practice to chemical control (i.e. cultivation methods, mechanical control and biological control)
		▨	---
		■ (green)	The producer uses alternative practices to chemical control (i.e. cultivation methods, mechanical control and biological control)
Soil conservation techniques	Description	The techniques used by the producer to protect the soil	
	PRP	Best expected practices	
	Justification / commentary	Different techniques allow protecting the soil, hence limiting erosion and safeguarding its fertility.	
	Evaluation scale	■ (red)	---
		□	The producer does not use any particular soil conservation technique (perennial crops, band cropping, grass bands, cover cropping, green fertilizers, ridges, etc.)
		▨	---
		■ (green)	The producer uses one or more soil conservation techniques
Water sources protection	Description	Whether the producer protects the rivers/water sources on his farm by limiting their access to animals and by using grass buffers	
	PRP	Best expected practices	
	Justification / commentary	Different techniques allow protecting the water sources located on farmland to safeguard them from pollution and contamination.	
	Evaluation scale	■ (red)	---
		□	The producer has not set up grass buffer strips near water sources and gives access to his animals to rivers/water sources (if applicable)
		▨	The producer protects water sources either by using grass buffer strips or by limiting their access to his animals
		■ (green)	The producer protects water sources by using grass buffer strips and by limiting their access to his animals

SOCIETY (continued)			
Animal welfare			
Training and practices	Description	Assess whether the producer and/or his employees are informed, trained and if they have changed their practices in regard to animal welfare	
	PRP	Best expected practices	
	Justification / commentary	In order to respond to the growing awareness and questioning of consumers in regard to animal welfare issue, producers and farm workers can inform themselves and participate to training activities, in order to enhance their practices.	
	Evaluation scale	■ (red)	---
		□ (empty)	The producer has neither read the "Codes of Practice for the care and handling of farm animals" from the National Farm Animal Care Council, 2) fulfilled the "Checklist for Dairy Animal Welfare on Farms" published by the DFC nor 3) attended any training activity regarding animal welfare issue
		▨ (hatched)	The producer has performed one of the previous training activities, but has not change his practices to enhance his animals' welfare
		■ (green)	The producer has performed one of the previous training activities and has changed at least one of his practices to enhance his animals' welfare

VALUE CHAIN ACTORS			
Responsible procurement practices			
Effort to promote social responsibility	Description	Producers purchasing decisions are influenced by social and environmental considerations or criteria	
	PRP	Best expected practices	
	Justification / commentary	By referring to socially responsible procurement practices, producers can ensure that their suppliers and their products respect both the environment and the individuals.	
	Evaluation scale	■ (red)	---
		□ (empty)	The producer does not make purchasing decisions on the basis of social and environmental considerations or criteria
		▨ (hatched)	---
		■ (green)	The producer makes purchasing decisions on the basis of social and environmental considerations or criteria

VALUE CHAIN ACTORS (continued)			
Responsible supplier practices			
Practices ensuring the product's quality	Description	The producer has joined the Canadian Milk Quality (CMQ) program	
	PRP	Best expected practices	
	Justification / commentary	By joining the CMQ, the producers engage themselves in a food-safety program assuring processors and consumers that their milk and meat are produced in a safe manner.	
	Evaluation scale	■ (red)	---
		□	The producer has not joined the Canadian Quality Milk Program
		▨	---
		■ (green)	The producer has joined the Canadian Quality Milk Program

In the case of dairy farms, the Specific Analysis is conducted by scoring, at the level of each socioeconomic indicator, the behaviour or practice of each participating farm. However, given that the project aims at evaluating the socioeconomic performance of the milk production sector as a whole, and in order to preserve the respondents' privacy, the individual scores have been compiled at the provincial level to get a weighted[6] average score of the socioeconomic performance of the Canadian milk production sector. The methodology used to conduct the compilation is presented below.

- First, for each indicator, all the individual answers have been added up according to their ranking on the evaluation scale. For example:

Indicator 1 (four-level indicator)

Behaviour	■ (red) Risky behaviour	□ Compliant Behaviour	▨ Proactive behaviour	■ (green) Committed behaviour
Number of dairy farms	1	0	2	4

To weight the individual answers into an average sectorial score, a value was attributed to each level of the behavioural scale in the following way:

■ (red) = 1 □ = 2 ▨ = 3 ■ (green) = 4

In the case of Indicator 1, we would get:

$$\frac{1 \times 1 + 0 \times 2 + 2 \times 3 + 4 \times 4}{7 \text{ (number of answers)}}$$

= 3.29

[6] In order to get a representative national average score, the individual answers have been weighted according to each province's relative importance in the Canadian sector, in terms of their number of milk producers they host. See section 5.3.4 for details.

The attribution of the average sectorial score for Indicator 1 is obtained through a last step implying reporting the average value on the behavioural scale using the following equally-distant bounds:

■ = [1.00 – 1.75 [□ = [1.75 – 2.50 [▨ = [2.50 – 3.25 [■ = [3.25 – 4.00]

In this example, the socioeconomic performance of the sector in relation with Indicator 1 would be rated: ■ **Committed behaviour**

- As previously noted, some indicators are reported on an evaluation scale of only two or three levels. In those cases, the individual answers compilation is done the same way as for a four-level evaluation scale, but the bounds used to report the average value are modified. For example:

Indicator 2 (three-level indicator)

Behaviour	✖ Not available	□ Compliant behaviour	▨ Proactive behaviour	■ Committed behaviour
Number of dairy farms	---	3	3	1

To weight the individual answers, the following value was attributed to each level of the behavioural scale:

✖ = --- □ = 2 ▨ = 3 ■ = 4

Accordingly, for the Indicator 2 we would get:

$$\frac{3 \times 2 \quad + \quad 3 \times 3 \quad + \quad 1 \times 4}{7 \text{ (number of answers)}}$$

= 2.71

The attribution of the average sectorial score for the Three-level indicator is obtained through the reporting of the average value on the behavioural scale using the following equally-distant bounds:

✖= --- □ = [2.00 – 2.66 [▨ = [2.66 – 3.33 [■ = [3.33– 4.00]

This Indicator 2 would then get a score of ▨ **Proactive behaviour** for the corresponding behaviour assessed at the sectorial level.

- For a **Two-level indicator**, a similar logic is followed:

Indicator 3 (two-level indicator)

Behaviour	✖ Not available	□ Compliant behaviour	✖ Not available	■ Committed behaviour
Number of dairy farms	---	5	---	2

The values used to weight the answers are the following:

✖ = --- ☐ = 2 ✖ = --- ■ = 4

In this third example, the average score would be calculated the following way:

$$\frac{5 \times 2 + 2 \times 4}{7 \text{ (number of answers)}}$$

= 2.57

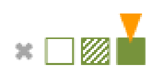
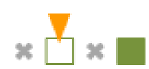
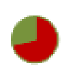
To report this average value on the evaluation scale, the bounds would be set as follows:

✖ = --- ☐ = [2.00 – 3.00 [✖ = --- ■ = [3.00– 4.00]

The Indicator 3 would hence get a score of ☐ **Compliant behaviour** for the corresponding behaviour assessed at the sectorial level.

To provide a more transparent and complete picture of the socioeconomic performance of the sector, the distribution of the individual scores, i.e. the variability of behaviors among the respondents, is presented in a pie chart for each indicator, in addition to the average sectorial socioeconomic performance indicated by a cursor pointing out the final score on the corresponding evaluation scale.

For example:

INDICATORS	VARIABILITY	AVERAGE PERFORMANCE
Indicator 1		
Indicator 2		
Indicator 3		

As for **Indicator 1**, the sector is considered as having a committed behaviour on the average, given that 6 out of 7 firms (here the farms) have such behaviour, the sixth one having a proactive one. Since it was not possible to document risky behaviours in this example, the evaluation scale has a "X" in place of a potential risky level.

The results for **Indicator 2** show that the average sectorial score is a compliant behaviour, since 4 firms have such conduct compared to the three others that have committed one. Only those two levels were assessed in this particular case.

The results for **Indicator 3** indicate that the sector has a risky behaviour on the average. Five firms have such behaviour against two having a committed one. Intermediary levels were not assessed in this last example and were hence replaced by the ✖ symbol on the evaluation scale.

Since the dairy Boards fulfill many tasks on behalf of dairy farmers in areas such as R&D and sponsorship, their behaviours were also assessed by using a similar approach. Table 5-7 lists the socioeconomic indicators documented at the Board level.

Table 5-7 - Impact subcategories and the corresponding socioeconomic indicators per stakeholder categories documented at the dairy Boards level

LOCAL COMMUNITY			
Community engagement			
Milk donation	Description	The Board manages and/or supports a milk donation program (except for schools)	
	PRP	Best expected practices	
	Justification / commentary	Milk is a healthy and nutritive food product that should be part of a balance diet. But some individuals do not have access to a sufficient amount of healthy food. By supporting milk donation, the Board contributes to food security for those individuals.	
	Evaluation scale	■ (red)	---
		□ (white)	The Board does not hold a milk donation program
		▨ (hatched green)	---
		■ (green)	The Board does hold a milk donation program
School milk	Description	The Board manages and/or supports a school milk program	
	PRP	Best expected practices	
	Justification / commentary	Milk is a healthy and nutritive food product that should be part of a balance diet, especially for children. But some of them do not have access to a sufficient amount of healthy food. By supporting school milk program, the Board contributes to these children's diet.	
	Evaluation scale	■ (red)	---
		□ (white)	The Board does not hold a school milk program
		▨ (hatched green)	---
		■ (green)	The Board does hold a school milk program
Scholarship	Description	The Board grants scholarships to students	
	PRP	Best expected practices	
	Justification / commentary	As a corporate citizen, the Board can encourage and support students' education by granting them scholarships.	
	Evaluation scale	■ (red)	---
		□ (white)	The Board does not grant scholarship
		▨ (hatched green)	---
		■ (green)	The Board does grant scholarships

LOCAL COMMUNITY (continued)			
Community engagement (continued)			
Sponsorship	Description	The Board sponsors non-for-profit organizations based on a formal and public engagement	
	PRP	Best expected practices	
	Justification / commentary	As a corporate citizen, the Board can sponsor non-for-profit organizations. It can be done on an ad-hoc basis, or via a formal and public policy or engagement.	
	Evaluation scale	■ (red)	---
		□	The Board does not sponsor non-for-profit organizations
		▨	The Board does sponsor non-for-profit organizations in an ad-hoc way
		■ (green)	The Board does sponsor non-for-profit organizations via a formal and public policy or engagement
SOCIETY			
Commitment to sustainability issues			
Promotion of sustainable development	Description	The Board holds a formal strategy/policy/engagement on sustainable development	
	PRP	Best expected practices	
	Justification / commentary	In order to promote sustainable development, the dairy Board can commit itself by holding a formal and public strategy or policy stating, for example, a vision and specific objectives to attain.	
	Evaluation scale	■ (red)	---
		□	The Board does not hold a formal strategy/policy/engagement on sustainable development
		▨	---
		■ (green)	The Board holds a formal strategy/policy/engagement on sustainable development
Technology development			
Research and development	Description	The Board supports R&D activities	
	PRP	Best expected practices	
	Justification / commentary	The Board can support R&D activities by funding research in different fields of public interest, such as health, nutrition, technology and environment.	
	Evaluation scale	■ (red)	---
		□	The Board does not support R&D activities
		▨	---
		■ (green)	The Board does support R&D activities

SOCIETY (continued)			
Animal welfare			
Animal welfare	Description	The Board holds a mandatory code of practices, a certification or a set of specifications regarding animal welfare	
	PRP	Best expected practices	
	Justification / commentary	In order to support and supervise producers in their effort to enhance animal welfare, a Board can put in place a mandatory code of practices, a certification or a set of specifications, to be audited by a third party or not.	
	Evaluation scale	■ (red)	---
		□	The Board does not hold a mandatory code of practices, a certification or a set of specifications regarding animal welfare
		▨	The Board holds a mandatory code of practices, a certification or a set of specifications regarding animal welfare, but it is not audited
		■ (green)	The Board holds an audited mandatory code of practices, certification or set of specifications regarding animal welfare

VALUE CHAIN ACTORS			
Promotion of social responsibility			
Promotion of social responsibility	Description	The Board is involved in partnerships with NGOs to promote sustainability / social responsibility issues (ex.: fair trade, wetlands protection, food aid, education, etc.)	
	PRP	Best expected practices	
	Justification / commentary	As a corporate citizen, the Board has the possibility to get involved in initiatives and partnerships with other organizations to promote sustainability / social responsibility issues among market or public actors.	
	Evaluation scale	■ (red)	---
		□	The Board does not hold a mandatory code of practices, a certification or a set of specifications regarding animal welfare
		▨	The Board holds a mandatory code of practices, a certification or a set of specifications regarding animal welfare, but it is not audited
		■ (green)	The Board holds an audited mandatory code of practices, certification or set of specifications regarding animal welfare

While the assessment at the farm level relies exclusively on semi-quantitative indicators benchmarked against PRPs, a more qualitative evaluation is used to assess the issues of concern considered at the sectorial level (Table 5-8). The impact assessment is conducted by interpreting the relevant information and data gathered in relation with each issue of concern.

Table 5-8 - Issues documented at the sector levels

	IMPACT SUBCATEGORIES	DOCUMENTED ISSUES
FARM WORKERS	Labour standards (*Working hours, salary and contribution to fringe benefits*)	- Degree of exclusion of agricultural workers from provincial labour standard provisions
	Freedom of association and collective bargaining	- Degree of exclusion of agricultural workers from provincial labour relation codes
	Health and Safety	- Degree of dangerousness of agricultural occupation and workers coverage by the health and safety legislation
	Integration and/or discrimination (*for temporary foreign workers*)	- Immigration programs characteristics; - Degree of exclusion of temporary foreign workers from provincial labour standard provisions - Other documented abuses
	Hiring practices (*for occasional workers*)	- Documented abuses related to hiring agencies behaviours in the agricultural sector
	Young workers employment	- Degree of legal restrictiveness
SOCIETY	Contribution to economic development	- Relative contribution to job creations, farm receipts and tax revenues compared to milk production level
	Animal welfare	- Presence of national or provincial codes of practice / certifications / specifications to promote animal welfare
VALUE CHAIN ACTORS	Responsible supplier practices	- Share of producers participating to the Quality Milk Program
	Market power	- The main benefits and drawbacks of supply management and collective marketing in business relationships.

5.3.4. Data collection process

Conducting a Specific Analysis requires a significant amount of data and information to document the PRPs and the organisations' behaviours. Unfortunately, there are very few databases that cover and record on a regular and systematic basis social and socioeconomic issues at a sector or organisation level. Primary data, i.e. data collected directly from the participating businesses and organizations, are thus generally needed to undertake such an analysis.

Due to the scope of the Specific Analysis performed in this project, the data collection process was expectedly challenging. In addition to the large variety of undocumented information needed, it was also necessary to document this information in a standardized manner across all provinces in order to get consistent results at the Canadian level.

This challenge was first met with the PRPs. The lack of data and reliable documentation on most of the issues of concern under assessment made it difficult to assess not only these issues, but also to select standardised PRPs suited for the milk production context in each province. For that reason, most of the PRPs used have been based on experts' judgement and on our own knowledge of the Canadian dairy sector and agricultural production.

Primary data were used to assess dairy farms' behaviours and practices. To do so, questionnaires were sent to 817 milk producers located in six (6) provinces: Prince-Edward-Island, Nova-Scotia, New-Brunswick, Quebec, Ontario and Alberta. The participation to the survey was on a voluntary basis[7]. Different techniques were used to distribute the questionnaires. In Quebec and New Brunswick, the producers participating to the annual cost of production study were asked to complete a complementary questionnaire. In Ontario, Nova Scotia and Alberta, questionnaires were sent to all dairy producers, who were offered a 20$ compensation for sending back the form completed. in Table 5-9 presents, for each participating province, the number of completed questionnaires received compared to the number of active dairy producers. Three hundred (300) completed questionnaires were collected. Depending on each farm's characteristics, all questions were not always answered. The number of answers supporting the assessment of each socioeconomic indicator varies consequently.

The data collection process was not designed to provide a statistically representative sample of farms at a national level. However, both the sample's size and the characteristics (number of cows, ownership, cultural practices, etc.) of the participating dairy farms in each province reflect fairly well the population they represent.

The data, collected at a provincial level, have been pooled up and weighted at a national level to assess the average Canadian dairy farmers' socioeconomic performance. Weighting was necessary because the provincial samples were not of relative equivalent size, and the Canadian average score has been determined by compiling, for each indicator, farmer's individual answers. Consequently, the weight of each individual answer was established according to the relative size, in terms of number of dairy producers, of the province hosting them.

For example, Ontario counts 4,137 dairy producers, or 35% out of the 11,674 producers covered by this assessment[8]. The Ontarian sample regroups however almost 50% of all the respondents. For a given indicator, the score of the Ontarian dairy farmers needed hence to be weighted down to account for 35% of the national socioeconomic performance. Each individual answer has thus been weighted according to the corresponding provincial weight as shown in Table 5-9.

[7] Surveys were sent in provinces where the board showed at the beginning of the project an interest in participating to the data collection process.

[8] The six participating provinces accounted for 11,674 dairy producers among the 12,746 active producers in 2011.

Table 5-9 - Number of completed questionnaires compared to the number of active producers

Province	Population	Provincial weight (%)	Completed questionnaires	Sample weight (%)
Atlantic (Prince-Edward-Island, Nova-Scotia, New-Brunswick)	664	6%	17	6%
Quebec	6,281	54%	97	32%
Ontario	4,137	35%	146	49%
Alberta	592	5%	40	13%
TOTAL	11,674	**100%**	300	**100%**

At the Board level, a questionnaire was also sent to document their practices in areas such as R&D, support to local organizations, etc[9]. In addition to those primary data, secondary data were also compiled mostly by consulting the organizations' annual reports.

Finally, sectorial issues have been documented using secondary data collected from various sources, including NGOs' reports, governmental publications, scientific articles, etc. This documentation is cited in the result section.

5.4. The Potential Hotspots Analysis

The Potential Hotspots Analysis (PHA) aims to provide a screening of the socioeconomic performance of the companies involved in the product system. This assessment uses generic data, i.e. data that are not site-specific, and is therefore easier to run than a Specific Analysis.

The PHA assesses the risk of encountering behaviours going against accepted social norms among businesses being part of the system's supply chains (upstream system). More specifically, this assessment method allows identifying **potential socioeconomic hotspots**[10], i.e. the presence of risky behaviours which might negatively impact groups of stakeholders. A PHA hence provides a preliminary overview of the social issues found among a product's supply chains to bring awareness

9 With the exception of Newfoundland and Labrador.

10 In the Guidelines (UNEP/SETAC, 2009), a social hotspot is defined as an activity «located in a region where a situation occurs that may be considered as a problem, a risk or an opportunity, in function of a social theme of interest". As suggested by Parent, Cucuzzella and Revéret (2012) «for the sake of consistency in the use of concepts in LCA and SLCA, social hotspots are therefore defined as areas where an improvement is required. This definition is also more consistent with the hypothesis that an organization uses SLCA to enhance enterprises' behaviours as a way to reach the ultimate goal of improving social conditions along the product life cycle, as implicitly suggested in the Guidelines". National and regional context influences businesses' behaviours, but at the end it is those behaviours that are of interest. Therefore, a country's situation is considered as a factor influencing the possibility of encountering – or not – companies behaving in such ways that they can induce negative social impacts.

over the socioeconomic risks related to current procurement practices and to point out issues requiring deeper analysis.

The following sections describe the PHA methodology in more details. As for the Specific Analysis framework, the PHA framework is built upon the UNEP/SETAC's Guidelines, which have been adjusted to be operationalized. Section 5.4.1 presents the stakeholder categories to which this assessment refers. The list of issues of concern (impact subcategories) covered by this assessment is proposed in section 5.4.2. Then, sections 5.4.3, 5.4.4, 5.4.5 respectively present the scope of this PHA, the data collection process and finally, the impact assessment method.

5.4.1. The Stakeholder categories

The stakeholder categories considered in the PHA framework are the same as those considered in the Specific Analysis: **workers**, **local communities**, **society** and **value chain actors**. The "consumers" category is also excluded as they are not significantly and directly impacted by the behaviour of the assessed businesses operating upstream in the milk's value chain.

5.4.2. Issues of concern (Impact Subcategories)

The PHA assesses the possibility of encountering risky behaviours according to a list of issues of concern (impact subcategories) related to a particular stakeholder category. The list is presented in Table 5–10. While most issues are drawn from the UNEP/SETAC's Guidelines, some adjustments have however been made in the context of the PHA. The first column lists the subcategories proposed in the Guidelines. The second column indicates whether these subcategories are kept, adjusted or removed of the PHA framework. The last column provides a definition for each subcategory assessed in the PHA framework and a justification for any changes made to the original framework.

Since the PHA framework is developed to cover a vast array of organisations operating in various countries, impact subcategories have not been adjusted to take into account specific sectorial or regional issues of concern. The reasons why subcategories have been removed or adjusted are rather related to methodological concerns. In some cases, it is due to the lack of relevant generic data necessary to assess a particular issue. Some subcategories have also been removed because they are not related to risky behaviours that could negatively impact individuals (e.g. social benefits and social security or end-of-life responsibility). When possible, those subcategories have been adjusted (or reworded) to cover social risks rather than benefits (e.g. "social benefits and social security" has been replaced by "employment insecurity"). Finally, some have been merged because of their similarity, but also because the subtlety between them could not be adequately captured by the PHA methodology (e.g. access to material resources, access to immaterial resources, delocalization and migration and cultural heritage have been merged).

Table 5-10 - Impact subcategories according to the corresponding stakeholder categories

UNEP/SETAC (2009) IMPACT SUBCATEGORIES	PHA ISSUES OF CONCERN	DEFINITION AND ADAPTATION
Workers		
Freedom of association and collective bargaining	Ibid.	**Definition**: The right to form associations and to collectively bargain is considered as a fundamental human right by the International Labour Organization (ILO) – companies should not violate this right.
Child labour	Ibid.	**Definition**: The abolition of child labour is considered as a fundamental human right by the ILO. Companies are thus expected not to hire children.
Fair salary	Ibid.	**Definition**: Salary is a central component of working conditions. Minimally, it must be sufficient for workers to have decent living conditions – companies are expected to provide an adequate salary.
Working hours	Ibid.	**Definition**: Working hours are a major proxy of working conditions quality; too many working hours or an irregular working schedule can affect workers' welfare, while well-balanced working hours might increase it – businesses are expected to not impose excessive hours of work.
Forced labour	Ibid.	**Definition**: The elimination of forced and compulsory labour is considered as a fundamental human right by the ILO – businesses are expected to not use any form of forced labour.
Equal opportunities/Discrimination	Ibid.	**Definition**: The elimination of discrimination regarding employment and occupation is considered as a fundamental human right by the ILO – companies are expected not to discriminate workers.
Health and Safety	Occupational health and safety	**Definition**: Employees should benefit of safe and secure conditions to avoid incidents which could compromise their physical or psychological health. Businesses are expected to have a minimum record of occupational H&S issues.
Social Benefits/Social security	Employment insecurity	**Adaptation:** The PHA assesses the probability of encountering inappropriate behaviours, i.e. social insecurity rather than social security. **Definition**: Employment security is seen as an important aspect of decent work (Anker et al., 2002). Businesses are expected not to fire employees without proper motives.

UNEP/SETAC (2009) IMPACT SUBCATEGORIES	PHA ISSUES OF CONCERN	DEFINITION AND ADAPTATION
Local community		
Access to material resources Delocalization and Migration Access to immaterial resources Cultural Heritage	Access to material or immaterial resources	**Adaptation**: These impact subcategories all address the resources access issue. They have been merged together for simplification given that available data do not allow discerning whether the resources considered are material, immaterial, concern land or a cultural site. **Definition**: In the course of their activities, companies can reduce, directly or indirectly, access to some resources for other users, including land and cultural sites. Companies are expected to minimize the negative implications in resources access.
Safe and healthy living conditions	Ibid.	**Definition**: This subcategory assesses how organizations impact the safety and health of local communities. This includes the general safety conditions of operations and their public health implications. Companies are expected not to create an environment that might affect negatively the safety and health of people living near plants.
Respect of indigenous rights	Ibid.	**Definition**: According to the LCI's methodological sheets, "Indigenous peoples have a historical continuity with pre-invasion and precolonial societies that developed on their territories and consider themselves distinct from other sectors of the societies now prevailing in those territories, or parts of them" (UN Global Compact, Indigenous Peoples). Respect of indigenous rights includes the right to lands, resources, cultural integrity, self-determination and self-government" (LCI 2010). Companies are expected to not infringe their rights.
Community engagement	*Removed*	**Adaptation**: Excluded because this issue is related to social benefits rather than to negative impacts.
Local employment	*Removed*	**Adaptation**: Excluded because this issue is related to social benefits rather than to negative impacts.
Society		
Secure living conditions	Ibid.	**Definition**: According to the LCI's methodological sheets, "this subcategory assesses how organizations impact the security of local communities with respect to the conduct of private security personnel and how the organization interacts with state-led forces" (LCI 2010). Businesses are expected to not be involved in violent events affecting local communities.
Public commitments to sustainability issues	*Removed*	**Adaptation**: Excluded because not complying with this principle does not directly lead to social negative impacts.
Contribution to economic development	*Removed*	**Adaptation**: Excluded because this issue is related to social benefits rather than to negative impacts.

UNEP/SETAC (2009) IMPACT SUBCATEGORIES	PHA ISSUES OF CONCERN	DEFINITION AND ADAPTATION
Society (continued)		
Prevention & mitigation of armed conflicts	Involvement in armed conflicts	**Adaptation:** The PHA assesses the probability of encountering inappropriate behaviours, i.e. the probability of a company being involved in armed conflicts rather than in its prevention and mitigation. **Definition**: According to the LCI's methodological sheets, "this subcategory assesses the organization's role in armed conflicts or situations that might in the future develop into armed conflicts" (LCI 2010). In the context of the PHA, what is documented is the potential involvement of an business into armed conflicts.
Technology development	*Removed*	**Adaptation**: Excluded because this issue is related to social benefits rather than to negative impacts.
Corruption	Ibid.	**Definition**: According to the LCI's methodological sheets, this subcategory assesses whether an organization has implemented appropriate measures to prevent corruption and if there is evidence that it has engaged or has been engaged in corruption" (LCI 2010). In the context of the PHA, what is assessed is the probability that businesses are involved in corruption.
---	Fair distribution of revenues	**Definition**: The fair distribution of a company's revenues among its shareholders, workers as well as with the society through taxes is a prerequisite of a fair distribution of wealth in a society. It is expected from a company to distribute fairly its revenue among different stakeholders.
Supply chain actors		
Fair competition	Ibid.	**Definition**: According to the LCI's methodological sheets, this subcategory assesses if the "organization's competitive activities are conducted in a fair way and in compliance with legislations preventing anti-competitive behaviour, anti-trust, or monopoly practices" (LCI 2010).
Promoting social responsibility	*Removed*	**Adaptation**: Excluded because not complying with this principle does not directly lead to social negative impacts.
Supplier relationships	*Removed*	**Adaptation**: Excluded for being impossible to assess with generic data.
Respect of intellectual property rights	Ibid.	**Definition**: According to the LCI's methodological sheets, "this subcategory assesses whether organization's actions safeguard and value the creators and other producers of intellectual goods and services. The legal rights dealing with the intellectual property entail intellectual activities in the industrial, scientific, literary, and artistic fields" (LCI 2010).

5.4.3. Scope of the PHA

To perform a PHA it is first necessary to identify and localise the companies involved at each step in order to document afterwards their behaviours. The product system defined in section 5.2 identified nine (9) main supply chains associated to milk production. Each supply chain has been defined by identifying only one or two representative inputs and by limiting its range up to the last major auxiliary input identifiable.

In order to assess the presence of potential social hotspots, the PHA refers to proxies such as representative sectorial practices or frequently observed behaviours, informing on businesses' behaviours. According to Macombe *et al.* (2010), "companies belonging to one industry tend to become similar with time". Therefore, one can assume that the information gathered at a sector or industry level is a representative proxy of individual behaviours of the companies operating in that sector or industry.

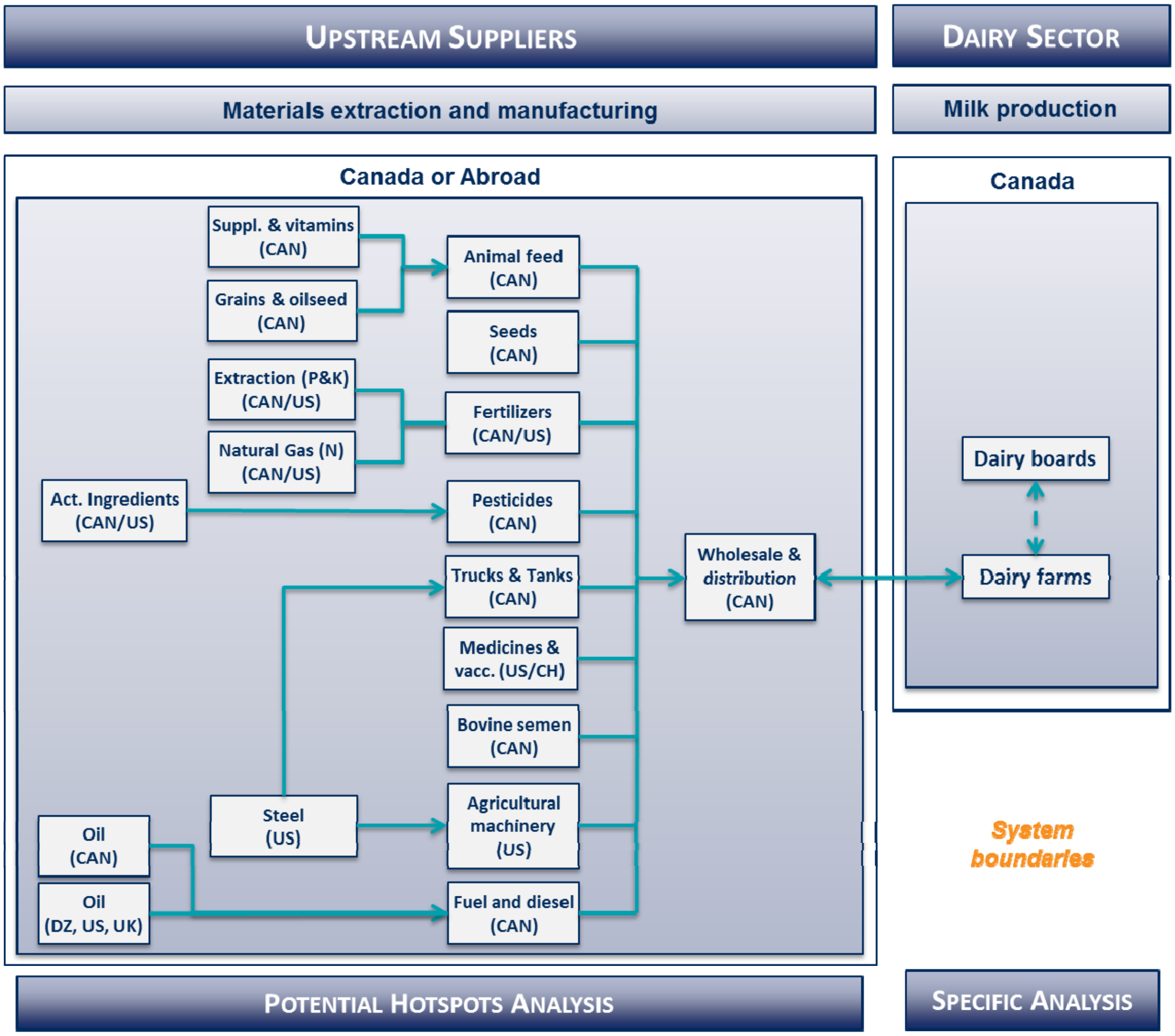
Moreover, given that the legal and cultural context can influence businesses' behaviour, it is also important to specify where the companies, sectors or industries assessed conduct their operations. As one product or input supplied to the Canadian market can come from several countries, only the main or outweighing sourcing countries for each input have been taken into consideration, in line with Bienge *et al.* (2010). As a consequence, the possibility of encountering businesses behaving inappropriately (or in a risky way in comparison with the commonly accepted social norms) has been assessed, at each step of each supply chain, at the sector level and in the different countries where the companies are supposed to carry out their activities.

For this purpose, the relevant representative sourcing regions have been specified. To do so, the relative weight of imports compared to the domestic consumption level has been calculated to make, first, an assumption on whether the supply of each input is mostly ensured by the domestic market or by a foreign one[11]. Then, countries supplying the Canadian market have been identified using a trade database[12].

Based on this approach, Figure 5-3 describes the system assessed under the PHA by identifying the sectors/industries considered at each step of each supply chain as well as the assumed sourcing regions.

[11] An activity was considered taking place fully abroad when, for a given input, imports accounted for 60% or more of the total domestic consumption. The same activity was considered taking place fully in Canada when imports level accounted for 40% and less of the total domestic consumption. When imports level was similar to domestic production level, the activity was considered taking place in Canada as well as abroad. Data were collected in the Canadian Trade by industry database (data for 2010 were collected online between February and June 2012 from the Canadian Industry Statistic database [http://www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home]). Data for 2009 were collected online between February and June 2012 from CANSIM, table 379-0025.
[http://strategis.ic.gc.ca/eic/site/cis-sic.nsf/eng/Home]. Data for 2007 collected online in February [http://www5.statcan.gc.ca/cansim/a01?lang=eng] from CANSIM).

[12] Only countries holding a share of 30% or more of the total value of imports have been included in the system. Data were collected in the Canadian Trade by industry database (data for 2010 were collected online between February and June 2012 [http://www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home]).



CAN: Canada; US: United States; DZ: Algeria; UK: United Kingdom; KZ: Kazakhstan; CH: Switzerland

Figure 5-3 - System assessed under the PHA

5.4.4. Data collection process

The PHA approach relies on generic data and is thus dependent of their availability. In order to document potential risky behaviours among supply chains, three complementary data collection techniques were hence used depending on the information needed.

First of all, when available, data on potential behaviours in a **specific sector located in a specific country** have been collected from national and international statistical databases, country specific human rights reports and from a variety of other sources identified through a web search and a literature review.

While data collected at the sector level are relevant proxies to document behaviours of specific companies, they are generally scarce. To fulfil this gap, another proxy was used. It involved documenting behaviours of a **small sample of companies** belonging to the sector and localised in the country under assessment. Samples were built by identifying the major businesses operating in the sector/country under assessment by using, for example, the Canadian Industry Statistic database[13]. Information on those businesses' behaviour was also collected from human rights literature and other sources. Business and Human Rights Resources Centre[14] gathers articles on Businesses practices related to human rights issues. Wikipedia also compiles social issues related to specific companies. Those two sources were systematically used. As the goal of the PHA is to highlight the risk of encountering potential hotspots, it was not necessary to validate the collected information. The information as well as the data sources are listed and discussed in the result section in a transparent manner.

Finally, when no data were available either at the sector level or by referring to the sample of companies, the social performance of the **country** was used as a proxy. It is acknowledged that the national context in which a business carries its activities greatly influences its behaviour (Macombe *et al.*, 2010).

In summary, for each step of each supply chain under assessment, three proxies were used to collect data giving insight on the potential behaviour of companies:

1. Sectorial data;
2. Information related to the behaviour of a sample of representative businesses;
3. Country level data.

5.4.5. Impact assessment method

This section details how the possibility of encountering companies not behaving in compliance with accepted social norms was assessed. As for the Specific Analysis, each issue of concern was assessed using an assessment method. Since the PHA relies on generic data, the method varies according to their availability. For some issues of concern, it was possible to document behaviours at a business or sectorial level. For others, information was only available at a national level. Depending on sources, quantitative, semi-qualitative and qualitative data have also been used. But in all cases, the assessment was carried out using a standardized three-level evaluation scale assessing the possibility (low, moderate, high) of encountering companies with risky behaviour, i.e. not behaving in compliance with the accepted social norms (Table 5-11).

13 Canadian Industry Statistics (CIS). Hosted by Industry Canada, available online [http://strategis.ic.gc.ca/eic/site/cis-sic.nsf/eng/Home], accessed from February to May 2012.

14 Business & Human Rights Resource Center, online library available [http://www.business-humanrights.org/], accessed from March to June 2012.

Table 5-11 - Risk evaluation scale

Low possibility	Moderate possibility	High possibility

The following tables describe the assessment method used to assess the possibility of encountering enterprises with non-complying behaviours for each issue of concern, depending on how the indicators have been documented. When more than one source of data could have been used to assess the level of risk related for a same issue of concern, only the most relevant, i.e. the most closely related to the sector, was used. Sector specific data, as well as data collected through a sample of companies, have been favoured because they constitute better proxies of businesses' behaviour than country level data. We relied on a country level indicator only when no sectorial data were found using available statistical databases or a web review. But given the current scarcity of information regarding companies' or sectors' behaviour, the assessment relied mostly on country level indicators.

SECTORIAL DATA

The issues of concern have first been documented using sectorial data collected from three different sources.

In the case of **Fair salary**, **Working hours** and **Occupational Health and Safety**, statistical data at the sector level have been used to assess the possibility of encountering social hotspots. Table 5-12 describes the indicators developed as well as the PRPs considered to assess the level of risk.

Table 5-12 - Risk evaluation scale

WORKERS			
Fair salary			
Adequacy of the median salary	Description	The possibility of encountering businesses offering an inadequate median salary is based on the comparison between the median salary of the sector and half the median salary at the national level.	
	PRP	50% and 60% of the national median salary	
	Rationale / commentary	This indicator is derived from the International Labour Organisation (ILO) works suggesting that a salary being half of the national median is inadequate (Anker *et al*., 2002). When the median wage was not available, the average wage was used.	
	Data sources	National and international statistical databases	
	Evaluation scale	High possibility	The sectorial median salary is < 50% of the national median salary
		Moderate possibility	The sectorial median salary is between 50% and 60% of the national median salary
		Low possibility	The sectorial median salary is > 60% of the national median salary

WORKERS (continued)			
Working hours			
Excessive hours of work	Description	The possibility of encountering excessive weekly hours of work, i.e over 48 hours worked per week, was assessed using the Occupational hours of work per country published in the October Inquiry statistics gathered by the ILO (the more recent data available are for 2008).	
	PRP	48 hours per week and 45 hours per week	
	Rationale / commentary	This indicator is based on the international standards set by ILO convention C-01, art.2 (ILO, 1919) stating that working over 48 hours per week is excessive. In this analysis working over 48 hours per week was considered as a high risk of hotspot and 45 hours, as a moderate risk. As the database provides the weekly hours of work for a variety of occupations in a same sector and that we are here interested in the risky behaviours in a sector, the occupation with the longer weekly hours of work was used.	
	Data sources	The possibility of encountering excessive weekly hours of work, i.e. over 48 hours worked per week, was assessed using the Occupational hours of work per country published in the October Inquiry statistics gathered by the ILO (the more recent data available are for 2008).	
	Evaluation scale	■ (solid red)	Occupational hours of work are ≥ 48
		▨ (hatched red)	Occupational hours of work are ≥ 45 and ≤ 48
		□ (empty)	Occupational hours of work are < 45
Occupational Health & Safety			
Rates of fatal and non-fatal injuries	Description	The possibility of encountering unsafe and unhealthy practices was assessed on the basis of the average rates of fatal and non-fatal occupational injuries at the sectorial level. They have been compared to the average rates of the different sectors in a country.	
	PRP	National average rates of fatal and non-fatal occupational injuries	
	Rationale / commentary	The statistic collected by the International Labour Organization (ILO) on rates of fatal and non-fatal occupational injuries were used. The rates were not compared between countries, since "varying reporting formats hamper the comparability of the data" (Anker *et al*., 2002). Comparing sectors in a same country is, however, expected to minimize this bias.	
	Data sources	International database (Laborstat)	
	Evaluation scale	■ (solid red)	Rate of fatal injuries is above country average
		▨ (hatched red)	Rate of non-fatal injuries is above country average
		□ (empty)	Rates of fatal and non-fatal injuries are below country average

The issues of concern **Freedom of association and collective bargaining**, **Child labour**, **Working hours**, **Forced labour** and **Occupational health and safety** have also been assessed at the sector level using information found in two human rights reports: the US Department of State Country report on Human Rights (U.S. Department of State, 2011) and in the Annual Survey of violations of Trade Union

Rights 2011 (ITUC, CSI, IGB, 2012). This qualitative information provide in those reports has been used to assess the possibility of encountering violations in the sectors under assessment[15]. The assessment method used to differentiate the risk level relied on our expert judgment. For a matter of transparency, this judgment is always justified in the "detailed justifications" sections found in Appendix J.

Finally, a Web search has been conducted to document all issues of concern at a sector and country level. The collected information was assessed based on our expert judgment and transparently detailed in the "detailed justifications" sections found in Appendix J.

DATA COLLECTED FROM A SAMPLE OF BUSINESSES

To complement the sectorial data, a review of the available publications was conducted to document, for each issue of concern, the potential risky behaviours of the main companies involved in the sectors and regions under review. This review focused on the criticisms directed towards the businesses included in the sample for practices going against accepted social norms. Here again, the collected information was assessed based on our expert judgment and transparently detailed in the results sections (Appendix J).

COUNTRY LEVEL DATA

Finally, for issues that could neither be documented through the sector level assessment nor through the sample of businesses, country level data were used. The possibility of encountering companies behaving inappropriately compared to accepted social norms was assessed using social indicators selected from several sources[16].

Three main sources of data have been used:

- The **World Economic Forum's** (WEF) annual Executive Opinion Survey which results are published in The Global Competitiveness Report 2011-2012 (WEF, 2011);
- The **Social Hotspots Database** (SHD), a database that can be used to inform the social assessment phase of the S-LCA;
- And a **variety of other sources**, such as the GINI and the Corruption Perception Index.

Some issues of concern were assessed using data collected from the **WEF annual Executive Opinion Survey**. This survey, published in The Global Competitiveness Report 2011-2012 (WEF, 2011), asks business executives about the situation in their respective country regarding several socioeconomic

[15] Except for the U.S. as no report on Human Rights is available. The issues of concern Freedom of association and collective bargaining, Child labour, Working hours and Forced labour were assessed at the country level when no better information was found through the web and libraries search.

[16] The Task Force for the integration of social aspects to LCA has gathered a broad range of national data sources in their Methodological Sheets (Benoît-Norris et al. 2011). Indicators that could inform on a possibility of encountering businesses not behaving in compliance with accepted social norms were selected through a review of those sources.

issues, some of them being similar to the ones addressed in the PHA. For each issue, the survey respondents' opinion was scaled from 1 to 7, with 1 representing the worst situation and 7, the best one. The score represents the average opinion.

Table 5–13 lists the WEF indicators to which we referred to in the PHA. The assessment method, which is similar for all indicators, is described below.

Table 5-13 - Indicators of the WEF annual Executive Opinion Survey

Subcategories assessed by the WEF			
Stakeholders	**Subcategories**		**WEF indicators**
Workers	Freedom of association and collective bargaining		Cooperation in labour-employer relation
	Employment insecurity		Hiring and firing practices
Society	Secure living conditions		Reliability of police services
	Corruption[17]		Transparency of government policymaking
			Ethical behaviour of firms
Value chain	Fair competition		Effectiveness of anti-monopoly policy
	Respect of intellectual property rights		Intellectual property protection
Evaluation scale[18]	■	The survey result is > 5	
	▨	The survey result is ≥ 3 and ≤ 5	
	□	The survey result is > 5	

Table 5–14 presents the list of indicators selected from the Social Hotspots Database (SHDB), which is being developed to support S-LCA practice. Only the stakeholder category Workers is evaluated using the SHDB indicators. The SHDB offers a risk assessment analysis at the country level. The evaluation scales come from the document Social Hotspots Database: Risk and Opportunity Table Development (Benoît *et al.*, 2010). Data sources are not listed in the present document but can be found in Benoît *et al.* (2010).

[17] When the two WEF indicators for corruption did not provide the same result, the level of risk was determined based on our expert judgment. Justification is provided in the «detailed justifications" sections found in Appendix J.

[18] The scale is reversed for «Hiring and firing practices" for which the best situation is easiness in hiring and firing. We interpreted it as a treat to employment security. The scale is also slightly modified to better represent the different level of probability: > 6 is a high risk, between 4 and 6, a moderate risk, and below 4, a low risk.

Table 5-14 - Indicators selected from the Social Hotspots Database

WORKERS			
Working hours			
Risk of population working more than 48h per week	Description	The possibility of excessive hours of work is based on the percentage of the population working more than 48 hours per week (when quantitative country data were available) and/or on qualitative description of some criteria.	
	PRP	Percentage of a country population working more than 48 hours per week	
	Evaluation scale	■	>25 of the population[19]
		▨	10-25% of the population
		□	<10% of the population
Risk of population working more than 48h per week	Description	The possibility of excessive hours of work is based on qualitative description of some criteria.	
	PRP	Presence of laws, proofs of enforcement or violations	
	Evaluation scale	■	If more than one "medium" issue exists
			If laws are "frequently not enforced"
		▨	If no laws exist for compulsory overtime or compensated overtime
			If only domestic workers work overtime
			If only formal sector abides by laws
			If foreign workers do not have adequate labour laws
			If laws are not "actively enforced"
		□	Laws are enforced and overtime is compensated
Forced labour			
Risk of forced labour	Description	The possibility of encountering forced labour in a country is based on qualitative description of the situation regarding this issue.	
	PRP	Importance of the evidence	
	Evaluation scale	■	Forced labour is indicated in 2 or more of the main resources or, if only one source is available, the evidence is very compelling
		▨	Forced labour is indicated in one of the main sources
		□	From available sources, risk of forced labour seems low as there is minimal evidence as such

[19] The scale used in the SHDB has 4 levels: low (<10% of the population), moderate (10-25% of the population), high (25-50% of the population) and very High (>50% of the population). We aggregated the «high" and «very high" levels in order to be consistent with our evaluation scales. When the SHDB attributes a very high score for a specific country, this will be mentioned in the results section.

WORKERS (continued)			
Equal opportunities/Discrimination			
Overall fragility of Gender Equity	Description	The possibility of encountering non-compliance with the right to equal opportunities is represented by a composite index on gender inequity. In the SHDB, the risk of gender inequity in a country is based on a weighted mean of five gender equity indicators derived from different data sources (see Benoît et al., 2010): the "Social Institutions and Gender Index (SIGI)" (30%), the "Global Gender Gap (GGG)" (30%), the CIRI (20%), the GDI (10%) and the GEM (10%).	
	PRP	Interval throughout the scores of the composite index	
		■ (solid red)	>2,3 [20]
		▨ (hatched red)	1,3 – 2,3
		□ (empty)	< 1,3
Child labour			
Risk of Child labour	Description	The possibility of child labour is based on the population of children working over the entire population of children in a country.	
	PRP	Interval in percentage of children working	
	Evaluation scale	■ (solid red)	> 10 [21]
		▨ (hatched red)	> 4 – 10%
		□ (empty)	< 4%

[20] The scale used in the SHDB has 4 levels: low (<1,2), moderate (1,3 - 2,3), high (2,3 – 3,3) and very High (< 3,3). We aggregated the «high" and «very high" levels in order to be consistent with our evaluation scale. When the SHDB attributes a very high score for a specific country, this will be mentioned in the results section (see section 5.5.2).

[21] In the SHD, the scale for the risk of child labour has 4 levels: low (< 4%), moderate (> 4 – 10%), high (> 10 – 20%) and very High (> 20%). We aggregate high and very high in order to be consistent in our evaluation scale. However, when the SHD attributes a very high score for a specific country, this will be mentioned in the results section (see section 5.5.2).

Finally, Table 5–15 presents a list of country level indicators selected from various sources. Issues of concern related to the stakeholder categories **Local community** and **Society** are evaluated using these indicators. The PRP and the scales of evaluation are also presented.

Table 5-15 - Indicators selected from a variety of sources

LOCAL COMMUNITY			
Delocalization and Migration			
Centre of Housing Rights and Evictions (COHRE)	Description	The possibility of impairment to the access to material or immaterial resources is based on the presence or not of the country in the reports database of the Centre of Housing Rights and Evictions (COHRE) and the likelihood that a violation could be related to an economic activity (potentially found in the life cycle of a product).	
	PRP	Presence of a country in a database; experts judgment on the possibility that the violation can be related to an economic activity	
	Evaluation scale	■	The violations mentioned are related to an economic activity (other than war or politic)
		▨	The country is in the COHRE database
		□	The country is not in the COHRE database
Indigenous Rights			
Violations in Human Rights Reports	Description	The possibility of encountering cases of non-respect of indigenous rights is based on the presence of violations reported in two Human Rights reports: the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011).	
	PRP	Presence and importance of the evidence	
	Evaluation scale	■	There is at least one mention of violations of indigenous rights in the US Department of State Country reports or the State of the World's Human Rights country report of Amnesty International reserves a section to the indigenous issue
		▨	There are mentions of poor living conditions of the natives without specific violations of Indigenous Rights in any of the reports
		□	There is no mention of concerns related to Indigenous people in any of the reports

SOCIETY			
Corruption			
Corruption Perception Index	Description	The possibility of encountering corruption is based on the Corruption Perception Index (2010)which is a measure of the perceived level of corruption in the public sector of a country by business people. Lower the score is, higher is the perceived level of corruption.	
	PRP	Interval in the index scores	
	Evaluation scale	■	< 3
		▨	≥ 3 to < 6
		□	≥ 6
Fair distribution of revenues			
GINI	Description	The GINI Index is an index of the equity in the distribution of wealth where 0 is a completely equal distribution and 100 a totally unequal distribution. The GINI is used here as a proxy of the distribution inside the enterprises of a country. Data comes from the World FactBook from the American Central Intelligent Agency (CIA).	
	PRP	Interval in the GINI scores	
	Evaluation scale	■	GINI ≥ 50
		▨	GINI ≥ 30 et < 50
		□	GINI < 30

5.5. S-LCA Results

The socioeconomic performance of the Canadian milk production sector can be declined in two ways: by describing the dairy farms' and dairy Boards' level of social engagement on the one hand, and by providing a preliminary overview of the social risks (potential hotspots) related to the sector's supply chains on the other hand.

5.5.1. Socioeconomic Performance at the production level

Socioeconomic performance at the dairy farm level

Figure 5-4 shows the average socioeconomic performance of the Canadian dairy farms towards their stakeholders, i.e. the farm workers, their local communities, the society and the value chain actors i.e. their suppliers and business partners (including the consumers). Each circle represents a level of the social responsibility evaluation scale, going from "risky behaviour" in red to "committed behaviour" in dark green (Section 5.3.3). The red line represents the average socioeconomic performance of the Canadian dairy farmers according to each indicator. The more the red line is at the circle's outskirts, the more the sector's average socioeconomic performance is good with a leading socially responsible behaviour.

The Canadian dairy farms globally have a positive socioeconomic performance. That is the case, for instance, for the agroenvironmental practices, whether it concerns water sources protection, manure storage or soil conservation. If this commitment is obvious from an environmental point of view, it is also significant in a socioeconomic perspective, as it also meets the Canadian society's expectation.

The dairy farmers' engagement towards their local community is also significant, the vast majority being involved in their communities in many different ways. More could however be done in terms of cohabitation, with more producers adopting practices minimizing odours propagation for instance.

The picture is also contrasted in regards to farm workers. Although dairy farmers provide overall working conditions that go beyond the labour standards – to which they are mostly not legally subjected – there is still room for improvements regarding various issues, such as professional training and communication of working conditions. The same holds true with respect to their suppliers and business partners, given that a majority of dairy producers do not usually consider their suppliers' performance in regards to social responsibility in their procurement decisions.

Figure 5-4 - Socioeconomic performance of the Canadian Dairy Farms

The average performance of the Canadian dairy farmers, as seen before, can hide some variability within the sector. For a given issue of concern, some producers might have a proactive or committed behaviour where others will only comply with the expected social norms, as it is the case with the odours spread reduction practices. This variability suggests that there is always room for improvements, since the average socioeconomic performance can be improved and, when already committed, reinforced as more dairy producers could adopt some more socially responsible practices. Moreover, given that a today committed behaviour could become a minimal expectation in the future, a continuous engagement from all the producers is also advisable in order to improve, but also to preserve, the sector's socioeconomic performance over time.

This variability is shown in Table 5-16. For each indicator, the average score is presented according to the evaluation scale used, as well as the variability of the practices and behaviours documented.

Table 5-16 - The average socioeconomic performance of the Canadian dairy farms

FARM WORKERS		Variability	Average performance
Working hours	Workweek length		
	Work overload		
Social benefits	Scope of protection		
Salary and contribution to fringe benefits	Average hourly wage of workers		
	Annual increments		
	Paid overtime		
	Leaves and bonuses for statutory holidays		
Working conditions transparency	Communication of working conditions		
	Negotiation of working conditions		
Health and safety	Health and safety training		
Professional accomplishment	Performance		
	Professional development		
	Turnover rate		

LOCAL COMMUNITY		Variability	Average performance
Community engagement	Implication within the community		
Natural and built heritage	Preservation of natural and built heritage		
Cohabitation	Communication with the neighbourhood		
	Odours spread reduction		
	Manure spreading technology		
SOCIETY		**Variability**	**Average performance**
Commitment to sustainability issue	Environmental certification		
Agroenvironmental practices	Manure storage structure		
	Manure management		
	Chemicals management		
	Alternative practices to chemical control		
	Soil conservation techniques		
	Water sources protection		
Animal welfare	Training and practices		
VALUE CHAIN ACTORS		**Variability**	**Average performance**
Responsible procurement practices	Effort to promote social responsibility		
Responsible supplier practices	Practices ensuring the product's quality		

Note
: risky behaviour; : compliant behaviour; : proactive behaviour;
: committed behaviour; : non-available evaluation level

Based on the results presented above, it is possible to draw different highlights on the global socioeconomic performance of the Canadian dairy farms (Table 5-17).

Table 5-17 - Detailed analysis of the socioeconomic performance of the Canadian dairy farmers

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Workers[22]	**OVERALL COMMENT**	On the average, the Canadian milk producers offer working conditions that go beyond the labour standards, even when they are not compelled to do so. This is for example the case with the salary and working hour issues, although a significant proportion of farm workers have heavy working schedules and a minority of producers offer them fringe benefits, such as paid overtime. The same holds true for other non-salary related issues: while many producers provide benefits and contribute to their workers' professional accomplishment, there is still room for adopting some more committed and formal practices. It should be noted that the hiring of non-family related workers is a relatively new and growing phenomenon in the Canadian dairy sector but still not yet widespread. Less than one fourth of the responding producers declared hiring such workers. Consequently, the issues and challenges related to the hiring of non-family related workers are relatively new to producers, who are now supported by provincial and national organisations, such as the Canadian agricultural human resources council, to help and supervise them in regards to working conditions issue.
	Working hours	Farming activities are labour intensive and heavy working schedules are often unavoidable. There are furthermore generally no legal requirements as for the maximum hours of work that a farm worker should work on a weekly basis[23]. Even if farm workers might benefit financially from long working hours, too many working hours can have negative consequences on workers' health and safety. In this regards, on the average, most regular farm workers have working hours that do not exceed the 48 hours per week threshold established by the ILO's standard. Furthermore, the work overload periods, if any, are often of limited length. However, more than a third of dairy producers hiring non-family workers do declare that their regular farm workers' working hours exceed these thresholds.

[22] This category refers exclusively to regular and non-family related farm workers (see section 5.3.1).

[23] Except in New-Found-Land-Labrador, where the provision on work schedule applies to agricultural workers. In British-Columbia, the labour standards state that farm workers must not work excessive hours detrimental to their health or safety.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Workers	Benefits	Almost half of the participating producers who hire non-family workers do not provide any benefits to their regular farm workers and one fifth offer them no more than one, including in-kind benefits. Only a third of dairy producers offer more than one benefit. Paid sick days and health insurances are the most commonly provided benefits, while wage and life insurances are the least frequently granted.
	Salary and contribution to fringe benefits	In many provinces, farm workers are not covered by the labour standards' provision on minimum salary[24]. Only Quebec and Nova-Scotia, among the participating provinces, guarantee this minimal standard to farm workers. Nevertheless, the assessment shows that the salary offered to regular workers on dairy farms is set at a much higher rate, which exceeds on the average the provincial median hourly wage rate in the agricultural sector. The picture is more contrasted in regards to the other fringe benefits. For example, more than a third of dairy farmers who hire non-family workers did not offer a salary increment to their farm workers last year. Notwithstanding the reason, such practice impairs the purchasing power of workers. In addition, less than a fourth of producers paid for workers' overtime and only a fraction offered them a premium in these occasions. The situation is more balanced in regards to leaves and bonuses, given that half of producers offer such bonuses to workers when they have to work during statutory holidays. The fact that Quebec's Labour standards' provision on statutory holidays applies to farm workers might explain this more committed behaviour. The overtime provision does not apply to farm workers in any province.
	Working condition transparency	In most jobs, it is expected from employers that they deliver their employees, at the time of hiring, a formal contract describing the working conditions agreed on by the two parties. Such practice is however rarely observed in the agricultural sector – including the milk production sector. The assessment indicates that only a fraction of dairy producers deliver such a contract to their employees. While a majority of producers do negotiate working conditions with their employees, a more formal approach could nevertheless be beneficial to ensure a better understanding of working conditions and contribute to avoid conflicts.

[24] Farm workers are excluded from this provision in Alberta, Saskatchewan, Ontario, New-Brunswick and Prince-Edward-Island.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Workers	Health and Safety	With a few exceptions, farm workers are covered in all provinces by the health and safety legislation[25] and benefit therefore of a compensation scheme in case of injuries, in addition to other prevention tools. More can however be done to prevent such incidents. The assessment indicates however that only half of the dairy producers hold a formal procedure in case of injury or employ farm workers who received a first training. Just a small proportion of them adopted both practices.
	Professional accomplishment	In regards to performance and professional development, the assessment shows that more than a third of dairy farmers offer premiums, end-of-year bonuses or give to their employees access to training activities or conferences in order to enhance their skills, recognize their competences or simply to show gratitude for their work. These contributions are highly related to the worker's professional accomplishment. Even though the turnover rate does not appear to be problematic in the sector, with a majority of producers keeping their workers employed for more than three years, there is still room for promoting professional accomplishment among farm workers.
Local communities	**OVERALL COMMENT**	The Canadian dairy farmers are recognized for their engagement in their communities and this assessment shows it well. While this evaluation gives just one part of the picture, as only the practices were assessed and not the intensity of their implementation (i.e. number of hours, the amount of money donated, etc.), it gives a clear idea of the importance of the dairy farmers' dynamism for their community. The same can however not be said in regards to all the issues documented and there are still many ways by which dairy farmers can improve their commitment towards their local communities.
	Community engagement	The assessment shows that dairy producers are especially committed toward their local communities. The survey indicates in particular that more than half of respondents are actively engaged in local organisations (sometimes in more than one), going from agricultural related associations (fair boards, coops, Holstein Clubs, etc.) to more socially committed ones (4H, Churches, historical societies, sport clubs, etc.). A significant proportion of respondents also accept visits on their farm, have hosted trainees and offer donations (the total amount of which has not been assessed). Only one tenth of dairy producers are not engaged in their community.

[25] It is not for example the case in Alberta where farm and ranch workers are exempted from health and safety legislation by regulation (Barnetson 2009).

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Local communities	Natural and built Heritage	On the other hand, only a small proportion of the dairy farmers are involved in an initiative to preserve the heritage and natural agricultural landscape. This score is not surprising as this issue is relatively new and related programs might not be readily available to farmers in all regions. Many initiatives do exist however and there is hence room for further engagement from the producers in this field in order to protect and promote natural and built heritage.
	Cohabitation (i.e. life quality)	With an average behaviour rated as “compliant”, the assessment shows that the dairy producers are not highly committed in regards to the cohabitation issue, i.e. the efforts they are willing to make to minimize the nuisances (mainly odours) induced by their activities on the local life quality (such as manure spreading). For example, only one fourth of producers inform their neighbours before manure application. The situation is similar in regards to the use of manure spreading technology, as only about one third of dairy producers use odour minimizing technologies. While the actual practices are not necessarily problematic in a regulatory perspective, they might nevertheless be risky in some situations and create conflicts with the neighbourhood.
Society	**OVERALL COMMENT**	Over the years, dairy producers have been increasingly been asked to reduce the environmental impacts of their activities. Today the vast majority of them meet the regulatory standards by continuously adopting more environmentally friendly practices. But it is still possible to go beyond the current standards and adopt cutting-edge practices to anticipate and exceed the evolving and growing public expectations, which now include the animal welfare issue. The same can be said about the use of formal certifications, which could serve to better focus and communicate the producers’ effort in regards to sustainability issue.
	Commitment to sustainability issues	Most Canadian dairy farmers try to develop their enterprise in a sustainable way by adopting more sustainable practices on a continuous basis. But as the assessment shows, only a part of them hold a certification, an accreditation or a set of specifications compelling them to further reduce their environmental impacts. And while the Canadian environmental standards are already very restrictive, it is still possible for dairy farmers to go beyond the legal requirements in order to adopt more sustainable practices.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Society	Agroenvironmental practices	On the average, the Canadian dairy producers perform very well in regards to their agroenvironmental practices, the majority of them having manure storage structures, performing analysis before manure applications, adopting alternative practices to chemical control and protecting water sources found on their farms. This overall good performance is important on a socioeconomic perspective, given that there is a growing concern among the society regarding the environmental impacts of farming activities. This assessment shows also that the dairy producers are globally committed to adopt more environmentally friendly practices. It is important to stress however that the PRPs used to assess the level of social engagement of producers in regards to their agroenvironmental practices follow mainly the environmental standards found in some provinces. Without minimizing the current performance of the sector, this caveat means that it is still possible for dairy producers to pursue their efforts to get even more committed with respect to this issue by adopting the best expected practices developed in their respective region.
	Animal welfare	Since 2009, the dairy farmers can follow the Code of Practice for the Care and Handling of Farm Animals and complete the Checklist for Dairy Animal Welfare on Farms published by the DFC in order to improve animal welfare on their farms. There is also a vast range of trainings and conferences provided on this topic accessible to producers. The assessment shows that more than two-third of the dairy farmers consulted one of these sources of information on animal welfare and that one fourth changed their practices afterward. Given the newness of this issue, this commitment is positive. There is not yet a third-party monitored certification available in Canada in regards to animal welfare, but one could expect based on this score that many dairy producers would be in good position to participate in such a program.
Value chain actors	**OVERALL COMMENT**	In a life cycle perspective, as well as in a corporate social responsibility one, it is important to consider not only the consequences of its own impacts upon the surrounding stakeholders, but also to take into account the ones of the suppliers belonging to the value chains. This is because a business has the responsibility to question its suppliers and, when possible, to influence their practices towards more socially responsible behaviours in the whole system. This perspective is relatively new and still complex to apply in day-to-day activities. But the dairy farmers, individually and collectively, have the opportunity to pursue their engagement in this domain in order to become a leading sector in regards to social responsible procurement and supplier practices.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
Value chain actors	Responsible procurement practices	One third of the dairy producers declared being influenced by social and environmental considerations or criteria when purchasing farm inputs. The most frequently mentioned considerations are the willingness to “buy local”, the use of biodegradable products and the purchasing of organic ones. Even if the proportion of producers following such considerations is relatively low, the performance can be considered as being positive, given the recent nature of this issue. The importance of having socially responsible procurement practices is however critical, both to promote more sustainable behaviour among its suppliers and to manage the risks of doing business with socially irresponsible suppliers. Such considerations should hence be more widespread in the sector and, eventually, be formalized into responsible procurement practices. A growing number of businesses, including retailers, are now adopting such responsible purchasing policies to question their own suppliers. This is an issue in which dairy producers could get more involved, individually and collectively.
	Responsible supplier practices	It is important for the dairy farmers, as an actor of the dairy products’ supply chain, to provide a product of high quality to their clients. In this project, this issue has been assessed by evaluating the level of participation of producers to the Canadian Milk Quality program. There are currently 40% of producers registered to the program, while almost all of them have been trained to implement it.

Socioeconomic performance at the dairy Board level

Figure 5-5 portrays the dairy Boards' level of social engagement towards the stakeholders with which they interact. As for the assessment conducted at the dairy farm level, the figure shows (here with a purple line) an average socioeconomic performance, according to the three-level risk evaluation scale defined earlier (section 5.3.3).

The assessment indicates that the Canadian dairy Boards are, on the average, committed corporate citizens, especially towards their local communities, as most of them support milk donation, school milk programs, scholarship and sponsorship to local organizations, even if these actions are not always part of a formal policy or agreement. For example in 2011, through levies on milk marketing, Dairy Boards granted directly over 3.4 M$ to their local communities in addition to milk donations and their involvement in other initiatives. They are also committed towards the Society by funding research in areas such as public health, nutrition and environment. Over 4.5 M$ were directly invested in 2011 in such activities, without including the dairy Boards' participation to other research clusters.

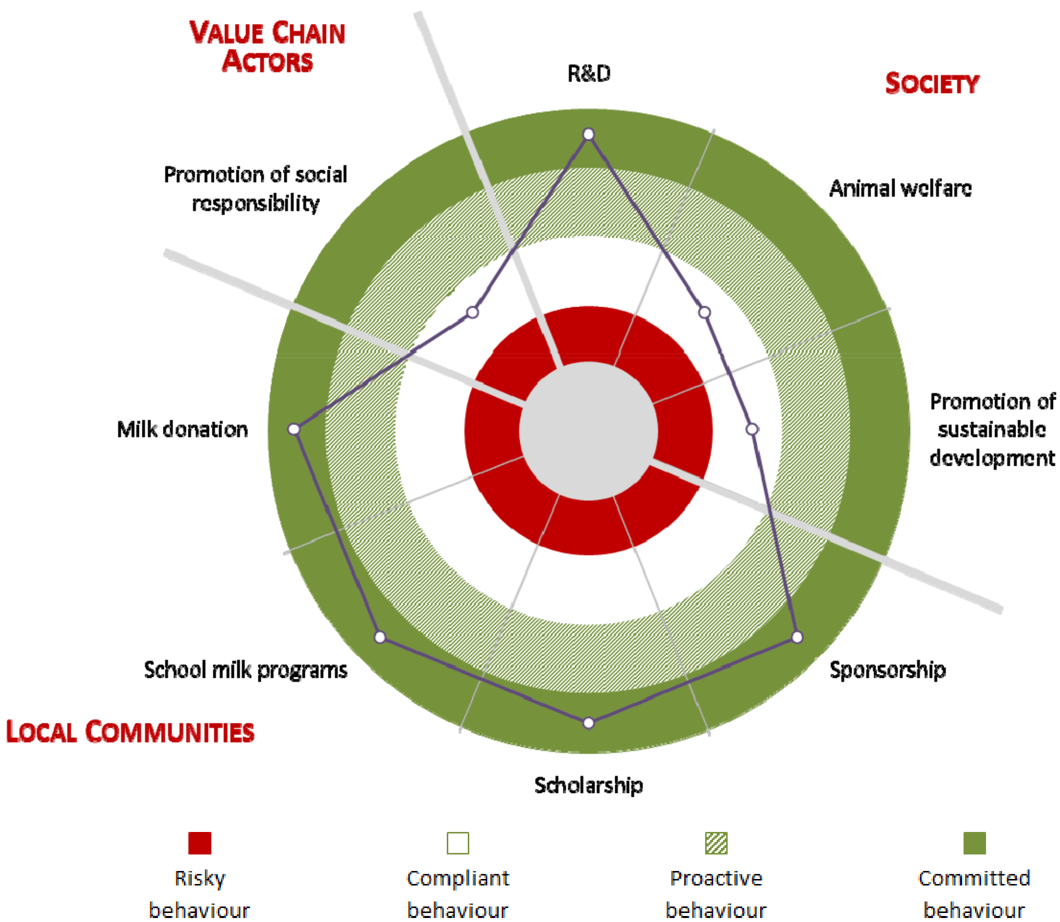


Figure 5-5 - Socioeconomic performance of the Canadian Dairy Boards

The assessment also pointed out issues for which dairy Boards could be more committed. This is the case for the promotion of sustainable development and social responsibility, since only a minority of Boards holds formal commitments or has partnerships in those fields and grants resources to realize them. The same can be said in regards to the animal welfare issue. While the Dairy Farmers of Canada have, in collaboration with the National Farm Animal Care Council, set up a code of Practice to support and supervise producers, it has not been yet audited. And if provincial Boards provide trainings and support material on the subject, none of them have put in place a certification, a set of specifications or an audit system to complement this national initiative.

It is worth stressing however that if the dairy Boards to do not necessarily hold formal engagement in regards to these issues, most of them are nonetheless committed to improve their level of social engagement over time. The realisation of this project demonstrates for example the interest of the Dairy Farmers of Canada in assessing the sector's socioeconomic performance to raise awareness about the social issues it faces and the best practices to adopt, at the farm and Board levels, with the ultimate goal of becoming more socially responsible citizens. By itself, such an assessment constitutes a strong commitment of the sector and a first step towards some more formal engagements.

Table 5-18 - The average socioeconomic performance of the dairy Boards

LOCAL COMMUNITIES		Variability	Average performance
Community engagement	Milk donation *		
	School milk program *		
	Scholarship *		
	Sponsorship		
SOCIETY		**Variability**	**Average performance**
Commitment to sustainability issues	Promotion of sustainable development		
Technology development	R&D		
Animal welfare	Animal welfare		
VALUE CHAIN ACTORS		**Variability**	**Average performance**
Promotion of social responsibility	Promotion of social responsibility		

* As these actions come under the provincial scope, the DFC's practices have not been taken into consideration. Nine provincial dairy Boards participated to the questionnaire, in addition to the DFC.

The following highlights come out from the assessment conducted at the dairy Boards level (Table 5-19).

Table 5-19 - Detailed analysis of the socioeconomic performance of the dairy Boards

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
OVERALL COMMENT		The Canadian dairy Boards are globally active corporate citizens engaged towards their stakeholders through diverse initiatives and investments. There is however room for improvement, as a large part of these involvements could be more formal through programs or strategies that could be in turn related to performance objectives.
LOCAL COMMUNITIES	Community engagement	Overall, the Canadian dairy Boards can be considered as active and committed citizens in their communities as most of them sponsor local or regional non-for-profit organisations, grant scholarships and donate – or support donation of – milk to sensitive local groups or organisations. The sponsorship covers a large range of organisations and activities, going from rural groups and events (ex.: agricultural fairs and associations), to cultural (ex.: festivals, museums, classroom activities, etc.) and sport activities (ex.: 4-H clubs, YMCA, athletic associations, etc.). Many also contribute to foundations by supporting health research (ex.: osteoporosis Canada) as well as local food banks and other projects on an *ad hoc* basis. In 2011, over 3M$ were hence directly invested into such sponsorship activities all over the country, in addition to other forms of contribution. It is also noteworthy that all the participating provincial dairy Boards grant scholarships to students, mainly in milk production related programs (food science, veterinary medicine, agronomy, rural economy, etc.). Over 100,000$ were granted in direct sponsorship in 2011. The Boards' engagement towards their communities also takes the form of milk donations through school milk programs or local food banks. The volume of milk donated or the kind of support provided vary from one dairy Board to another, but this practice is nonetheless widespread across the country. Whilst the assessment focused on the practices rather than on the intensity or the consequences of their implementation, it provides a clear view of the Canadian dairy Boards' engagement in their communities. And even if part of these contributions is related to promotion and marketing activities, they still contribute to support local organisations and activities.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
SOCIETY	Commitment to sustainability issues	Over the years sustainability has become a central preoccupation in the Canadian agricultural sector and most of its protagonists are now aware and mobilised behind this issue. This is particularly true in the Canadian milk production sector. It is still possible however, to go beyond awareness and progress toward sustainability through a formal and public committed engagement, policy or strategy. The assessment indicates that four dairy Boards do hold such a commitment aiming at enhancing the sector's level of sustainability and grant resources to reach this objective. Given that this issue is relatively new and that the Boards are in most cases already involved in activities aiming at promoting a more sustainable milk production, this score is positive. More formal engagements could nevertheless be desirable as they allow reporting as well as assessing the organisations' performance in regards to their commitments.
	Technology development	The Canadian dairy Boards are involved in many joint research projects generally lead in collaboration with research centers and governmental agencies. The fields of research are diverse and vary according to the Board's size and priorities. New technologies development is among the most supported research area, but numerous projects also focus on consumer health, animal nutrition, milk quality and environmental research. For example, Alberta Milk is currently involved in two health related projects (*Development of anti-atherogenic milk to improve human health and Communicating the ruminant (natural) trans-fatty acids (rTFA) health evidence*) while also focusing on subjects such as longevity of dairy cows, dairy cattle nutrition, nutrient management, calves and young stock, etc. Most Boards have a similarly vast research agenda. It is worth noting that many projects are based on long-term partnerships. For example, the Fédération des producteurs de lait du Québec (FPLQ) works with Novalait Inc., which is a private research group whose stocks are shared between the Board and the Quebec's dairy processors association. Other Boards are also supporting research with various national and provincial organisations. It is difficult to establish precisely the annual investment of Boards in R&D, because some funding is made on an ad hoc basis while other projects extend over several years. There are also joint research projects. But according to the available data, it is possible to estimate at 4.5 M$ the amount directly invested in R&D by the Canadian dairy Boards in 2011.

STAKEHOLDER CATEGORIES	ISSUES OF CONCERN	HIGHLIGHTS
SOCIETY	Animal welfare	Developed with the participation of the DFC and other industry's stakeholders, the Code of Practice for the Care and Handling of Farm Animals of the National Farm Animal Care Council has been published to contribute to the national understanding of animal care requirements and to recommend best practices to dairy farmers. The DFC, in collaboration with the provincial Boards, have been active in promoting the Code among their members, notably by providing them with a "checklist" to assess their practices. In addition, Boards have been involved in many initiatives, going from training, promotion, to research, in order to develop knowledge in this field and tool up dairy farmers. Recent evidences suggest however that there is still room for improvements in order to improve animal welfare at the farm level (Vasseur et al. 2010). Indeed, while the Code is based on transparent and rigorous scientific knowledge and includes best expected practices as well as requirements, i.e. minimally expected practices, it is still applied on a voluntary basis. Furthermore, its application is not yet subjected to a second or third-party audit system that would demonstrate its full implementation – as it is the case in the United States and Europe (De Passillé 2010). Further developments could hence be made in this field, both at national and provincial levels. It could be done by going beyond voluntary standards to go towards an audited certification that would encourage the adoption of best practices and facilitate the communication of these practices to consumers.
VALUE CHAIN ACTORS	Promotion of social responsibility	The Canadian dairy Boards maintain and develop partnerships with many organisations involved in a large range of areas, mainly in well-established activities such as research and development and local community's development, but also in some recent ones such as sustainable development and social responsibility. Although these issues are relatively new for the milk production sector, the assessment shows that four Boards are already involved in such partnerships, going from environmental organisations such as Duck Unlimited to more socially engaged NGOs like Équiterre. Such partnerships act as formal commitments and allow promoting more socially responsible behaviours by focusing and fostering efforts and resources on specific tasks or objectives. Canadian dairy Boards should therefore continue creating and participating in such activities.

Socioeconomic performance at the dairy sector level

The specific analysis conducted over the Canadian dairy sector focused primarily on the behaviours of the sector's main protagonists, e.g. the dairy farmers and their boards. There are however some issues of concern relevant to assess from a socioeconomic standpoint, but that are not directly or exclusively related to actual practices of these actors or cannot be readily assessed at the farm or board level. These issues of concern, listed in Table 5-4 (section 5.3.3), were hence briefly discussed and assessed at the sectorial level.

Employment standards

Current situation:

Every jurisdiction in Canada has enacted employment standards legislation, guaranteeing employees minimum rights. While parties cannot contract out these standards, they may agree to greater entitlements if they want to (Commission for Labour Cooperation 2010, p. 34). These legislations generally address the same working conditions related issues, such as minimum wage, overtime, general holidays and vacation. Specific provisions can however differ significantly from one province to another. And while most worker categories are covered by those standards, some others such as agricultural workers are partially or totally excluded from them.

Farm workers are for instance fully excluded from Alberta and Saskatchewan employment standards, while the application is highly restricted in New Brunswick and Prince Edouard Island. In provinces where these standards apply to farm workers, there are always major limitations related to central provisions, such as minimum wage or overtime. In no case farm workers are covered in regards to workweek length.

Table 5-20 - Employment standards in Canadian jurisdictions – application to agricultural workers

Issues	BC	ALB	SAS	MAN	ONT	QC	NB	PEI	NS	NFL
Labour standards	**R**	**No**[2]	**No**[3]	**R**	**R**	**R**	**R**[4]	**R**[5]	**R**	**R**
Minimum wage	Yes	No	No	Yes	No	Yes	No	No	Yes	Yes
Work schedule	No[1]	No	No	No	No	No	No	No	No	Yes
Overtime	No	No	No	No	No	No	No	No	No	No
Leaves bonuses	No	No	No	Yes	No	Yes	No	No	No	Yes

R: Restricted

1 The B.C. Employment Standards Regulation states that a farm worker must not work excessive hours detrimental to the employee's health or safety.

2 Alberta Employment Standards Code does not apply to employees employed on a farm or ranch (art. 2(4)).

3 Only employees engaged in the operation of 1) egg hatcheries, greenhouses and nurseries, 2) bush clearing operations and 3) commercial hog operations are covered by the Labour Standards Act (art.4(3)).

4 " This Act does not apply to employment contracts for the provision of agricultural services between employees and employers who employ three or fewer employees over a substantial period of the year, exclusive of employees who are in a close family relationship with the employer" (Employment Standards Act, art.5).

5 Farm labourers are excluded from the PEI Employment Standards Act, except for the provision related to the payment and protection of pay (art. 2(3)).

Sources: Commission for Labour Cooperation (2010) and provincial employment standards regulations.

***Overall comment*:**

Employment standards protect employees from potential abuses and guarantee them minimally socially accepted working conditions. The assessment shows that in all provinces, the application of these standards in regards to farm workers are subjected to restrictions, going from total to partial exclusion. While such exclusions do not prevent agricultural employers to provide equal or even higher benefits to their employees, it does not prevent them to offer lower working conditions as well. This regulatory context hence creates a socially risky situation for farm workers, against which the Canadian dairy sector should commit itself.

Freedom of association and collective bargaining

***Current situation*:**

In Canada, freedom of association is a right entrenched in the Canadian Charter of Rights and Freedoms (section 2(d)). However, "while the Charter guarantees the freedom of association, labour relation statutes in each Canadian jurisdiction are the legislative application of the constitutional obligation. These statutes guarantee that an employee has the right to join an union and to participate in lawful union activities", although "it has been held by the Supreme Court of Canada that the freedom of association does not equate with the right to join a union, but [rather] the freedom to work for the establishment of an association, to belong to an association, to maintain it, and to participate in its lawful activity without penalty or reprisal" (Commission for Labour Cooperation 2010, p. 24, 26).

In most provinces, farm workers are covered by the labour relation statutes. It is the case in British Columbia, Saskatchewan, Manitoba, Prince Edward Island, Nova Scotia and Newfoundland, where labour relation codes or acts state that every employee – without exception – is free to be a member of a trade union and to participate in its activities (Commission for Labour Cooperation 2010). But there are also some major exceptions. For example, the Albertan Labour relation code "excludes employers and employees in farm or ranch labour" from its application (section 2(e)), hence preventing them to join a union. In Quebec and New Brunswick, farm workers are not categorically excluded from the labour relation statutes. However, a restriction applies as only bargaining units of agricultural workers with a minimum size are allowed.

Such exception also exists in Ontario, where the Labour Relations Acts does not apply to "employee within the meaning of the Agricultural Employees Protection Act, 2002" (section 3 (b.1)). The purpose of the AEPA is to protect "the rights of agricultural employees to associate". It gives farm workers: 1) the right to form or join an employees' association, 2) the right to participate in the lawful activities of an employees' association, 3) the right to assemble, 4) the right to make representations to their employers and 5) the right to protection against interference, coercion and discrimination in the exercise of their rights. It does not, however, require employers to bargain with employee associations. Given this restriction, the constitutionality of the legislation has been challenged in Court. On April 29 2011, the Supreme Court of Canada finally ruled out that the Charter does not protect any particular type of collective bargaining and that the special labour regime created by the AEPA does not discriminate against agricultural workers.

Table 5-21 - Labour relation statutes in Canadian jurisdictions – application to agricultural workers

Provinces	Restriction	Details
BC	No	The Labour relations code states that "Every employee is free to be a member of a trade union and to participate in its lawful activities" (4(1)).
ALB	Yes	The Labour relation code "applies to most unionized employees in the province, but excludes employers and employees in farm or ranch labour, domestic work and in industries falling under federal jurisdiction, such as airlines, railways, interprovincial trucking and shipping, and telecommunications" (Alberta Labour Relations Board, 2012).
SAS	No	The labour relation law does not prohibit farm workers from joining a union[26].
MAN	No	The Labour relations Act states that "Every employee has the right (a) to be a member of a union; (b) to participate in the activities of a union; and (c) to participate in the organization of a union" (5(1)).
ONT	Yes	The Labour Relations Acts does not apply to "employee within the meaning of the Agricultural Employees Protection Act, 2002". The latter allows agricultural employees to join an association, but not to bargain collectively.
QC	Yes	The Code du Travail du Québec allows farm workers to unionize but at the following condition: "Les personnes employées à l'exploitation d'une ferme ne sont pas réputées être des salariés aux fins de la présente section, à moins qu'elles n'y soient ordinairement et continuellement employées au nombre minimal de trois" (art.21).
NB	Yes	The Industrial Relations Act states that "a unit, where an employee is employed in agriculture, shall comprise five or more employees". (art.1(5)a)
PEI	No	The Labour Act states that "Every employee has the right to be a member of a trade union and to participate in the lawful activities thereof." (art.9(1)).
NS	No	Trade Union Act states that "Every employee has the right to be a member of a trade union and to participate in its activities" (art.13(1)).
NFL	No	The Labour Relation Act states that: "An employee has the right to be a member of a trade union and to participate in its activities." (art.5(1)).

Source: Commission for Labour Cooperation (2010) and provincial labour relation laws.

For some observers, this decision, while confirming that the protection afforded to "freedom of association" in the Canadian Charter of Rights and Freedoms extends to collective bargaining, also restricts the scope of that protection (Broad 2011). Accordingly, this decision might have significant consequences in regards to the evolution of the labour relation statutes for agricultural workers in the upcoming years.

In Canada, the average rate of unionization in the agricultural sector is low (4%), NewFoundland (25%) and Quebec (8%) are the provinces with the highest rates of unionization whereas Alberta (1%), British-Columbia (2%) and Ontario (2%) are the provinces with the lowest rates.

[26] Personal communication.

Table 5-22 - Rate of unionization in the agricultural sector, 2011

	CAN	BC	ALB	SAS	MAN	ONT	QC	NB	PEI	NS	NFL
Union coverage	4%	2%	1%	5%	3%	2%	8%	5%	5%	3%	25%

Source: Statistics Canada. Table 282-0078.

***Overall comment*:**

With the increased presence of non-related family labour on farms, the issues of association and collective bargaining become a new challenge for the Canadian agricultural sector. While this phenomenon concerns primarily, at the farm level, labour intensive productions such as horticulture, it is an issue facing the whole agricultural sector from a legislative standpoint. These rights, embedded in International Conventions and Agreements such as the UN Declaration of Human Rights (Art. 20) and the ILO Convention (no98) on the Right to Organise and Collective Bargaining are indeed expected to be granted to all workers, including farm workers.

In this regards, the assessment shows that if freedom of association is right guaranteed to all workers across Canada – including agricultural workers – there are still major exclusions in some provinces regarding the right of farm workers to bargain collectively. Such exclusion applies in Alberta and more recently in Ontario. In Quebec and New Brunswick, this right is restricted to bargaining units with a minimum size.

In order to fully provide these rights to farm workers, Canadian agricultural sectors, including the dairy sector, could get committed to lift these exclusions were they apply.

Young workers

***Current situation*:**

Canada is among the 27 countries that have not yet ratified the International Labour Organization (ILO) Convention 138 on Minimum Age. Despite that, federal legislation, including employment standards, health and security working laws, education laws, etc., while not complying with Convention 138, do restrain the hiring of children and young people. The same is true at the provincial level, where employment standards (which cover the vast majority of workers), protect young people from most abuses, while not fully complying with Convention 138. Violations to the Convention are however minor and refer mostly to the minimal age standard (16 years old in the Convention) and working hour periods (Canadian Labour Congress).

Given that agricultural workers are partially or totally excluded from provincial employment standards, there are however limits to the protection these laws provide to young workers working in the agricultural sector. Provincial education laws do impose restrictions on young workers employment, but these limitations concern mainly working schedule (Commission for Labour Cooperation 2010, p. 34). This regulatory context thus puts young farm workers in a vulnerable situation.

***Overall comment*:**

Most Canadian dairy farms are family businesses and the presence of young – and generally family related – workers is widespread and well-accepted. If the federal and provincial legislations do protect this category of workers from most abuses, this protection does not fully apply in the agricultural sector, hence putting young farm workers in a vulnerable situation.

The working conditions of young farm workers are indeed a sensitive issue in the agricultural sector and the focus groups conducted among dairy farmers and representatives of sectorial organisations did highlight that discomfort in the specific case of dairy farming (Appendix I)[27]. For some, the presence of young – and generally family related – workers on dairy farms gives them the opportunity to gain experience and get more responsible, while making money. For others however, there are some abuses in particular in regards to working schedules and salary, as young farm workers may have to milk cows every morning before going to school for a small or no pay.

These contrasted views support the fact that young farm workers form a sensitive category of workers that can both benefit or be impacted by their job. The situation points out the importance of promoting good practices through trainings and publications, both at the producer and young worker levels.

Integration and discrimination

***Current situation*:**

In Canada, the number of foreign agricultural workers has increased rapidly over the last decade. Most of them are hired through the Seasonal Agricultural Worker Program (SAWP), as seasonal agricultural workers during peak production periods in the horticultural industry. SAWP allows farmers to hire agricultural workers in all provinces but Newfoundland. In 2011, nearly 24 000 people were hired under that program. Most of them (85%) are employed in Ontario, were the horticultural industry is mostly concentrated. Since January 1st, 2011, employers can also hire agricultural temporary foreign workers through the new Agricultural Stream of the National Occupational Classification C and D Pilot Project. Under that program, employers can hire temporary foreign workers for a maximum of 24 months for occupations requiring lower levels of formal training (NOC C and D) when there is a demonstrable shortage of Canadian citizens and permanent residents.

In Canada, both levels of government (Federal and Provincial) are involved in the process of foreign worker hiring. At the federal level, Human Resources and Skills Development Canada (HRSDC) makes sure that the Canadian labour market will likely benefit from the hiring, that offered salary conditions correspond to normal working conditions on the Canadian market and that the employer made important efforts to recruit workers on the Canadian market. If all the conditions are being met, HRSDC supports the employer request by giving a positive Labour Market Opinion. Thereafter, Citizenship and Immigration Canada (CIC) delivers the working permit. In September 2009, this procedure was challenged by the Auditor General of Canada. According to her, the procedure did not allow to verify if the request was authentic and it did not confirm the real existence of the employer

[27] In September 2011, the U.S. Department of Labour suggested changes to its regulations on child labor in agriculture in order to make youth labor regulations in on-farm and non-farm employment more similar to improve safety conditions for youth employed in agriculture. This proposal sparked many reactions among the farming community, some welcoming this initiative and other criticizing it, hence showing the sensitivity of this issue in the U.S. as well as in Canada.

and its capacity to pay the fixed salary (Office of the Auditor General of Canada, 2009). Consequently, some working permits could be delivered to non-existing employers what is very risky for foreign workers. Although recommendations were made, it appears that this situation is still problematic (Centre international de la solidarité ouvrière, 2010).

Overall, many issues surround agricultural foreign workers regarding employment standards, health and security, child labour, hiring agencies, unawareness of rights, reliance on employers, etc. Documented abuses under the SWAP include for example wages lower than Canadian counterparts, up to sixteen-hour workdays during peak season without receiving overtime or vacation pay, inadequate training, equipment and use of chemicals, and withdrawal passports, health cards and work permits (Shantz 2010, p. 78; UFCW 2010, North-South Institute 2006).

These abuses, while not necessarily widespread, are related to the fact that, while federal and provincial laws protecting workers generally apply regardless of the worker's immigration status, this protection is in some cases restricted in the agricultural sector (see above). Given the language barrier and the risk of repatriation specific to this group of workers, they are less able to denunciate non-complying working conditions. This situation hence increases the risk of inequity and injuries such excessive hours, unfair salaries, unpaid extra hours, limited rest periods (Commission for Labour Cooperation 2010, p. 35). Socioeconomic integration is also challenging for these workers, as they face significant impediments to labour market, "including work permits that are tied to employers, weak enforcement of contracts, language barriers and social isolation, especially for the large share of these workers who live in employer-provided housing" (Hennebry 2012, p. 1). Many organisations – among which nongovernmental organizations, community groups and unions – are however investing efforts to protect and promote the rights of this particular and vulnerable group of farm workers.

***Overall comment*:**

Compared to the horticultural sector, the Canadian dairy sector does not employ a significant number of temporary foreign workers. They nevertheless constitute a growing contingent of employees on dairy farms, as the need for labour force does not match with the local supply of farm workers. For example, a recent study conducted in Quebec by AGECO for AgriCarrières indicates that in 2009, 17 out of 233 surveyed dairy farms (7.3%) employed foreign farm workers on a full time basis (30 hours per week, at least 10 months per year). It was expected this proportion to rise to 9% in 2010 (AGECO 2010).

This situation highlights the importance for the Canadian dairy sector to become increasingly aware of the particular issues coming with the hiring of such workers to assure them fair working conditions. Regardless the improvements that could be brought to the regulatory framework establishing the minimal working condition standards, dairy farmers as well as their provincial associations have the opportunity to adopt and promote best practices to prevent all potential forms of abuses toward them.

Contribution to economic development

***Current situation*:**

The economic contribution of the Canadian dairy sector is well-known and well-documented. A recent study published by ÉcoRessources Consultants in 2011 provides in this regards a good overview of those contributions in terms of job creations, GDP and tax revenue. Their assessment was conducted using the Dynatec 2009 intersectoral model in order to measure the direct, indirect and induced economic spin-offs of the Canadian dairy sector activities (EcoRessources Consultants 2011). The main economic contributions documented in this study are here reviewed, with a particular attention given to the direct and indirect impacts measured at the farm level[28,29].

JOB CREATIONS

In Canada, dairy production generates more than 50 000 direct jobs and nearly 45 000 indirect employments. Quebec is the province where dairy production creates the most direct and indirect jobs, followed by Ontario and the Prairies. Quebec and Ontario are also the provinces accounting for the highest percentage of milk production, 37% and 33% respectively. Quebec is the only province that counts a higher rate of direct employment (46%) than a rate of production (37%).

Table 5-23 - Direct, indirect and induced employment[1,2] in the dairy production, Canada, M$, 2009

Regions	Direct	Indirect	Induced	Total
British-Columbia	2 727	3 187	2 282	8 196
Prairies	5 772	9 386	4 254	19 412
Ontario	15 901	13 399	12 858	42 158
Quebec	23 144	15 523	11 590	50 257
Atlantic Provinces	3 210	2 368	1 762	7 339
Canada	50 753	43 863	32 746	127 363

1 includes full and part time employment.

2 Full time equivalent ratio (2000 hours/year).

Sources: EcoRessources, 2011.

GROSS DOMESTIC INCOME (GDP)

The Canadian dairy sector's economic activities directly generated over 1.5 billion of dollars in GPD in 2009 and over 4.5 billions of dollars when considering the indirect contribution. Two thirds of this added value was created in Quebec and Ontario, where 70% of milk production is located.

28 The study also accounted for the economic contribution of the Canadian dairy processing sector, but these activities are located outside the scope of this LCA (section 5.2).

29 The report of EcoRessources also measured the induced effects, which correspond to the increased economic activity from an increase in revenues such as salaries and wages. In other words, it is the effects of the «redepense" of an income, as for example the impact of the salary paid to a farm employee who bought a car using his salary. Even if it could be evaluated using iteration in the input-output model, such exercise implies a certain degree of subjectivity since the number of iteration is arbitrary, and so is the choice of the simulation of the redepense. For this reason, we chose not discussing the impacts of the redepense in this analysis.

Table 5-24 - Direct, indirect and induced GDP in the dairy production, Canada, M$, 2009

Regions	Direct	Indirect	Induced	Total
British-Columbia	138	210	190	537
Prairies	177	701	388	1 266
Ontario	553	970	1 061	2 584
Quebec	564	1 054	911	2 530
Atlantic Provinces	87	131	124	342
Canada	1 519	3 066	2 673	7 257

Sources: EcoRessources, 2011.

TAX REVENUES

Milk production also generates a significant economic impact in tax revenues. In 2009, milk production generated nearly $225M direct tax revenues and almost $600M in direct and indirect tax revenue. More than half of those tax revenues came from Quebec ($155M) whereas a third came for Ontario ($75M). Quebec is the province that produces the higher level of tax revenues per produced hectoliter ($4.04/hl), followed by Ontario, Atlantic Provinces, British-Columbia and the Prairies.

Table 5-25 - Direct tax revenues[1], milk production, 2009, $M

Regions	Direct	Indirect	Induced	Total
British-Columbia	14	28	48	90
Prairies	9	40	97	146
Ontario	75	144	304	523
Quebec	115	142	314	571
Atlantic Provinces	11	16	38	65
Canada	224	370	802	1 396

1 Tax revenues include personal Federal and Provincial income taxes, business federal and provincial income taxes, municipal realty taxes and direct and indirect federal and provincial taxes.

Source : EcoRessources, 2011.

***Overall comment*:**

In addition of being on average socially responsible corporate citizen, dairy farmers also significantly contribute to the Canadian economy. These contributions are diversified and allocated all over the country, according to the size of the sector in each region. As they are constant over time, they also bring a significant flow of investment and revenue on which every province in Canada, and many rural regions, can rely. A contribution partly due to the supply management system under which the Canadian dairy sector operates since 1971 (see below).

Fair competition

***Current situation*:**

The Canadian dairy sector does not operate in a competitive market. Since 1971, the sector rather evolves under a supply management system, just as the Canadian egg and poultry sectors have, following the adoption of the Farm Products Agencies Act in 1972. This kind of trade regulation system is designed to solve a dual issue that is characteristic of the agricultural market that is, ensuring an adequate level of income for the production side while maintaining a balance on the market side. It is with that perspective that the initial objectives of supply management were formulated (Hiscoks 1972, Proulx and Saint-Louis 1978, pp. 3-4):

- Adjust agricultural production in order to secure a market price that can maintain or increase the income of producers of a particular commodity;
- With this pricing level, ensure adequate compensation for all resources committed to the production process, including the resources, capital and labour of agricultural producers;
- Stabilize over time the income generated by the sale of TRQ agricultural products.

Thus, the supply management system implemented in the Canadian dairy sector provides for stability and predictability of paying prices to producers and, consequently, of the income of dairy producers. Further, since producer compensation is essentially drawn from the market, budget costs for support provided to this key sector of the Canadian agricultural economy are minimal.

Although the supply management system was originally implemented to correct problems arising from price instability and cyclical overproduction found on the production side, it has also impacted the other links of the dairy chain. Price and production stability and predictability greatly simplify the management of inputs for processors. The resulting business environment is also more stable and less risky.

As for Canadian consumers, they can depend on a stable supply of quality dairy products. In addition, analysis of retail price trends over the long term shows that Canadian consumers have also benefited from the sector's stability without having to bear any kind of penalty in terms of pricing, when comparing price trends to those from other major dairy economies (Gouin 2005).

The stability afforded by supply management is also accompanied by some side effects. Indeed, the Canadian dairy sector does not operate in an open and competitive market. By definition, supply management is intended to regulate the supply that gets to the market and as a matter of fact, it limits access to the sector, both in terms of national milk production and dairy products imports. Therefore, quotas limit the introduction of new producers, regardless of what individual production quota management mode is selected. In Canada, this limitation has been driven by the value that production quotas have gained on the market over time. Due to the very attractive income stability found in the production sector, the value of quotas tends to be particularly high.

As for dairy products imports, they must be limited in order to maintain the stability of prices and of the income generated through the supply management system that is in place. This kind of limitation can be perceived as a restriction imposed on Canada's ability to participate in the free trade of agricultural products. However, until the fairly recent (about five years) increase in the price of dairy products on the international market, the supply management system could be viewed in a different perspective. Indeed, the system as implemented in the Canadian dairy sector contributes very little to the supply of dairy products on the international market. The sector therefore plays no role in the lack of balance observed in that market, which used to be caused by export subsidies implemented by other dairy producing economies (most notably the European Union and the United States).

At another level, the Canadian dairy supply management system allows producers to actively participate in decisions that shape the evolution of the regulation system that governs their sector of activity. This situation has ensured that collective values are taken into consideration in the management of the system. Most notably, milk production is allocated over the entire Canadian territory and, within each of the provinces, over a large portion of the territory. The stability provided by the supply management system allows producers to make collective choices that foster this kind of production allocation, such as the equalization of transportation costs. Without this kind of measure, it would be very difficult to maintain production in areas located away from major consumption centers.

Still on the subject of collective decision-making, quality at the primary production level is ensured by control systems that are closely overseen by producer associations in each of the provinces. Canadian dairy products benefit from national ad campaigns that are collectively financed by producers. As a group, producers also invest, in partnership with processors, in research conducted in milk production and processing.

In the end, the effect of managing this type of regulation system is that Canadian dairy farms never reach the giant proportions that can be seen in some competing regions, such as the South-West United States. However, this structural reality also places the entire Canadian dairy chain at risk to any opening of the market that could lead to the introduction of unfair competition within the Canadian dairy industry.

***Overall comment*:**

The Canadian dairy sector does not operate under a competitive market and the supply management system under which it evolves is subjected to several critics from its detractors (Hall Findlay 2012; Milke 2011; MEI 2005). Based on a review of recent cases of market liberalisation in the dairy sector, Doyon (2011) points out however that the very nature of the dairy sector requires some kind of market regulation, or at least of coordination in a deregulated context, without which it is not possible to get a stable and efficient market in the sector. In fact, while the system does come with some trade-offs, it does also benefit the Canadian dairy industry and consumers by contributing to the economic stability and development of the sector.

5.5.2. The Potential Hotspots Analysis results

Although this S-LCA primarily aimed at assessing the socioeconomic performance of Canadian milk at the farm level, the study also looked at social risk potentially present in the suppliers upstream of the dairy sector, such as manufacturers of machinery, fertilizers, pesticides or pharmaceuticals. Using the PHA methodology developed in this project (section 5.4), this section draws a preliminary overview of the potential social hotspots that can be found along the main supply chains of the Canadian dairy sector.

The PHA has been conducted over nine supply chains in order to assess, by using generic data, the possibility of encountering risky behaviours among the businesses involved at each stage. The detailed description and evaluation of these risks can be found in Appendix J. This section presents the overall results and discusses their implications for the Canadian dairy sector.

Table 5-26 presents the **aggregated results** as well as the main potential hotspots related to the Canadian dairy sector's supply chains. The results have been aggregated for simplification, by measuring the average risk related to each stakeholder category, given the score attributed to each associated issue of concern. No weighting method has been used between the issues of concern or the regions, when it applied.

Globally, this preliminary overview indicates that most supply chains show low social risk. The main suppliers being located in Canada or the United States, the prevalence of social hotspots is generally lower than in countries such as China. Yet, there are some socially troubling practices occurring upstream in the sector's supply chains, beyond the first-tier suppliers (which were not covered in this study). Among the most troubling practices are found corruption, unsafe working conditions, non-respect of indigenous rights and unfair competition.

This for example the case in the fertilizer and oil extraction industries, where it was possible to document disturbing practices of collusion as well as bank rolling techniques from subsidiaries companies of some major players. Potential hotspots were also identified in the Canadian grain and oilseed sector with regards to working conditions, as workers are generally not protected by labour standards. The analysis also brought up public health issues, as well as conflicts of use of natural resources related to many industries, among which the pesticides and pharmaceutical sectors. Some links are also characterized by a lack of competition.

Unfortunately, the use of generic data does not allow having a precise and detailed analysis of the actual hotspots occurring in the supply chains. Manufacture information is only available at a national level for instance and is hence characterised by a high level of uncertainty regarding the actual behaviours of the businesses operating there. Furthermore, many of the identified hotspots are related to companies, sectors or regions located far upstream and on which the Canadian dairy sector has little power to influence.

The objective of this PHA was however to provide a preliminary overview of the social issues found among a product's supply chains in order to bring awareness over the socioeconomic risks related to current procurement practices and to point out issues requiring deeper analysis. In a social responsibility perspective, it is important for the Canadian dairy farmers as well as for their organizations to consider the risks but also the potential socioeconomic consequences related to their sourcing practices. By getting involved and by considering environmentally and socially responsible criteria in their procurement practices, the Canadian dairy sector could improve the overall socioeconomic performance of milk production in a life cycle perspective. This assessment can be seen as a starting point in this direction.

Table 5-26 - Aggregated results and main potential hotspots related to the Canadian dairy sector's supply chains [1 2]

SUPLLY CHAINS	AGGREGATED RESULTS				MAIN POTENTIAL HOTSPOTS
	W	LC	S	VCA	
Retail and wholesale	☐	☐	☐	▨	There are no major hotspots identified at this stage of the supply chain, apart from the relatively high rate of non-fatal occupational injuries occurring in this sector and the rapid concentration taking place in the farm retail sector, which could lead to a decreased level of competition.
Fertilizers manufacturing					The PHA indicates that there are some preoccupying situations occurring in the fertilizers sector. There are for instance some hotspots related to the working conditions and in particular with the occupational health and safety and working hours issues, especially in the Canadian and U.S. mineral extraction sector. Also related to the mineral extraction activities, it was possible to document criticisms addressed to the mining industry in Canada and the United States in regards to the safe and healthy living conditions issue. More preoccupying are however the documented behaviours regarding the implication of some major fertilizer manufacturers in armed conflicts and corruption practices in North America and abroad. While these documented behaviours are localised and isolated, they suggest that they might be more widespread in this industry.
Extraction	☐	☐	▨	☐	
Gas distribution	☐	☐	☐	☐	
Manufacturing	☐	☐	▨	☐	
Pesticides	☐	▨	■	☐	There are some disturbing hotpots identified in the pesticides system. Among them, the documented contamination cases in the U.S. and abroad from major pesticides manufacturers, which impacted the health and safety of a vast number of individuals. Similarly, there are preoccupying incriminations hanging over some major companies for their involvement in armed conflicts, in addition of proven practices of corruption, falsified entries and bribing. Here again these documented practices are isolated, since they are related to specific actors and circumstances. However, given that the six main companies operating in this sector own 85% of the market worldwide, such behaviours can be more widespread than this assessment infers.
Seeds	☐	▨	☐	▨	The main potential hotspots related to this input are associated to issues related to local communities. The PHA documented for example a contrasted situation regarding the responsibility of the agribusiness sector in general and the seed breeding companies in particular towards the food (in)security issue. Similarly, the assessment suggested a possibility of encountering risky behaviours related to the protection and preservation of the cultural heritage, as well as a risk of encountering behaviours negatively impacting the living conditions of local population. There are also preoccupying indications that the seed breeding sector evolves in a non-competitive market and that its main operating companies adopt unfair behaviours against each other and their clients.

SUPLLY CHAINS	AGGREGATED RESULTS				MAIN POTENTIAL HOTSPOTS
	W	LC	S	VCA	
Animal feed					As discussed in the Specific Analysis, agricultural workers in Canada are, depending of the region where they work, partially or totally excluded from the labour standard’s provisions. Such situation makes them more vulnerable to abuses or potential risky behaviours. The main hotspots documented are consequently related to this stakeholder category. For example, the salary and working hours issues at the farm level are both related to moderate hotspots based on the assessment framework used in this PHA. The same can be said in regard to the occupational health and safety issue, given that the grain production sector, as well as the feed manufacturing one, are characterised by significant and documented risks..
Feed manufacturing	☐	☐	☐	▨	
Additives and supplements	☐	☐	☐	▨	
Grain production	▨	☐	☐	☐	
Medicines and vaccines	☐	▨	▨	☐	There are no major hotspots identified in the Medicines and vaccines supply chain. The main issues are globally related to the lobbying efforts of the main companies operating in this sector whether to protect their markets by jeopardizing the efforts made to facilitate the access to cheap generic medicines, or to promote politically their interests with politicians.
Bovine semen	☐	☐	☐	☐	There is no significant hotspot specifically related to this supply chain.
Agricultural machinery					The PHA raised several hotspots in regards to the agricultural machinery sector and supply chain. Most of them are isolated and are related to a specific business in a particular region. There are however some more preoccupying ones. The occupational health and safety of workers operating in the steel production and recycling sector is, for instance, still characterised by the high level of fatal injuries, despite all the efforts made by this industry to improve the situation. Among the other hotspots are also some preoccupying practices in regards to land appropriation, as well as to environmental damages caused by the pollution generated by steel plants activities.
Machinery manufacturing	☐	☐	☐	☐	
Steel production and recycling	☐	▨	☐	☐	
Trucks and trailers manufacturing	☐	☐	☐	☐	There is no significant hotspot specifically related to this supply chain.

SUPLLY CHAINS	AGGREGATED RESULTS				MAIN POTENTIAL HOTSPOTS
	W	LC	S	VCA	
Fuel and diesel					The PHA indicates that there are many potential socioeconomic hotspots related to this input and this, at all stages of the supply chain. In regards to the worker category, the PHA has documented for example moderate and high possibilities of encountering impairment to the rights of freedom association and of collective bargaining at the step of oil extraction in Algeria and Kazakhstan. The same is true regarding the child labour issue. The overall working conditions in the oil extraction sector, especially Algeria and Kazakhstan, are in fact preoccupying. Local communities are also affected by this industry, with its activities impacting the health and safety of local population as well as limiting and degrading their access to natural resources. Numerous lawsuits have been launched against oil companies, in Canada and abroad, regarding these issues. Potential social hotspots are also significant on a societal perspective, as major companies operating in this industry are involved in serious controversies related to armed conflicts and corruption practices.
Fuel distribution	□	□	□	□	
Petroleum refining	□	▨	□	□	
Oil extraction	▨	▨	■	▨	

1 Risk evaluation scale: □ Low possibility ▨ Moderate possibility ■ High possibility

2 These are aggregated scores measured by calculating the simple average of all scores related to a specific stakeholder category, regardless the region. No weighting was used. This aggregation is for a simplification purpose only. The detailed evaluation is available in Appendix J.

6. Conclusions

The purpose of this study was to profile the environmental and socioeconomic performance of average Canadian milk. Using data from over 300 farms as well as provincial and national statistics, a regionalized characterization of average provincial scenarios allowed for nation-wide understanding and assessment of milk production. While variability in farm practices and results were discussed at every stage of the life cycle steps and for the different environmental and socioeconomic indicators, it is important to remind the reader that such variability was evaluated only between the provincial averages, and in such, does not come close to evaluating and understanding the variability between different farms. As a result of this, the current study provides understanding on how different scenarios and locations affect the environmental profile of milk, without however being able to assess the potential by which best practices within one type of management can contribute to reducing the overall burdens. With respect to the assessment of the average socioeconomic performance of Canadian milk production, the study evaluated the Canadian dairy farmers and their Boards at a national level based on their degree of social engagement and was not intended to assess the performance at an individual level.

This concluding section proposes a summary of results (section 6.1), an identification of areas of improvement (section 6.2) and finally points out some next steps the Canadian dairy sector could follow to pursue their path towards a sustainable development strategy (section 6.3).

6.1. Summary of Results

Overall, the LCA indicated an existing commitment from dairy producers to the supply chain's sustainability, which characterizes to an overall good performance – both at the environmental and socioeconomic levels. On an international level, Canadian milk places very well, with a relatively low carbon footprint and a water footprint among the best in provinces where there is no irrigation. While there is no available benchmark to compare the sector's level of social engagement, the assessment shows that the Canadian dairy farms and their Boards are already socially committed corporate citizens in regards to many social issues.

6.1.1. Environmental Profile of Canadian Milk

More specifically, the environmental footprint of Canadian milk includes water use, greenhouse gases as well as the potential impacts on ecosystem quality, human health and resource depletion. The average profile of the kilogram of fat and protein corrected milk has a carbon footprint of 1.01 kg CO2e/kg FPCM, a water footprint of 20 L of water consumed per kg FPCM, and a land footprint of 1.7 m2 (for crop production only) for the same kg FPCM.

Moreover, the assessment of contributions from the life cycle stages (from raw material extraction to processing plant) identifies the hotspots. Results indicate that a majority of impacts happen at the farm, while for most impact categories (except for climate change), these are linked to crop production, specifically with fertilization (from manure and synthetic fertilizers) and land use. Although not included in the baseline results, a sensitivity analysis shows that mineral supplements are also linked to potential aquatic ecotoxicity and human toxicity. With respect to climate change, it is the methane emitted in enteric fermentation as well as the greenhouse gases emitted from manure management that contribute the most, with emissions from cultivated soils are not far behind. Further comparing the average performance by province across Canada helps understand how different practices or geographical conditions contribute to this impact.

With respect to greenhouse gases, the contributing sources confirm what is known from literature, with enteric fermentation dominating the footprint. While there is some variability, current models do not allow for precise characterization of emissions based on feed crops, and as such, no recommendations can be made. Furthermore, the impact of the diet is inherently linked to its impact in feed production and the trade-offs between the two must be evaluated. Analysis shows that the different crops have different contributions to the environmental impact (Table 4–2), according to a variety of factors. Therefore, there is an important potential for carbon footprint reduction based on a choice of feed that has a lower environmental footprint and that is digested efficiently, however more research using life cycle modelling is necessary.

Emissions from manure management follow in terms of importance. The contribution from methane and nitrous oxide varies based on the type of manure management (Table 4-3), however it is higher overall with liquid manure management (almost double the emissions from solid storage), and much higher with liquid lagoons (by 500%). While liquid lagoons are not so common, they represent 38% of farms using liquid storage in Ontario (18% of Ontario farms overall). While it is accepted that conversion from liquid to solid storage is not easily achieved, due to infrastructure and costs involved, related to storage as well as manure spreading, the reduction or elimination of manure lagoons can in itself help reduce the carbon footprint of Canadian milk by up to 4%. This would translate however to a reduction of more than 0.6 kg CO2e/kg FPCM for the milk produced on a farm using these lagoons.

Feed production is responsible for approximately 20% of GHG emissions, however it is responsible for a majority of the impact on ecosystem quality, human health, resource depletion and water use. This is also the category where there is most variability, between provinces as well as within a province itself, when farm sampling results were available. Most of the impacts are linked with fertilization, including emissions of GHG’s to ammonia, and potential leaching of nitrates and phosphates. These are in turn linked to yield and land use, and further affecting costs, which is the main determinant in diet composition. Meanwhile, it is also the fertilization practices (including manure and synthetic fertilizers, the spreading techniques and concentrations) for which there is the least data. As a result, broad assumptions of fertilizing recommendations followed must be taken. With so many potential impacts at stake, there is a need for better tracking and understanding of the impacts linked to fertilization practices at the farm.

Water use is largely dominated by irrigation where it is used. One area (Southern Prairies) is also characterized by its water scarcity, which emphasizes this area as having the highest water footprint in the water stress assessment. When looking at the potential impacts on ecosystem quality, human health and resource depletion linked to water use only, it becomes obvious that potential impact from water pollution (eutrophication and ecotoxicity, characterized under ecosystem quality) are much more significant, even in the Southern Prairies.

Uncertainty

An uncertainty assessment on data gives a high confidence of the carbon footprint, based on variability in the data. However, there is more uncertainty in the emission models that was not quantified and taken into account in this evaluation. Uncertainty on the overall potential impact on ecosystem quality was deemed high, while uncertainty for potential impact on human health was not as high. While the most important sources of uncertainty are related to feed production. Uncertainty is linked to quantity of feed consumed (produced), yield as well as quantities of natural and synthetic fertilizers used. Fertilization practices would benefit from a better tracking, to understand variability in results comparing practices.

Variability

Results analysis comparing provincial averages served as a first assessment to sensitivity of variable parameters, i.e. farm practices. These were found to be most variable around feed production, while greenhouse gas emissions from manure management were also very sensitive to storage type. With regards to feed production, results were sensitive to a combination of crop type, yields, fertilization rates and types. Methane emissions from enteric fermentation are also sensitive to diet, however better models are necessary to represent this appropriately.

Applying the life cycle assessment to production across Canada asked for a method that allowed and facilitated characterization of the different provincial contexts, in terms of practices (inventory) and geophysical conditions (CF). In assessing the results, it became obvious that variability was driven by both aspects, depending on the indicators. By separating the two, it was easier to understand where reductions are possible, and where observance of best practices is even more important (sensitive areas based on location).

6.1.2. Socioeconomic Profile of Canadian Milk

It is made clear from this assessment that the Canadian dairy farms have an overall positive performance. It is furthermore obvious with respect to the agroenvironmental practices, whether it concerns water sources protection, manure storage or soil conservation. The engagement of dairy farmers towards their local community is also significant, the vast majority being involved in their communities in many different ways. More could be done however in terms of cohabitation, with producers adopting practices minimizing odours propagation.

The picture is also contrasted in regards to farm workers. Although dairy farmers provide overall working conditions that go beyond labour standards – to which they are mostly not legally subjected – there is room for improvements regarding various issues, such as professional training and communication of working conditions. The same holds true with respect to their suppliers and business partners, given that a majority of dairy producers do not usually consider their suppliers' performance in regards to social responsibility in their procurement decisions.

This suggests that there is always room for improvements, now and in the future. For example, with more producers adopting more socially responsible practices, the average socioeconomic performance could be enhanced. Moreover, given that a committed behaviour today can become a the standard in the future, continuous improvement from all producers is also required to improve, but also to preserve, the sector's socioeconomic performance.

Since dairy Boards fulfill many tasks on behalf of dairy farmers in areas such as R&D and sponsorship, their behaviours were also assessed for some issues of concern. The assessment also demonstrates that the Canadian dairy Boards are in average committed corporate citizens, especially in regards to local communities, as most of them support milk donation, scholarship and sponsorship to local organizations, even if these actions are not always part of a formal policy or agreement. Last year, Dairy Boards granted directly over 3.4 M$ to their local communities, in addition to milk donation and participation to other initiatives. They are also committed relating to society by funding research in areas such as public health, nutrition and environment. Over 4.5 M$ were directly invested last year in such activities, not including participation to other research clusters.

The assessment also pointed out issues for which dairy Boards could be more committed. This is the case for example with regards to the promotion of sustainable development and social responsibility, since only a minority of Boards holds formal commitments or has partnerships in those fields and grants resources to realize them. The same can be said in regards to the animal welfare issue. While the DFC have set up, in collaboration with the National Farm Animal Care Council, a code of Practice to support and supervise producers, it has not been yet audited. And if provincial Boards provide trainings and support material on the subject, none have either set up a certification, a set of specifications or an audit system to complement this national initiative.

Finally, the study also looked at social risk potentially present in the suppliers upstream of the dairy sector, such as manufacturers of machinery, fertilizers, pesticides or pharmaceuticals. The main suppliers being located in Canada or the United States, the prevalence of social hotspots is generally lower than in countries such as China. The fact remains however that some risks seem present in a few links of the supply chains. This is the case in the fertilizer and oil extraction industries for example, where it was possible to document disturbing practices of collusion as well as bank rolling techniques from subsidiaries companies of some major players. Potential hotspots were also identified in the North American grain and oilseed sector with regards to working conditions, as they are generally not protected by labour standards. The analysis also brought up public health issues, as well as conflicts of use of natural resources related to many industries, among which the pesticides and pharmaceutical sectors. Some links are also characterized by a lack of competition. Although the Canadian dairy sector has little power to influence these actors located far upstream, in a life cycle perspective, it falls under the responsibility of dairy farmers and their associations to get involved. This assessment can be seen as a starting point in this direction.

6.1.3. Integration of Results

While the assessments were achieved in parallel and mutually compared for synergies and contradictions, they did not identify areas where trade-offs exist between best environmental practices and best socioeconomic practices. However, it is clear that a committed behaviour towards best environmental practices at the farm represents an important commitment towards society from dairy farmers. Conversely, an existing commitment to agroenvironmental practices, as identified in the S-LCA, suggests that evolving environmental recommendations could help sustain best practices and lower impact. Results of the assessment identify this proactive attitude. It is thereby further important to identify and continuously update these practices while it is even more critical to communicate them well, to make the most of this commitment towards sustainable development.

6.2. Areas of improvement

With continuous improvement in mind, target areas were identified through this project. Some present behaviour changes that can be considered as low-lying fruits, while others are broader areas that require further research before specific recommendations can be made. These are listed below.

- The result of this study, including sensitivity analysis, showed interesting opportunities for Canadian farmers with the elimination of manure (dug-out) lagoons;
- A lack of data on fertilizer use (all types) indicate a need for better tracking, especially as fertilizers are linked to each category of environmental impact through their production and use. The use of water and fertilization is also linked to land efficiency, such that there is a need to understand the optimal balance between inputs and outputs to and from the land;
- There is also a significant opportunity to better understand the environmental impact of different crop production as well as the methane emissions caused in their digestion, to establish best practices based on life cycle management;
- Ammonia emissions at the farm are a potential local concern with respect to respiratory problems;
- While water scarcity is close to null in most of the country, its presence in the Southern Prairies, also causing the need for irrigation, thereby greatly increasing the water footprint of local farms, is a local area of concern;
- There is room for improvements regarding various socioeconomic issues, such as professional training and communication of working conditions. The same holds true with respect to their suppliers and business partners, given that a majority of dairy producers do not usually consider their suppliers' performance in regards to social responsibility in their procurement decisions.

Through its "life cycle" perspective, this assessment brings attention to the impacts induced by the activities taking place upstream, outside the dairy farm's boundaries. This focus which encompasses the sector's whole supply chain accentuates the importance of considering the social and environmental impacts related to the inputs used in producing milk. This study showed that this perspective is not yet fully integrated in the producer's procurement practices and daily activities. Adopting a "life cycle" perspective is hence considered as a potential improvement that could be fostered at the farm as well as the Board levels.

6.3. Next Steps

LCA is the first step towards engaging all stakeholders in a comprehensive sustainable development strategy. This assessment provides the Canadian dairy sector with an innovative, comprehensive and actionable roadmap to move in the direction of a more sustainable milk production in Canada. Moreover, capitalizing on these results also depends on the extent of communication with involved parties. This is a crucial part of the next steps. The model generated here can also serve as a basis for a self-assessment tool aimed at farmers, which could be improved to better identify best practices. There are indeed many ways by which the sector could take stock of the results, address the hotspots and pursue its efforts to tend towards more sustainable practices. This section proposes some next steps that could be considered.

6.3.1. Communication

The quality of the study and the depth of the assessment are most valuable if the study is made useful to the Dairy Farmers of Canada. An LCA study is the first step in taking action to reduce the environmental and socioeconomic impact of a production system. It brings awareness and understanding of the scale of impact of the different inputs, outputs and activities, such that it can help prioritise actions in a more efficient manner.

The steps forward hence begin with communication over the project and the results, to help bridge the knowledge gap and increase awareness at the farm. Communication is also key in the development of a self-assessment tool.

6.3.2. A Dynamic Assessment, Including Mitigation Practices

In this study, many limitations were identified. Improvements to the model based on current research and consultation with specialists will help improve the detail of assessment toward developing a dynamic assessment of best practices. Collaborations with AAFC researchers have been identified. These will target especially enteric fermentation models and feed production and manure management practices, but also the best socioeconomic practices adjusted to each producer's location and activities.

Additionally, further developments in life cycle impact characterization are needed to improve modelling of changes in soil composition and impacts on biodiversity. An ongoing collaboration with CIRAIG will ensure integration of the latest developments on a global scale.

6.3.3. Ecological Goods & Services

Agriculture is both a recipient and provider of environmental benefits, also known as ecological goods and services (EGS). These benefits are not typically recognized in the market system. The principle behind the monetization of EGS is one geared towards its use in policy. While there are various options of methodology to apply a monetary value to the ecological goods and services generated from changes in land management practices, the exercise itself promotes the understanding of benefits and consequences with respect to cost and revenue.

"The principles underpinning ecological goods and services policy focus on environmental objectives based on sound scientific knowledge of the state of the environment, reflect the expectations of Canadians, and are sensitive to regional issues and opportunities." (AAFC, 2010b). Undertakings under this policy framework will support the viability of farming through a greater understanding of how ecosystem processes such as soil renewal, climate regulation, and water cycling are affected by production practices. They will also communicate and substantiate the concept that well managed agricultural lands can provide benefits to society, such as fish and wildlife habitat, scenic views, and purification of air and water through natural processes.

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LCA helps put everything in perspective, in a comprehensive and objective manner. It sheds light on where and how to improve. Specifically, this environmental and socioeconomic assessment was conducted to support the Canadian dairy producers, individually or collectively, in their decision making by introducing new parameters to consider in producing milk in an economically efficient, environmentally sustainable and socially responsible way.

The results and conclusions presented here are valid only within the context of this study. Consideration of the boundaries and assumptions is imperative when using the information provided in this document.

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Appendix A Abbreviations and acronyms

CH_4	Methane
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
DALY	Disability Adjusted Life Years
FU	Functional unit
GHG	Greenhouse gas
GWP	Global Warming Potential (in general in g or kg of CO_2-eq)
Kg	kilogram = 1,000 grams (g) = 2.2 pounds (lb)
kWh	Kilowatt-hour = 3’600’000 joules (J)
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MJ	Megajoule = 1,000,000 joules
NOx	Nitrogen oxides
PDF*m^2*year	Potentially Disappeared Fraction per Square Meter of land per Year
PHA	Potential Hotspots Analysis
PM2.5	Fine particles
PRP	Performance Reference Point
RER	Europe (in ecoinvent)
SHD	Social Hotspots Database
SIA	Social Impact Assessment
S-LCA	Social life cycle assessment
T	Metric tonne (1,000 kg)
U	Unit process

Appendix B Inventory Data

Feed per kg of milk produced (includes replacement animals)

Kg dry matter / kg FPCM		BC	AB	SK	MB	ON	QC	NB	NS	PE
Dairy ration	kg purch	0.124	0.121	0.115	0.117	0.091	0.101	0.204	0.167	0.256
Hay (dry)	kg total	0.326	0.350	0.358	0.468	0.104	0.137	0.115	0.064	0.000
Haylage	kg total	0.353	0.182	0.171	0.266	0.364	0.420	0.388	0.449	0.609
Corn silage	kg total	0.283	0.419	0.384	0.202	0.312	0.171	0.183	0.295	0.110
Dry corn	kg total	0.015	0.013	0.013	0.012	0.234	0.139	0.153	0.269	0.024
Small Grain	kg total	0.139	0.121	0.113	0.105	0.260	0.033	0.064	0.013	0.183
Soy	kg total	0	0	0	0	0.117	0.171	0.102	0.103	0.012

On-farm Energy		BC	AB	SK	MB	ON	QC	NB	NS	PE
Gas Expenses [1]	**$/ferme**	23011	24878	28583	27171	16627	11848	15252	17749	14736
Price at pump	**$/L**	1.277	1.277	1.277	1.277	1.277	1.277	1.277	1.277	1.277
Gas consumption	**Litres/ferme**	18019.6	19481.6	22382.9	21277.2	13020.4	9278.0	11943.6	13899.0	11539.5
Gas per kg FPCM	**L/kg lait**	0.0145	0.0177	0.0192	0.0241	0.0212	0.0198	0.0198	0.0200	0.0239
Electricity (on-farm only) [1]	**$/ferme**	11275	13501	12672	9803	9926	6558	7845	7416	7325
Electricity Price (HQ, 2010)	**$/kWh**	0.0876	0.0832	0.1085	0.0702	0.11	0.0894	0.1209	0.1271	0.1684
Electricity consumption	**kWh/ferme**	128710.0	162271.6	116792.6	139643.9	90236.4	73355.7	64888.3	58347.8	43497.6
Electricity per kg FPCM	kWh/kg lait	0.10336	0.14741	0.10002	0.15848	0.14687	0.15625	0.10761	0.08390	0.08991

Average Farm Data	Unit	BC	AB	SK	MB	ON	QC	NB	NS	PE
Milk Sold ALL	kg FPMC/prov	678679180.8	662679155.3	227707870.1	319845679	2600691575	3011295512	138079759	175243750	104014819
Number of farms	#	545	602	195	363	4233	6414	229	252	215
Milk Sold	kg FPMC/farm	1,245,282.90	1,100,795.94	1,167,732.67	881,117.57	614,384.97	469,487.92	602,968.38	695,411.70	483,789.85
Milk Cows	hd/farm	138	133	147	110	76	58	81	94	65
Bulls	hd/farm	0.696	0.673	0.745	0.558	0.281	0.179	0.286	0.286	0.857

Average Farm Data	Unit	BC	AB	SK	MB	ON	QC	NB	NS	PE
Young bulls	hd/farm	1.010	0.977	1.082	0.810	0.205	0.393	2.071	0.000	0.071
Veal Male	hd/farm	2.328	2.250	2.492	1.867	2.418	1.112	1.000	0.143	1.643
Veal Female	hd/farm	35.103	33.929	37.585	28.149	18.664	10.719	23.143	26.714	16.000
Bred Heifers	hd/farm	39.049	41.133	36.731	30.108	21.932	12.556	22.429	18.643	21.929
Open Heifers	hd/farm	39.049	41.133	36.731	30.108	25.589	14.903	25.143	23.929	14.903
% Replacement	%	57%	62%	50%	55%	62%	48%	59%	45%	57%
Milk per day	kg/dairy cow	24.80	22.68	21.72	21.89	22.06	22.29	20.47	20.29	20.52
Milk per year	kg/dairy cow	9,053.31	8,279.77	7,928.93	7,988.37	8,052.23	8,136.71	7,471.73	7,405.88	7,489.01
TieStall	% tie stall	3%	8%	11%	29%	55%	91%	86%	43%	86%
Bedding - Straw	kg/hd	650	650	891	891	891	650	750	750	750
Bedding - Wood residues	kg/hd	228	228	0	0	0	228	0	0	0
Sold to Slaughter - Cows	hd/farm	35	37	33	27	18	11	16	17	24
Sold to Slaughter - Calves	hd/farm	89	83	99	72	27	41	41	44	32
Allocation factor		82%	80%	80%	80%	85%	82%	83%	84%	75%
Purchased - Head	hd/farm	5.5546	5.3688	5.9473	4.4542	3.3973	2.8163	2.1429	3.1429	3.5714
Milk weighting factor	% production	8.6%	8.4%	2.9%	4.0%	32.8%	38.0%	1.7%	2.2%	1.3%

Manure management	BC	AB	SK	MB	ON	QC	NB	NS	PE
Solid Storage	44%	22%	22%	25%	29%	35%	42%	42%	42%
Solid on Pasture	11%	13%	13%	10%	24%	9%	13%	13%	13%
Liquid with Crust	30%	52%	52%	50%	20%	35%	29%	29%	29%
Liquid with Cover	1%	1%	0%	4%	3%	8%	6%	6%	6%
Liquid (no crust/cover)	10%	6%	6%	2%	6%	8%	9%	9%	9%
Liquid Lagoon	4%	7%	7%	9%	18%	5%	1%	1%	1%

Appendix C Review of Literature

Table C-1Summary Table of the Literature Review

Study	Foster et al. (2007). "The Environmental, Social and Economic Impacts Associated with Liquid Milk Consumption in the UK and its Production. A Review of Literature and Evidence". **Produced for DEFRA by The University of Manchester, EuGeos, Delta-innovation and Cranfield University.**	Swedish Dairy Association (2000). "Milk and the environment." (http://www.svenskmjolk.se/ImageVault/Images/id_153/scope_128/ImageVaultHandler.aspx)	Cederberg, C. and B. Mattsson (2000). "Life cycle assessment of milk production -- a comparison of conventional and organic farming." Journal of Cleaner Production
Goal	Literature review and test the LCA model for agriculture developped by the University of Cranfield to present environmental, social and economical impacts of production, transformation, sale and consumption of milk in the UK.	• Evaluate environmental impacts over the entire life cycle from the consumption of half-skimmed milk in Sweden • Identify hot spots and compare organic and conventional production	• Identify hot spots differences between the two • Test the hypothesis that conventional systems have more impact than self-sustained systems (organic). •Collect data on the production of food centrate for animals to be used in other LCAs for animal products.
Purpose	Information support for the Milk Roadmap, developed by the dairy industry and DEFRA to improve the sustainability of the supply chain of fluid milk in the UK.	Determine an action plan to reduce environmental impacts in the supply chain.	Propose a strategy for improvement based on hot spots identified
Target audience	Working groups of the Milk Roadmap of DEFRA	Swedish Dairy Association and the greater public	Swedish Farmers Foundation for Agricultural Research, the Swedish Farmers Union and the Swedish Dairy Association
Critical review	Because of a great uncertainty around quantities of milk loss at the wholesale and downstream to consumption, the overall footprint of consumed milk displays this overall uncertainty. - Lack of detailed information on LCA model used	- ISO 14040–14043. - Revised by a third party. - Full report not available (no info on data sources, etc).	- Analysis on two farms only, not sector wide - Dates back to 1997/1998. - No official method used (or stated) to evaluate impacts. -Many impact categories not evaluated : water use, soil quality, biodiversity, ecotoxicology.
Conclusions and limits	Most of the impact on nonrenewable resources and land use come from feed production. For acidification and eutrophication, these are also linked to onfarm operations. Results linked to GHG have a high uncertainty because of the uncertainty around N2O emission factors. The LCA methodology is only used for the feed production step, using the strict model developed by Cranfield university	Most of the emissions come from milk production, contributing significantly to eutrophication and acidification.	- organic farming reduces commercial inputs to the system, providing environmental advantages, by reducing the use of pesticides and phosphorus - Improvement measures are still necessary in both systems to decrease impact on climate change, from acidification and eutrophication.

Study	Eide, M. H. (2002). "Life cycle assessment (LCA) of industrial milk production." *Int. J. LCA* 7(2): 115-126.	Basset-Mens et al. (2005). "First Life Cycle Assessment of Milk Production from New Zealand Dairy Farm Systems". *ANZEE conference : Ecological Economics in Action*, Massey University, Palmerston North, New Zealand.	Haas et al. (2001). "Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment." *Agriculture, Ecosystems & Environment* 83(1-2): 43-53.
Goal	Assess the life cycle impact of Norwegian milk over its entire life cycle to understand hot spots Evaluate the contribution from transformation and transport.	Portrait of the average milk production system in New Zealand Comparison with 2 studies from Sweden (Cederberg and Mattsson, 2000) and Germany (Haas et al., 2001).	Use and adapt LCA for analysis of all environmental impacts relevant to farm operations. Compare 3 production systems : intensive, extensive and organic.
Purpose	N/A	N/A	N/A
Target audience	N/A	N/A	Farmers, agricultural counselors, policy development
Critical review	- Land use and impacts on soil quality were not evaluated. - Impacts from pesticides were not included.	- Less detailed processed than Einde (2002); - The lack of concentrates in the diet involves less upstream processes, a significant advantage	- Not iso-standard LCA - Focused mostly on inventory data - Measure of biodiversity indicators - No allocation to meat, not justified
Conclusions and limits	- Full « *cradle-to-grave* » study based on previous contributions from 1995 to 2000. - Large variability over time and geographical location (Sweden + Norway) - Methodological choices made here on allocation have become the reference in the dairy sector.		- One of the first LCA's in dairy, often cited, however dated (data from 1997) - Interesting indicators, however not used in other studies

Study	Roger et al. (2007). "#Systèmes bovins lait bretons: Consommations d'énergie et impacts environnementaux sur l'air, l'eau et le sol. " Rencontres Recherches Ruminants (3R) #14, Paris, France.	Thomassen et al. (2008). "Life cycle assessment of conventional and organic milk production in the Netherlands." Agricultural Systems	Hospido et al. (2003). "Simplified life cycle assessment of galician milk production." International Dairy Journal
Goal	- Develop a tool to evaluate the sustainability of farms (EDEN). - Establish impact levels and resource consumption data for the dairy production in Brittany - Evaluate the effects of soil nitrogen replacement using legumes.	Evaluate the life cycle production of milk and identify the hot spots Compare production systems: organic vs conventional	Come up with the life cycle inventory of milk production and processing for consumption in Galicia, Spain
Purpose	N/A	N/A	LCA
Target audience	Dairy Producers	N/A	N/A
Comments	- Significant farm sample - No use of standardised method of impact analysis - Large variation between different farms, regardless of production mode. - The impact of emissions related to medication were not evaluated - A rare inclusion of heavy metals and waste water sludge. - Significant sample size: 60 farms	- The exclusion of the impact category "ozone depletion potential" based on the results of two studies is arguable. The decision should be based on refrigerant types used and a sample calculation made. - Significant sample size of farms (necessary when comparing two types of production) - The authors justify the use of attributional LCA as oppose to consequential LCA, since the goal is to describe an existing farm. - Since there is no consensus on the inclusion of land use for biodiversity and soil quality, only the Land Use category is evaluated, which works against organic production (despite its benefits on other impact categories not evaluated here). Negative soil and biodiversity impacts of pesticides are hence ignored.	- Arguable choice of calculation for average inventory values, considering sample size (3) - Questionable representation considering variability in data. - Relatively incomplete emissions inventory (only methane is considered) and only DCO and solid missions are considered in waste water. No nitrogen inputs or outputs are taken into account. - On-farm solid waste are included (but not detailed) - Incomplete inventory for emissions of two concentrate production sites: no direct emissions except solid waste - Good audit of farms and plants, with data collection spread over 3 years (which unfortunately did not help eliminate great variability) - Data missing for farm-plant transportation
Conclusions and limits	Farms included in the sample are part of a livestock network that is expected to have better equipment and financial results, which somewhat creates a bias.	- Detailed and transparent, including discussion of limits and choices made, statistics presented to help compare results - Good presentation of results including impacts on and off farm, with hot spots of each. - Comment on the importance of doing a thorough LCA for the production of feed, an important hot spot (even in organic production)	- A farm sample of 3 farms is deemed insufficient, despite the different efforts to measure data on farm. - Impacts are not characterised, however this was outside the scope of the study.

Study	Thoma (2010), GHG emissions of US fluid milk, University of Arkansas and Michigan Technological University,	Heller et al. (2008). "Life-cycle Energy and GHG Analysis of a Large-Scale Vertically Integrated Organic Dairy in the U.S." 6th international conference on LCA in the Agri-Food Sector, November 12-14, 2008, Zurich (Switzerland).	Lundie S et al. (2009), "Carbon Footprint Measurement: Methodology Report", University of NSW and Fonterra Co-operative Group, New Zealand
Goal	Determine GHG emissions associated with the distribution of a gallon of milk to US consumers	Determine energy used and GHG emissions generated over the life cycle of a vertically integrated dairy system (*Aurora Organic Dairy*)	Determine the product carbon footprint of butter, powdered milk, whey protein powder and cheese over the entire life cycle including transportation overseas
Purpose	- Generate a great deal of data which will serve in the establishment of best practices.	- Reduce environmental impacts - Improve energy efficiency - Reduce GHG emissions	
Target audience	Dairy producers (*Dairy Management Inc./National Milk Producers Federation*), and the greater public	*Aurora Organic* (largest American organic milk private company) and the greater public	
Conclusions and limits	The scale of farm sampling and the completeness of the study seem impressive, even if limited to GHG. - Relative contribution of manure to total footprint larger than previously estimated from literature review, with feed and on-farm fuel lower than expected. - Deep bedding (stored longer than one month) and anaerobic lagoons are two of the largest sources of methane from Man Mang - Feed production very important – conservation and no-till operations are opportunities, tillage practices significantly influence carbon retention in soils. - Dairy farmers to produce their own feed to exercise control - Feed conversion efficiency is the most important individual factor in explaining differences in the footprint. Not surprisingly, more efficient feed conversion results in a lower footprint, since it affects feed production, enteric emissions and the quantity of manure excreted.	Energy use is higher than comparable literature (3 to 4 times) There is a need for better data with respect to organic farming in the US.	- Allocation base on a thorough physical-chemical evaluation for milk & meat (86% milk/14% meat) and for the different dairy products. - Impacts linked to capital investments (equipement, construction) are excluded in accordance with the PAS 2050 - N2O and CH4 emissions from cows were calculated using specific feed composition with N and C

Study	University of Kansas (2008), Carbon Footprint and the Dairy Industry (Results not released and full-LCA not completed)	FAO (2010). Greenhouse Gas Emissions from the Dairy Sector – A Life Cycle Assessment, Food and Agriculture Organization of the United Nations	DEFRA (2007) The Environmental, Social and Economic Impacts Associated with Liquid Milk Consumption in the UK and its Production (REVIEW?)
Goal		- Assess the dairy sector's contribution to GHG emissions - Identify the major GHG "hotspots" along the dairy food chain.	Review work achieved elsewhere for a comprehensive picture of the sustainability of the dairy industry.
Purpose	Identify opportunities for effeciciency and innovation across the fluid milk supply chain	- To understand the contribution of dairy production in global GHG emissions - To understand regionalised differences and identify inefficiencies	To inform the "roadmap" being developed and to improve the sustainability performance of UK milk. Also wanted to answer questions regarding sustainable development impacts, to question robustness and relevance to the UK of current results, the potential of improvement through innovation, intervention or system changes. The study also attempted to evaluate socioeconomic impact by keeping track of employment, but the information was not available throughout the supply chain.
Target audience	US dairy farmers and greater public	- the private sector, the consumers, policy-makers, and technicians in governmental and nongovernmental organizations (NGOs), international organizations, academia and LCA practitioners	
Critical review	- Exceptional size of data sample (500 milk producers, 51 plants) Includes all transformation and transportation required until it reaches American customer	- Is based on many assumptions and broad estimates. Profiling for Canada is usually lumped with North America in general.	
Conclusions and limits	- Limited to GHG - Managmeent practices are an important driver of the carbon footprint		DEFRA also evaluates the impact of conventional and organic milk production separately. As a result, organic milk production has 16% more impact on climate change, while the potential for acidification and eutrophisation is up by more than 60%, probably because land use (ha) is double.

Study	Yan et al. (2010), An evaluation of life cycle assessment of European milk production, UCD Biosystem Engineering, University College Dublin, Moorepark Dairy Production Research Centre, Ireland	Vergé et al. (2007), Greenhouse gas emissions from the Canadian dairy industry in 2001, Agriculture and Agri-Food Canada	Williams, et al. (2006) Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Cranfield University and Defra
Goal	- to evaluate the comparability of European milk production LCAs up to the farm gate. (lit review)		To develop, and later realise, a conceptual model to quantify the environmental burdens and resource use associated with the production of agricultural and horticultural commodities using LCA.
Purpose			To identify and classify the major typical production systems, their mass and energy flows, and identify hot spots, in a model that will be reusable.
Target audience			
Conclusions and limits	- paper is restricted in scope to peer-reviewed LCA studies where the authors claimed to have used ISO methodologies - LCAs can be made incompatible by author-derived decisions and assumptions. - LCAs of milk should ensure that: (1) the production system is appropriately characterized according to the goal of study; (2) a clear description of the system boundary and allocation procedures is provided according to the statement of ISO standards; (3) a common functional unit, probably Energy Corrected Milk, should be used or the assumed fat and protein content should be presented to enable future comparisons; (4) where appropriate, site-specific emission factors and characterization factors should be used in environmental hotspots (e.g. manure management, synthetic fertilizer production and spreading, production of purchased feed), and phosphorous loss should be better addressed; (5) a range of impact categories including climate change, energy use, land use, acidification and eutrophication should be used to address environmental tradeoffs, perhaps in the future biodiversity should also be included;	-	- Does not mention allocation between meat and milk - Average footprint of milk: 1.06 kg CO_2/L milk, Is lower with more corn silage.

Appendix D Emission models

Nitrous Oxide from Crop Production

Direct and indirect N2O emissions were calculated based on IPCC recommendations Tier 2. For the direct emissions factors, ecodistrict specific emission factors for Canada were used (based on Rochette et al., 2008).

Ammonia from Crop Production

In accordance to the model used by ecoinvent, the losses of NH3 during the spreading of manure were calculated using the models by Katz (1996) and Menzi (1997) (as per Nemecek et al., 2007). Ammonia emissions from mineral fertilizers were given by Asman (1992) (as per Nemecek et al., 2007).

Other contaminants from Crop Production

Pesticides

The general assumption from windrift was that 16.5% of pesticides applied are emitted in the air, while the rest is emitted to the soil (Fantke et al., 2011). The impact models then translate these emissions into potential impacts.

Phosphorus Emissions

Phosphorus and phosphate emissions to water were calculated following ecoinvent models (Nemecek, 2007), based on the emission models SALCA-P (Prasuhn 2006, as per Nemecek, 2007), calculating three types of phosphorus emissions to water:

- Leaching of soluble phosphate to ground water
- Run-off of soluble phosphate to surface water
- Erosion of soil particles containing phosphorus

Nitrate Emissions

Nitrate leaching to water were modelled based on ecoinvent practices (Richner et al., 2006 as per Nemecek, 2007) comprising of the following elements:

- Nitrogen mineralisation from the soil organic matter
- Nitrogen uptake by vegetation
- Nitrogen input from spreading of fertilizer
- Soil depth

Metals

Certain metals, typically referred to as minerals, such as copper, zinc, magnesium, selenium, cobalt, arsenic, iron and manganese, are commonly present in feed, and necessary for the cow's diet. Because of the need of a balanced supply of minerals in a cow's diet, supplements are also provided.

Meanwhile, metals not transferred to milk are released in the manure. This, in turn, is spread onto crop fields. In order to estimate how much can accumulate in the ground and leach to water streams, the assumption is that there is a closed loop from feed to manure and back to feed, however that the supplements provided annually to the cow on top of feed content serves to compensate for what is lost, either released in the milk, or accumulated in the environment.

Benchmarking comparisons were made between the mineral content of a kg of milk (U of Guelph, 2012) and the mineral content of the equivalent slurry manure needed to produce this milk (less than 4 kg). The mineral content in milk was found to be less than 1% than the content found in the manure generated for its production. Therefore, an average intake (communication Top Feeds, 2012) of mineral supplements was used as a proxy for the accumulation in soil.

Methane Emissions from Enteric Fermentation

Methodology

Enteric fermentation of cattle generates methane emissions as food energy is lost during the digestion process. A Tier 2 characterisation method was performed to calculate these emissions as outlined in the IPCC Guidelines for National Greenhouse Gas Inventories (2006). To estimate the total emissions, an emission factor for each cattle category was determined based on the gross energy intake (GE) and methane conversion factor (Y_m).

Gross energy intake (GE)

The gross energy intake is the total amount of energy in the diet that is ingested by the animal. The enteric model suggested by the IPCC (2006) is derived from the energy for maintenance, energy for animal activity, energy for lactation, energy for pregnancy, digestible energy, energy for pregnancy and energy for growth. The following equation (IPCC, 2006) was used to calculate the gross energy intake for each cattle category in each region studied:

$$\mathrm{GE} = \frac{\left(\frac{\mathrm{NE_m} + \mathrm{NE_a} + \mathrm{NE_l} + \mathrm{NE_p}}{\mathrm{REM}}\right) + \left(\frac{\mathrm{NE_g}}{\mathrm{REG}}\right)}{\frac{\mathrm{DE\%}}{100}}$$

Where: GE = gross energy intake, MJ d^{-1}

NEm = net energy required by the animal for maintenance, MJ d^{-1}

NEa = net energy for animal activity, MJ d^{-1}

NEl = net energy for lactation, MJ d^{-1}

NEp = net energy for pregnancy, MJ d^{-1}

NEg = net energy for growth, MJ d^{-1}

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed

REG = ratio of net energy available for growth in a diet to digestible energy consumed

DE% = digestible energy as a percentage of gross energy, %

The following table summarizes the equations used to calculate the parameters found in the gross energy intake equation above. More details on the coefficients used in each equation can be found in Appendix X.

Parameter	Equation	Source
Net energy required by the animal for maintenance (NE_m, MJ d^{-1})	$\mathrm{NE_m} = \mathrm{Cf_i} \times (\mathrm{BW})^{0.75}$ Where: Cf_i = 0.322 (for non-lactating cows) or 0.386 (for lactating cows), MJ $day^{-1}kg^{-1}$; BW = live body weight, kg	IPCC, 2006 - Eq. 10.3
Net energy for animal activity (NE_a, MJ d^{-1})	$\mathrm{NE_a} = \mathrm{Cf_a} \times \mathrm{NE_m}$ Where: C_a = 0.00 (for stall), 0.17(for pasture) or 0.36 (for grazing large areas), dimensionless	IPCC, 2006 - Eq. 10.4
Net energy for lactation (NE_l, MJ d^{-1})	$\mathrm{NE_l} = \mathrm{Milk} \times (1.47 + 0.4 \times \mathrm{Fat})$ Where: Milk = amount of milk produced, kg day^{-1}; Fat = fat content of milk, % by weight	IPCC, 2006 - Eq. 10.8
Net energy for pregnancy (NE_p, MJ d^{-1})	$\mathrm{NE_p} = \mathrm{Cf_{pregnancy}} \times \mathrm{NE_m}$ Where: $Cf_{pregnancy}$ = 0.10 (for cattle)	IPCC, 2006 - Eq. 10.13
Digestible energy - percentage of gross energy (DE%, %)	$\mathrm{DE\%} = \mathrm{A} \times 80 + \mathrm{B} \times 60$ Where: A = percentage of cattle fed with high concentrate diet; B = percentage of cattle fed with pasture or forage diet	
Ratio of net energy available in a diet for maintenance to digestible energy consumed (REM)	$\mathrm{REM} = \left\{1.123 - (4.092 \times 10^{-3} \times \mathrm{DE\%}) + [1.126 \times 10^{-5} \times (\mathrm{DE\%})^2] - \left(\frac{25.4}{\mathrm{DE\%}}\right)\right\}$	IPCC, 2006 - Eq. 10.14
Net energy for growth (NE_g, MJ d^{-1})	$\mathrm{NE_g} = 22.02 \times \left[\frac{\mathrm{BW}}{\mathrm{C} \times \mathrm{MW}}\right]^{0.75} \times \mathrm{WG}^{1.097}$ Where: MW = cattle mature live body weight, kg; WG = average daily weight gain of the animals in	IPCC, 2006 - Eq. 10.6

	the population, kg day^{-1}	
Ratio of net energy available for growth in a diet to digestible energy consumed (REG)	$REG = \left\{1.164 - (5.160 \times 10^{-3} \times DE\%) + [1.308 \times 10^{-5} \times (DE\%)^2] - \left(\frac{37.4}{DE\%}\right)\right\}$	IPCC, 2006 - Eq. 10.15

Methane conversion factor (Y_m)

The methane conversion factor for each cattle category was calculated as follow (IPCC, 2006):

$$Y_m = \frac{(CH_4 \text{ production})}{GE} \times 100$$

Where: CH_4 production = methane produced daily, kg CH_4 head^{-1} day^{-1}

GE = gross energy intake, MJ day^{-1}

To calculate the amount of methane produced daily, an equation developed by Ellis (2007) was selected since it had a low root mean square and required only one variable (i.e. dry matter intake) that could be calculated from data already available (i.e. cattle body weight and digestible energy). The table below presents the equations for the methane produced daily and the dry matter intake.

Parameter	**Equation**	**Source**
Methane produced daily *(CH_4 production, MJ head^{-1} d^{-1})*	$CH_4 \text{ production} = 3.23\ (\pm 1.12) +\ 0.809\ (\pm 0.0862) \times DMI$	Ellis et al., 2007
Dry matter intake for mature dairy cows *(DMI, kg d^{-1})*	$DMI = \left[\frac{\left(\frac{(5.4 \times BW)}{500}\right)}{\frac{(100 - DE\%)}{100}}\right]$	IPCC, 2006 – Eq. 10.18b

When the dry matter intake could not be calculated, the methane conversion factor was estimated to be 6.5% as recommended by the IPCC. This value has also been reported in a Canadian study (McGinn et al, 2004) which measured the total digestibility of feed using chromic oxide and established that 6.5% of the gross energy consumed was lost as methane emissions, according to the scenario studied.

Methane emission factor ($EF_{CH4\ ent.ferm}$)

Finally, the methane emission factor specific to each cattle category was determined with the following equation (IPCC, 2006):

$$EF_{CH_4\ ent.ferm.} = \left[\frac{GE \cdot \left(\frac{Y_m}{100}\right) \cdot 365}{55.65}\right]$$

Where: EFCH4 ent.ferm = methane emission factor, kg CH4 head-1 day-1

GE = gross energy intake, MJ head-1 day-1

Ym = methane conversion factor, percent of gross energy in feed converted to methane

55.65 = energy content of methane, MJ kg CH4-1

365 = number of days in a year

This emission factor was then multiplied with the total number of heads in each cattle category to evaluate the total methane emissions due to enteric fermentation.

Methane Emissions from Manure Management

Methodology

Methane emissions due to manure management systems were calculated according to the IPCC (2006) Tier 2 characterisation method. To estimate the total emissions, an emission factor for each cattle category was calculated based on the volatile solid excretion rate (VS), the maximum methane producing capacity of the manure (B_o), the methane conversion factors for each manure management system ($MCF_{s,x}$) and the fraction of cattle manure handled using specific manure management system ($MS_{(T,S,k)}$).

Volatile solid excretion rate (VS)

The volatile solid content of manure corresponds to the portion of the feed consumed that is not digested and therefore excreted as both biodegradable and non-biodegradable organic materials. The volatile solid excretion rate was calculated using the equation below (IPCC, 2006):

$$VS = \left[GE \cdot \left(1 - \frac{DE\%}{100}\right) + (UE \cdot GE)\right] \cdot \left[\frac{1 - ASH}{18.45}\right]$$

Where: VS = volatile solid excretion rate, kg VS day^{-1}

GE = gross energy intake, MJ day^{-1}

DE% = digestible energy as a percentage of gross energy, %

UE = urinary energy, MJ $head^{-1}$ day^{-1}

ASH = ash content of manure

18.45 = conversion factor for dietary gross energy per kg of dry matter, MJ kg^{-1}

The following table summarizes the parameters that were first calculated in order to determine the volatile solid excretion rate for each cattle category.

Volatile solid excretion rate (VS)

The volatile solid content of manure corresponds to the portion of the feed consumed that is not digested and therefore excreted as both biodegradable and non-biodegradable organic materials. The volatile solid excretion rate was calculated using the equation below (IPCC, 2006):

$$VS = \left[GE \cdot \left(1 - \frac{DE\%}{100}\right) + (UE \cdot GE)\right] \cdot \left[\frac{1 - ASH}{18.45}\right]$$

Where: VS = volatile solid excretion rate, kg VS day^{-1}

GE = gross energy intake, MJ day^{-1}

DE% = digestible energy as a percentage of gross energy, %

UE = urinary energy, MJ head^{-1} day^{-1}

ASH = ash content of manure

18.45 = conversion factor for dietary gross energy per kg of dry matter, MJ kg^{-1}

The following table summarizes the parameters that were first calculated in order to determine the volatile solid excretion rate for each cattle category.

Parameter	**Equation / Default value**	**Source**
Gross energy intake *(GE, MJ d^{-1})*	$GE = \frac{\left(\frac{NE_m + NE_a + NE_l + NE_p}{REM}\right) + \left(\frac{NE_g}{REG}\right)}{\frac{DE\%}{100}}$	IPCC, 2006 - Eq. 10.16
Digestible energy - percentage of gross energy (*DE%, %)*	$DE\% = A \times 80 + B \times 60 + C \times 50$ Where: A = percentage of cattle fed with high concentrate diet; B = percentage of cattle fed with pasture or forage diet	
Urinary energy *(UE, MJ/head.day)*	$UE = 0.04 \cdot GE$ or $UE = 0.02 \cdot GE$	IPCC, 2006
Ash content of manure *(ASH)*	0.08 for cattle	IPCC, 2006

Maximum methane producing capacity of manure (B_o)

The maximum methane producing capacity of manure is based on the cattle's diet and species. Estimations for B_o in North America were used in the calculations of the methane emissions due to manure management as no country-specific data were available. The IPCC (2006) estimated the B_o to be 0.24 m^3 CH_4 kg VS^{-1} for dairy cows and 0.19 m^3 CH_4 kg VS^{-1} for other cattle.

Methane conversion factors for each manure management system ($MCF_{S,k}$)

The methane conversion factors indicate how much of the maximum methane producing capacity of manure is achieved. They are specific to each manure management system and are based on the temperature of the system and the retention time of organic material in the system. The IPCC (2006) gathered in a table $MCF_{S,k}$ values by temperature for manure management systems. Based on the average annual temperatures of each region studied, the $MCF_{S,k}$ values were determined. Since the average annual temperatures of all the Canadian regions fall in the cool temperature category (below or equal to 14°C), the $MCF_{S,k}$ were the same across all regions.

To match the manure management systems described in the IPCC guidelines and the ones that were available in this study the following assumptions were made:

Description of the manure management systems recorded in Sheppard (2011)	Corresponding system in IPCC guidelines (2006)
Uncovered outdoor piles or bunkers Piles or bunkers covered with tarp or straw Piles or bunkers under a roof	**Solid storage** *"The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation."*
Tank above ground, lined or cement pit, lagoon or dugout with a natural crust and open so rain can get in	**Liquid/slurry (with a natural crust cover**) *"Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year."*
Tank above ground, lined or cement pit, lagoon or dugout with: - an applied floating cover such as a tarp or; - a straw has been added to make a floating cover	**Liquid/slurry (with or without a natural crust cover)** Same definition as above
Tank above ground or lined or cement pit with no floating cover or crust	**Liquid/slurry (without a natural crust cover)** Same definition as above
Lagoon or dugout with no floating cover or crust	**Uncovered anaerobic lagoon** *"A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields."*

Methane emission factor ($EF_{CH4\ manure}$)

Finally, the methane emission factor ($EF_{CH4\ manure}$) specific to each cattle category was determined with the following equation (IPCC, 2006):

$$EF_{CH_4\ manure} = (VS_T \cdot 365) \cdot \left[B_{O(T)} \cdot 0.67 \cdot \sum \frac{MCF_{S,k}}{100} \cdot MS_{(T,S,k)}\right]$$

Where: $EF_{CH4\ manure}$ = methane emission factor, kg CH_4 head^{-1} day^{-1}

VS_T = volatile solid excretion rate, kg VS day^{-1}

365 = number of days in a year, day

B_o = maximum methane producing capacity of manure, m^3 CH_4 kg VS^{-1}

0.67 = conversion factor of m^3 CH_4 to kg CH_4

$MCF_{S,k}$ = methane conversion factor for each manure management system S by climate region k, %

$MS_{(T,S,k)}$ = fraction of animal's manure handled using specific manure management system

The emission factor was then multiplied with the total number of heads in each cattle category to evaluate the total methane emissions due to manure management.

Nitrous Oxide Emissions from Manure Management

Direct nitrous oxide emissions due to manure management systems

Methodology

The direct emissions of nitrous oxide come from the storage and treatment of manure before it is spread on the land. These emissions were calculated using a Tier 2 characterisation method (IPCC, 2006). To estimate the total direct emissions, an emission factor for each cattle category was calculated based on the nitrogen intake rate, the nitrogen retention rate and the nitrogen excretion rate.

Nitrogen intake rate ($N_{intake(T)}$)

The nitrogen intake rate corresponds to the gross energy intake that is in the form of crude protein in the diet and was calculated as follow (IPCC, 2006):

$$N_{intake(T)} = \frac{GE}{18.45} \cdot \left(\frac{\frac{CP\%}{100}}{6.25}\right)$$

Where: $N_{intake(T)}$ = daily nitrogen consumed per animal of category T, kg N animal^{-1} day^{-1}

GE = gross energy intake of the animal (from enteric model), MJ animal^{-1} d^{-1}

18.45 = conversion factor for dietary GE per kg of dry matter, MG kg^{-1}

CP% = percent crude protein in diet

6.25 = conversion from kg of dietary protein to kg of dietary N, kg feed protein $(kg\ N)^{-1}$

Nitrogen retention rate ($N_{retention(T)}$)

The nitrogen retention rate is based on the milk production, the milk protein content, the daily weight gain and the net energy for growth. The following equation was used to calculate the nitrogen retention rate (IPCC, 2006):

$$N_{retention(T)} = \left[\frac{Milk \cdot \left(\frac{Milk\ PR\%}{100}\right)}{6.38}\right] + \left[\frac{WG \cdot \left[268 - \left(\frac{7.03 \cdot NE_g}{WG}\right)\right]}{\frac{1000}{6.25}}\right]$$

Where: $N_{retention(T)}$ = daily N retained per animal of category T, kg N $animal^{-1}\ day^{-1}$

Milk = milk production, kg $animal^{-1}\ day^{-1}$

Milk PR% = percent of protein in milk, %

6.38 = conversion from milk protein to milk nitrogen, kg protein $(kg\ N)^{-1}$

WG = daily weight gain, kg day^{-1}

268 and 7.03 = constants from Equations 3-8 in NRC (1996)

NE_g = net energy for growth, MJ day^{-1}

1000 = conversion from grams per kilogram, g kg^{-1}

6.25 = conversion from kg dietary protein to kg dietary N, kg protein $(kg\ N)^{-1}$

365 = number of days in a year, day

The percent of protein in milk was derived from the following equation (IPCC, 2006):

$$Milk\ PR\% = [1.9 + 0.4 \cdot \%Fat]$$

Where : %Fat = percent of fat in milk, %

Nitrogen excretion rate ($Nex_{(T)}$)

The nitrogen excretion rate is based on the intake and retention rates and is calculated as follow:

$$Nex_{(T)} = N_{intake(T)} - N_{retention(T)}$$

Where: $Nex_{(T)}$ = daily N excretion rates, kg $animal^{-1} day^{-1}$

$N_{intake(T)}$ = daily N intake per head of animal of category T, kg N $animal^{-1} day^{-1}$

$N_{retention(T)}$ = daily N retained per animal of category T, kg N $animal^{-1}\ day^{-1}$

Direct nitrous oxide emission factor ($EF_{N2OD(mm)}$)

The direct nitrous oxide emissions specific to each cattle category was estimated with the following equation (IPCC, 2006):

$$EF_{N_2O_{D(mm)}} = \left[\sum_S \left[\sum_T \left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right)\right] \cdot EF_{3(S)}\right] \cdot \frac{44}{28} \cdot 365$$

Where: $EF_{N2OD(mm)}$ = direct nitrous oxide emissions from manure management, kg N_2O year^{-1}

$N_{(T)}$ = number of head of cattle category T in the region, head

$Nex_{(T)}$ = daily average nitrogen excretion per head of category T, kg N animal^{-1} day^{-1}

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each cattle category T that is managed in manure management system S

$EF_{3(S)}$ = emission factor for direct nitrous oxide emissions from manure management system S, kg N_2O-N/kg N in manure management system S

S = manure management system

T = cattle category

44/28 = conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

Indirect nitrous oxide emissions due to manure management systems

Methodology

The indirect emissions of nitrous oxide are also produced during the storage and treatment of manure before it is spread on the land. These emissions were calculated using a Tier 2 characterisation method (IPCC, 2006). The total indirect emissions are based on the nitrogen losses due to leaching from manure management systems.

Nitrogen losses due to leaching from manure management systems ($N_{leaching\text{-}MMS}$)

The nitrogen losses due to leaching are calculated with the equation below (IPCC, 2006):

$$N_{leaching-MMS} = \sum_S \left[\sum_T \left[\left(N_{(T)} \cdot Nex_T \cdot MS_{(T,S)}\right) \cdot \left(\frac{Frac_{leachMS}}{100}\right)_{(T,S)}\right]\right]$$

Where: $N_{leaching\text{-}MMS}$ = amount of manure nitrogen that leached from manure management systems, kg N year^{-1}

$N_{(T)}$ = number of head of cattle category T

$Nex_{(T)}$ = annual average nitrogen excretion per head of category T, kg N animal^{-1} year^{-1}

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each cattle category T that is managed in manure management system S

$Frac_{leachMS}$ = percent of managed manure nitrogen losses for cattle category T due to runoff and leaching storage of manure, %

Indirect nitrous oxide emissions due to leaching ($EF_{N2OL(mm)}$)

The indirect nitrous oxide emissions specific to each cattle category was calculated as follow (IPCC, 2006):

$$N_2O_{L(mm)} = \left(N_{leaching-MMS} \cdot EF_5\right) \cdot \frac{44}{28}$$

Where: $N_2O_{L(mm)}$ = indirect nitrous oxide emissions due to leaching and runoff from manure management, kg N_2O $year^{-1}$

EF_5 = emission factor for nitrous oxide emissions from nitrogen leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$ (default value 0.0075)

44/28 = conversion of (N_2O-N) emissions to N_2O emissions

Ammonia Emissions from Manure Management

Methodology

The volatilization of nitrogen from manure management in the form of ammonia and nitrogen oxides was calculated as indirect emissions of nitrous oxide. These emissions were calculated using a Tier 1 characterisation method (IPCC, 2006). The total indirect emissions are based on the nitrogen losses due to volatilization from manure management systems. There is potentially some ammonium from slurry storage in lagoons that is converted to N_2 gas, but since there were no data available for dairy cattle, these emissions are assumed to be negligible.

Nitrogen losses due to volatilization from manure management systems ($N_{volatilization-MMS}$)

The nitrogen losses due to volatilization are calculated with the equation below (IPCC, 2006):

$$N_{volatilization-MMS} = \sum_{S}\left[\sum_{T}\left[\left(N_{(T)} \cdot Nex_T \cdot MS_{(T,S)}\right) \cdot \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

Where: $N_{volatilization-MMS}$ = amount of manure nitrogen that volatilized from manure management systems, kg N $year^{-1}$

$N_{(T)}$ = number of head of cattle category T

$Nex_{(T)}$ = annual average nitrogen excretion per head of category T, kg N $animal^{-1}$ $year^{-1}$

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each cattle category T that is managed in manure management system S

$Frac_{GasMS}$ = percent of managed manure nitrogen for cattle category T that volatilises as NH_3 and NO_x in the manure management system S (Table 10.20 in IPCC, 2006), %

Ammonia and nitrogen oxides emissions as indirect nitrous oxide emissions due to volatilization ($N_2O_{G(mm)}$)

The indirect nitrous oxide emissions specific to each cattle category was calculated as follow (IPCC, 2006):

$$N_2 0_{G(mm)} = (N_{volatilization-MMS} \cdot EF_4) \cdot \frac{44}{28}$$

Where: $N_2O_{G(mm)}$ = indirect nitrous oxide emissions due to volatilization from manure management, kg N_2O $year^{-1}$

$N_{volatilization-MMS}$ = amount of manure nitrogen that volatilized from manure management systems, kg N $year^{-1}$

EF_4 = emission factor for nitrous oxide emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N+NO_x-N $volatilized)^{-1}$ (default emission value 0.01 from Table 11.3, IPCC, 2006)

44/28 = conversion of (N_2O-N) emissions to N_2O emissions

Ammonia Emissions from Housing

Sheppard et al (2011b) used models to estimate the intensity and spatial extent of NH3 emissions from various sources at the dairy farm, including housing. Emissions from housing facilities were based on emission fractions for the various facilities (barns, standing yards, exercise fields or pastures) and taking into account the variability in weather and manure management. Overall, lactating cows are found to be responsible for ammonia emissions in housing of 17 kg NH3/yr.head while dry cows are responsible for 7.6 and dairy calves and heifers for 3.1 kg NH3/yr.head. Dairy cows are assumed to be lactating for 305 days a year, and dry for the remaining 60.

In the IPCC Guidelines (2006), it is stated that volatilization nitrogen losses are in the form of NH3 and NOx, with most of the loss in the form of NH3. Considering the model that recommends evaluating indirect N2O emissions from NH3 (less than 1%), these emissions are also calculated, then NH3 is adjusted to not include this nitrogen in this outcome.

Carbon Sequestration from Land Use

It is common knowledge amongst stakeholders in climate change that soils present an important potential in GHG reduction, through carbon sequestration in soils.

Carbon is stored in the soil when plant decay occurs, releasing in the ground a fraction of the carbon that was originally absorbed from the atmosphere. Perennial plants are known to allow for a higher overall carbon intake than annual species because of the annual cropping and tillage operations required for the latter (Forage Technical Bulleting, 2008).

Grass and croplands which are already well managed are expected to operate close to their potential sink size, already at equilibrium with the atmosphere despite the exchanges of CO2 with the atmosphere in both directions (Baron, 2009).

Conversion of cropland to perennial pasture is one means of increasing C sequestration rates by farmland. While the current study followed the IDF guidelines (IDF, 2010) with respect to the exclusion of carbon captured in soils, communications with AAFC's Ray Desjardins explored that idea, based on research, that general trends of changes in crops from perennial to annual species and vice versa, observed in certain areas of the country, could contradict the assumption that sinks are stable.

General guidelines to optimize a carbon sink include choosing a species that is best suited to the local soil and climate, to help maximize growth and carbon sequestration, with a growth stage covering a longer period. Moreover, climate tolerance (to regular drought and heat) helps sustain productivity and carbon uptake during more stressful conditions. Species resistant to periodic flooding also help maintain CO2 intake while species with rapid regrowth potential after cutting or grazing minimize periods of slow growth when carbon dioxide releases (Forage Beef, 2001).

Adequate soil fertility helps to optimize carbon uptake, however, a lack of models prevents further analysis of the effect of over/under fertilizing on soil carbon.

Appendix E Data Quality Assessment

1 = Very Good, 2 = OK, 3 = Low		BC		AB		SK		MB		ON		QC		NB		NS		PEI	
Data	Impor-tance	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr	Rely	Repr
Average herd size – Dairy Cows	**High**	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Average herd size – Replacements	Medium	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1
Milk Production	**High**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stall management & bedding	Low	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1
Fertilizer type and amounts [1]	**High**	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1
Manure spreading areas	**High**	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Manure management practice	**High**	1	2	1	1	1	2	1	2	1	1	1	1	1	2	1	2	1	2
Pesticide type and amounts	Low	1	3	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Feed composition [2]	**High**	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Feed quantity [3]	**High**	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Dairy rations, Minerals & Supplements	Med-High	2	1	2	2	2	2	2	2	1	2	1	1	1	2	1	2	1	2
Housing	Low	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Equipment [4]	Low	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
Electricity at Farm	Low	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Water at Farm [5]	Low	2	2	2	2	2	2	2	2	2	1	2	1	2	1	2	1	2	1

1 = Very Good, 2 = OK, 3 = Low		BC		AB		SK		MB		ON		QC		NB		NS		PEI	
Gas at Farm	Low	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation for purchased feed	Low	3	1	2	1	3	1	3	1	2	1	2	1	3	1	3	1	3	1
Transportation - milk to processor	Low	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

1 Representative types, low reliability of concentrations.
2 Lack of data on protein supplements.
3 Extrapolated for West.
4 Based on EU datasets.
5 Good quality for tie-stall, proxy for free-stall.

The ratings in the table above are based on a 1 – 4 rating of reliability and representativeness, as described in the table below.

Qualification		Reliability		Representativeness	Comment
High quality	1	Specific validated or calculated data	1	Good geographical and technological representativeness	Satisfies high level standard
Acceptable quality	2	Validated or calculated data from other source	2	Geographical or technological lack of representativeness	Satisfies average standard
Low quality	3	Qualified estimate	3	Geographical and technological lack of representativeness	Satisfies minimum standard
Very low quality	4	Rough estimation	4	Proxy	Would require improvements

Reliability: Quality of data survey, size of data sample, robustness of extrapolation.

Appendix F Description of impact categories

Provided here are descriptions of each impact category evaluated by this study.

Human health

Impact that can be caused by the release of substances that affect humans through acute toxicity, cancer-based toxicity, respiratory effects, increases in UV radiation, and other causes; an evaluation of the overall impact of a system on human health has been made following the human health end-point in the IMPACT 2002+ methodology, in which substances are weighted based on their abilities to cause each of a variety of damages to human health. These impacts are measured in units of disability-adjusted life years (DALY), which combine estimations of morbidity and mortality from a variety of causes.

Ecosystem quality

Impairment from the release of substances that cause acidification, eutrophication, toxicity to wildlife, land occupation, and a variety of other types of impact; an evaluation of the overall impact of a system on ecosystem quality has been made following the Ecosystem quality endpoint IMPACT 2002+ methodology, in which substances are weighted based on their ability to cause each of a variety of damages to wildlife species. These impacts are measured in units of potentially disappearing fractions (PDF), which relate to the likelihood of species loss.

Resources depletion

Depletion caused when nonrenewable resources are used or when renewable resources are used at a rate greater than they can be renewed; various materials can be weighted more heavily based on their abundance and difficulty to obtain. An evaluation of the overall impact of a system on resource depletion has been made following the resources end-point in the IMPACT 2002+ methodology, which combines nonrenewable energy use with an estimate of the increased amount of energy that will be required to obtain an additional incremental amount of that substance from the earth based on the Ecoindicator 99 method (Goedkoop and Spriensma 2000).

Climate change

Alterations in the statistical distribution of weather patterns of the planet over time that last for decades or longer[30]; Climate change is represented based on the International Panel on Climate Change's 100-year weightings of the global warming potential of various substances (IPCC 2007). Substances known to contribute to global warming are weighted based on an identified global warming potential expressed in grams of CO_2 equivalents. Because the uptake and emission of CO_2 from biological sources can often lead to misinterpretations of results, it is not unusual to omit this biogenic CO_2 from consideration when evaluating global warming potentials. Here, the recommendation of the PAS 2050 product carbon footprinting guidance is followed in not considering either the uptake or emission of CO_2 from biological systems and correcting biogenic emissions of other gasses accordingly by subtracting the equivalent value for CO_2 based on the carbon content of the gas (BSI 2008).

Water Use

Inevntory of all volumes of water used in the life cycle of the product, with the exception of water used in turbines (for hydropower production). This includes the ground and surface water use (m^3 of water needed) whether it is evaporated, consumed or released again downstream. Drinking water, irrigation water and water for and in industrialized processes (including cooling water) are all taken into account. It considers freshwater and sea water.

30 Quantis definition.

Appendix G Detailed results by category

The following tables detail the overall impact by life cycle stage. These are **unallocated** (between meat and milk). A result allocated to milk only would be of 82% of the value of the unallocated result. The minimum and maximum provincial averages are also shown, with a variation range calculated, as a percentage of the average value.

Potential Impact on Climate Change	Kg CO2e	%	MIN	MAX	Range %
Feed Production	0.228083	19%	1.98E-01	3.52E-01	68%
Livestock Management	0.57965	47%	5.23E-01	6.31E-01	19%
Manure Management	0.327333	27%	1.98E-01	3.98E-01	61%
Energy & Buildings	0.05	4%	2.51E-02	1.71E-01	267%
Transportation	0.034844	3%	1.68E-02	5.71E-02	116%
Total	1.224482	100%	9.60E-01	1.61E+00	5.30E+00

Potential Impact on Ecosystem Quality	PDF.m2-yr	%	MIN	MAX	Range %
Feed Production	2.296257	98%	1.56E+00	2.67E+00	48%
Livestock Management	0.02474	1%	1.72E-02	3.49E-02	71%
Manure Management	0.00504	0%	3.47E-03	7.17E-03	73%
Energy & Buildings	0.01778	1%	9.19E-03	5.39E-02	252%
Transportation	0.00131	0%	5.41E-04	2.10E-03	119%
Total	2.34513	1.00E+00	1.59E+00	2.77E+00	5.64E+00

Potential Impact on Human Health	DALY	%	MIN	MAX	Range %
Feed Production	5.62E-07	60%	4.79E-07	6.33E-07	27%
Livestock Management	2.32E-07	25%	2.09E-07	2.56E-07	20%
Manure Management	4.8E-08	5%	4.34E-08	5.31E-08	20%
Energy & Buildings	5.62E-08	6%	3.56E-08	1.11E-07	134%
Transportation	3.65E-08	4%	1.75E-08	5.99E-08	116%
Total	9.35E-07	1.00E+00	7.85E-07	1.11E-06	3.18E+00

Potential Impact on Resource Depletion	MJ	%	MIN	MAX	Range %
Feed Production	1.732228	36%	1.52E+00	2.91E+00	80%
Livestock Management	0.521261	11%	1.90E-01	9.50E-01	146%
Manure Management	0	0%	0.00E+00	0.00E+00	-
Energy & Buildings	1.952249	41%	1.04E+00	3.02E+00	101%
Transportation	0.54382	11%	2.64E-01	8.93E-01	116%
Total	4.749558	100%	3.01E+00	7.77E+00	4.43E+00

Potential Impact on Resource Depletion	L water	%	MIN	MAX	Range %

consumed					
Feed Production	14.6	74%	4.7	65.0	578%
Energy & Buildings	1.8	9%	0.4	2.9	0%
Livestock Management	3.3	17%	3.0	3.5	14%
Transportation	0.1	0%	0.1	0.1	133%
Total	19.7	100%	10.9	70.8	500%

Results by midpoint damage categories

Impact category	Damage Category	Unit	AVG	% category
Respiratory inorganics	Human Health	DALY	9.08E-07	90.01%
Toxicity	Human Health	DALY	7.64E-08	7.57%
Carcinogens Indirect	Human Health	DALY	2.32E-08	2.30%
Ionizing radiation	Human Health	DALY	8.24E-10	0.08%
Respiratory organics	Human Health	DALY	3.39E-10	0.03%
Ozone layer depletion	Human Health	DALY	3.64E-11	0.00%
Global warming	Climate Change	kg CO2 eq	1.228141	100.00%
Non-renewable energy	Resources	MJ primary	4.801873	99.89%
Mineral extraction	Resources	MJ primary	0.005442	0.11%
Aquatic Ecotoxicity	Ecosystem Quality	PDF*m2*yr	8.583231	64.68%
Aquatic eutrophication	Ecosystem Quality	PDF*m2*yr	2.323798	17.51%
Land Arable	Ecosystem Quality	PDF*m2*yr	2.277137	17.16%
Acidification	Ecosystem Quality	PDF*m2*yr	0.071839	0.54%
Terrestrial Ecotoxicity	Ecosystem Quality	PDF*m2*yr	0.010226	0.08%
Turbined water	Ecosystem Quality	PDF*m2*yr	0.003537	0.03%
Aquatic acidification	Ecosystem Quality	PDF*m2*yr	0.000145	0.00%

Appendix H
Developing an Assessment Framework for a Social Life Cycle Analysis - a Literature Review

INTRODUCTION

The United Nation Environment Program (UNEP) in collaboration with the Society of Environmental Toxicology and Chemistry (SETAC) released the *Guidelines for Social Life Cycle Assessment of Products* (SLCA) in May 2009. These guidelines have been produced in order to provide the stakeholders engaged in a SLCA with a description of this tool and its scope, a framework of its design and, finally, a "flash light" that highlights areas where further research is needed (UNEP/SETAC, p. 5). Indeed, while being a significant step forward in the domain of social impact assessment, these Guidelines are still a work in progress that needs to be improved, refined and deepened in order to be fully implemented, especially in respect to the measurement issue.

The assessment of the social impacts induced by a product, a process or a company is indeed one crucial step of a SLCA. The Guidelines already offer a foundation – based upon a categorization of impacts categories and subcategories – allowing researchers and practitioners to consider the impacts incurred by different stakeholders. However, as the Guidelines point out, "further developments of impact assessment methods, socio and socioeconomic mechanisms and scoring systems are greatly needed" (p. 84). This requirement is indeed essential to assess the social impacts caused by the production of a specific product such as milk.

Accordingly, this appendix offers a review of the literature aiming at complementing and adapting the Guidelines in order to develop a specific framework to assess the social impacts of milk production, in a life-cycle perspective. More precisely, the review focuses on the stakeholder categories, the social issues of concern (subcategories) and the corresponding indicators that are relevant to milk production, but that are not actually covered by the Guidelines.

While S-LCA is a relatively new research field, a lot of work has been carried out in the last decade in the field of social impact analysis. For this reason, our review takes into account a vast array of sources, including fields of research such as *Social Impact Assessment* (SIA) and *Corporate Social Responsibility*, as well as different assessment models, like the one developed by the Global Reporting Initiative (GRI), most of which being in relation with the agricultural sector. Besides, there are also some interesting papers that have recently been published in line with the SLCA methodology and that are focused on the agricultural sector and the milk industry. The frameworks they propose, although still under development, deserve here a special interest.

In the following sections, we will thus review this vast literature and cover the identified frameworks in a stepwise manner, beginning with a discussion on the stakeholder categories commonly used (section 1), followed by an overview of the issues of concern considered (section 2) and finally by a description of a categorisation process to identify a list of potential socioeconomic indicators (section 3).

1. Stakeholder categories

The first attempts to include social aspects in the LCA framework date back to the mid-2000 (see Dreyer and al. 2006; Hunkeler 2006; Norris 2006; Weidema 2006). Although this research area is still in its infancy, the increasing efforts engaged in this field have contributed to the development of theoretical frameworks from which stem still many discrepancies, but from where consensuses also emerge. This is especially the case concerning the list of stakeholder categories commonly referred to.

According to the Guidelines, stakeholders are “those groups and individuals that can affect, or are affected by, the accomplishment of organizational purpose” (Freeman R., 1984 cited by UNEP/SETAC 2009, p. 47). The selection of the stakeholder categories in a SLCA depends on the scope of the study, but might also vary within each step of the supply chain. The Guidelines propose however a list of five stakeholder categories that are usually impacted by the life cycle of a product (section 5).

Our review shows that, notwithstanding the specific terms and definitions used, similar categorizations were used in studies that apply to the agricultural sector a S-LCA framework (Franze and Ciroth, 2011; Paragahawewa and al., 2009; Binder and al. 2008). Stakeholder categories such as “workers”, “local communities” and “consumers” are also commonly referred to in many studies analysing the social impacts related to agricultural production (see among others Bokkers and al. 2008; Caldeira Monteiro and al. 2006; Van Calker and al. 2003). This indicates that the list of stakeholder categories proposed by the Guidelines is globally adequate and exhaustive in regards to the existing literature.

There is, however, an interesting issue raised by Paragahawewa and al. (2009), following Labuschagne and Brent (2006) and Kölsch and al. (2008), concerning the inclusion of “Company” and “Future generations” as major stakeholder categories that should be included in a S-LCA.

According to the authors definition, the first category refers partly to the “Value chain actors” category found in the Guidelines, although it focuses more precisely on the social impacts caused by the company that produces the product rather than on those induced by the relationships of the firms involved in the production process, as it is the case in the Guidelines.

This specific perspective is a very relevant one since it questions the internal dimension of the social impacts at the company level, issue that is not directly tackled in the Guidelines but that can be found in many frameworks developed to assess the social impacts induced by agricultural production (Van Calker and al. 2003; Meul and al. 2008; Archer and al. 2008).

To assess the need to include such a category, it is necessary to recall that a SLCA is not intended to evaluate the sustainability of the firm itself, but rather the social impacts induced by its activities on the other stakeholders in order to promote sustainability. It is thus important to distinguish the S-LCA approach from other research programs that focus rather on the sustainability of the farm itself and on the social impacts that farming induces on the producer and his family (Zahm and al. 2005; Van Cauwenberg and al. 2007; Parent et al. 2010; Hayashi and Sato, 2010; Lord, 2011).

This said, the company is itself an entity distinct from its owners and shareholders. In respect to agricultural production, this distinction is even more significant, since the owner of a traditional family farm is usually its (sole) manager, employee and shareholder, while the farm is itself the home of the producer’s family. In this perspective, one could consider that farm activities induce on the producer and his family impacts similar to those affecting the employees and the surrounding neighbourhood.

The existing literature does not settle the question conclusively and the Guidelines' definition allows both perspectives. For this reason, we refer to the context of the current project to adopt a more conventional interpretation. We hence assume that the company and its owners, here the dairy farm and the dairy producers, are not stakeholder categories but rather those who impact their surrounding stakeholders by the accomplishment of their organizational purpose.

The second additional category under scrutiny is "Future generations". Paragahawewa and al. (2009) justify its inclusion given that S-LCA is being developed as a tool for sustainable development, and that the recognized definition of this notion specifically refers to the protection of the needs of future generations (pp. 17-18). There are however many challenges related to the inclusion of this category, among which the specification of what should be considered as the future generations as well as the way to conceptualize the social impacts they will have to support.

In regards to those issues, Paragahawewa and al. (2009) have adopted a perspective based on the preservation of natural resources for those who are not born yet, but other perspectives also exist. For example, Kölsch and al. (2008) measure the social impacts of the production process on future generations using the actual expenditures on some activities, such as R&D and capital investment, as a proxy to estimate the sustainability level to expect in the future. While the first point of view belongs to the field of an Environmental LCA, the second should be rather associated to the "Society" category, as it is already the case in the Guidelines. Consequently, "Future generations" will not be included in our framework. The corresponding impact subcategories and indicators will rather be associated to the others existing categories.

Finally, given the scope of our study, which focuses on milk production and its upstream supply chain activities, the relevance of including the "consumers" category was questioned. It has been finally decided to exclude it from the framework since dairy farm' activities – and the ones of their upstream suppliers – affect them only indirectly, mostly in regards to consumers' health and safety. The issues of concern potentially affecting consumers have instead been assessed in relation to the "Value chain actors" category, given that raw milk is the main input used by dairy processors to produce processed milk (or dairy products) sold to consumers.

2. Issues of concern (impact subcategories)

Most of the efforts deployed so far in the literature on social impacts assessment have been dedicated to the elaboration of conceptual frameworks aimed to list, describe and classify the diverse issues of concern (impact subcategories) that should be taken into account in regards to social sustainability.

In this section, we review these frameworks in order to select impact subcategories that capture issues of concern that are relevant with milk and agricultural production. The Guidelines' framework is adjusted accordingly. Each issue is classified in respect to one of the stakeholder categories retained for our study. Since the methodologies used in the literature covered are diverse and the frameworks proposed are not necessarily in line with the S-LCA's categorization, this allocation is sometime of our own.

Workers

The vast majority of the reviewed studies grant a significant importance to workers and their “working conditions”. Globally, the issues of concern considered, such as *working hours*, *social security*, *health and safety*, etc., are similar to those found in the Guidelines. Even impact subcategories that are not necessarily associated to the developed countries’ socioeconomic context, like “child labour” and “forced labour”, are sometimes included in frameworks, as it is the case with the model RISE[31]. Consequently, it doesn’t seem relevant at this point to subtract from our framework any of the actual impact subcategories used in the Guidelines in relation to the Workers category.

It is however possible to consider the inclusion of some other issues of concern in order to improve our framework, especially in relation to our focus on the agricultural sector and milk production. In this regards, the works of Paragahawewa & al. (2009) and Labuschagne & Brent (2006) offer an interesting point of view by suggesting the inclusion of “employment stability” and “capacity development” as two additional impact subcategories. According to Labuschagne and Brent, the first issue “addresses a business initiative's impact on work opportunities within the company, the stability thereof as well as evaluating the fairness of compensation”, while the second “addresses two different aspects namely research and development, and career development” (p. 6). Both focus thus on the professional growth opportunities created by the business and offered to its employees.

Moreover, this perspective also meets the idea of Caldeira Monteiro & al. (2006) and Abbing (2010), who both stress the importance of “Training” opportunities for employees as a major concern that affects their personal development and well-being.

Knowing that professional accomplishment has become a significant issue that affects each individual’s life quality, it seems particularly relevant to take into account a corresponding impact subcategory. Given the specific working conditions found in the agricultural sector, it appears even more relevant to tackle this issue. Consequently, we have decided to add the impact sub-category “**Professional accomplishment**” to our framework.

Local communities

There are many ways from which local communities can be affected by a given production process. Also, the Guidelines propose nine different impact subcategories. According to the nature and scope of the research project, some of them can naturally be subtracted. For example, Franze and Ciroth (2011) have only considered “indigenous rights”, “safe and healthy living conditions” and “local employment” in the S-LCA they conducted on the production of cut roses in the Netherlands and Ecuador. Similarly, some adjustments might also be needed in relation to our own study.

It is therefore possible to remove from the Guidelines’ list those impact subcategories that are not relevant with the context of milk production in Canada that is, “Delocalization and Migration”, “Cultural heritage”, “Respect of indigenous rights” and “Secure living conditions”. That is not to say

[31] RISE is an acronym for «Response-Inducing Sustainability Evaluation”. It is a computer-based tool that allows assessing the sustainability of agricultural production and trends hereof at farm level (early warning system). Information available online: http://www.shl.bfh.ch/index.php?id=310&L=2.

that these issues are of no importance, but rather that, according to their definitions[32], milk production do not have a significant impact upon them in Canada[33].

The other issues listed in the Guidelines are more relevant in the context of this study as it is attested by the review of the literature. In this regards, "Local economy" and "Community engagement" are two impact subcategories that are widely cited in the studies applied to the agricultural sector, as it is the case with authors such as Van Calker and al. (2003), Paragahawewa and al. (2009) and Lord (2011). The geographic concentration of this sector and its economic importance for some regions accentuate the relevance of these issues.

For authors such as Caldeira Monteiro and al. (2006) and Lord (2011), the "Safe & healthy living conditions" issue is also one major concern. These authors use respectively the expressions of "Occupational safety and health" and "Quality of the living environment" to encompass social impacts related to the risk exposure and the specific inconveniences (noise, vibration, dust, etc.) associated with agricultural production.

The Guidelines also refer to the expression "Access to material resources" to assess "the extent to which organizations respect, work to protect, to provide or to improve community access to local material resources (i.e. water, land, mineral and biological resources) and infrastructure (i.e. roads, sanitation facilities, schools, etc.)" (LCI 2010; Community, p. 42). While there is no direct reference to this issue in the reviewed literature, it is important to note that similar concerns are found in many studies, and could thus be capped under a specific impact subcategory.

For example, Van Calker and al. (2003) refer to notions such as "Landscape quality" and "multifunctionality" of agriculture, whilst Zahm and al. (2005) talk about the "Qualité des produits du terroir" and of the "Organisation de l'espace" to encompass concerns like the valorisation of built heritage, access to land and landscape quality. Meul and al. (2008) also refer to "Landscape management" and its corresponding notions (visual nuisance, nature conservation, architectural quality, etc.) as one crucial social aspect to tackle in relation with agricultural activity.

Moreover, Lord (2011) uses the expression "Quality of living environment" to relate to the "liveability of the built and natural environment in which people live and work" (p. 67), including the social (hospitals, counselling services, police, education) and physical (roads, water supply, sewage, harbour, gear storage) infrastructures. Using a monetised proxy, Paragahawewa and al. (2009) have for their part coined this concern about impacts on social infrastructures by referring to the "Tax allocation to social infrastructure" category. In sum, given the relevance granted to this issue in the literature, but also the specificity of its associated concepts, we have decided to include this impact subcategory to our framework under the expression "**Natural and built heritage**".

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[32] See their description in the Methodological sheet «Community" the Life Cycle Initiative (LCI, 2010).

[33] Even if the S-LCA methodology is designed to provide a generic framework to assess in a systemic manner the social impacts induced by a specific production or process, in most cases the cultural and geographical specificities cannot be avoided and the adaptation of the framework is preferable. This adjustment should thus be made according to the scope of the study and its final goal (a product/process/company comparison or a product / process improvement potentials identification). For example, Hayashi and al. (2010) have studied the famers' responses to social impact using the case of organic rice production in Japan. Accordingly, they give a significant attention to the «Cultural" and the «Family and community" issues to cope with the Japanese cultural specificities, whereas these issues are absent from the framework of Franze and Ciroth applied to cut roses sector in Ecuador and the Netherlands.

On the basis of our review, it would also seem relevant to bring a similar adjustment to the Guidelines' impact subcategory "Access to immaterial resources" in order to encompass some specific concerns that are not actually taken into account in the UNEP/SETAC's framework. According to the LCI's Methodological sheets, immaterial resources are defined as "community services, intellectual property rights, freedom of expression and access to information" (p. 34). Although most of these concerns are not necessarily relevant in relation to milk production in Canada, many studies raise concerns relative to "immaterial resources" that are of significant importance for the agricultural sector.

Among these concerns we find what Caldeira Monteiro and al. (2006) call "Social capital", Lord (2011) describes as "Family and community impacts", Van Cauwenbergh and al. (2007) as well as Lemay and al. (2008) refer to as "Social acceptability", and Meul and col. (2008) define as "Social services". Globally, all these notions are aimed to account for what affects the degree of harmony, acceptability and cohesion between the farmer and his surrounding community. Given that such "**Cohabitation**" is an issue of considerable relevance when it comes to assess social impacts of agricultural production, we propose to include this issue in our framework instead of using the category "Access to immaterial resources".

Society

As for the previous stakeholder categories, our review of the existing literature on social impact assessment in agricultural lead us to propose some adjustments to the Guidelines' list of impact subcategories related to "Society". Whereas issues such as "Contribution to economic development" and "Technology development" are two undisputable impact subcategories to consider in regards with the Canadian milk production supply chain, it doesn't seem relevant to include "Prevention & mitigation of armed conflicts", given this issue should assess for "the organization´s role in armed conflicts or situations that might in the future develop into armed conflicts" (LCI 2010; Society, p. 7).

Most of the reviewed studies focus however directly or indirectly on concerns related to the "Public commitments to sustainability issues" category. According to the LCI's Methodological sheets, "a public commitment is a promise or agreement made by an organization, or a group of organizations, to its customers, employees, shareholders, local community or the general public whose fulfilment can be evidenced in a transparent and open way" (p. 1).

In addition to such public commitments, some other "societal issues" of significant interest can be related to this "sustainability" concern. **Animal welfare** for instance, as discussed in the frameworks of Van Calker and al. (2005), Caldeira Monteiro and al. (2006), Bokkers and al. (2008), Meul and al. (2008), Maloni & Brown (2006), as well as in the Global Reporting Initiative's framework for food processing[34], is certainly the most significant in regards to our study. We also find in the work of Van Calker and al. (2003) and Maloni & Brown (2006) a similar preoccupation related to the use of genetically modified organisms (GMOs) and chemicals (fertilizers, pesticides, etc.) in agricultural production. The same could be said about the storage and spreading of manure, which can have a significant environmental impact depending on how it is performed. In fact, all the "**Agroenvironmental practices**" are of significant issue of concern for society and this category is hence included in our framework.

[34] Global Reporting Initiative (GRI). Available online: http://www.globalreporting.org/ReportingFramework/SectorSupplements/

Note that for authors such as Caldeiro Monteiro and al. (2006) and Zahm and al. (2005), "Food security", defined as the contribution of the firm to the global food supply, is also considered. In our view however, this issue de not constitute a relevant impact subcategory since it is not sufficiently correlated, in the Canadian context, to social impacts of significant importance.

Supply chain actors

Since most of the studies covered were not based upon a S-LCA methodology but have rather used methods focussed on the social impacts assessment at the company level (and many on the company itself), the impact subcategories associated to this stakeholder category have not been widely discussed.

Some authors did take, however, into account some related concerns, such as Franze and Ciroth (2011) who conducted one of the first S-LCA using the Guidelines' framework, and who referred to the impact subcategories "fair competition" and "promoting social responsibility" in relation to this stakeholder category.

In his study on the sustainability performance of the South African – European wine supply chain, Abbing (2010) uses the expression "Social Capital: Coherence and Trust" and "Trade & Finances" to tackle, respectively, the supply chain's "conduct towards interaction between chain actors and the flow of information with direct and indirect chain actors" and the "conduct of the wine supply chain towards ensuring honest and sustainable trade practices" (p. 22). Both perspectives refer broadly to the impact subcategories found in the Guidelines.

Using the Corporate Social Responsibility (CSR) framework, Forsman-Hugg and al. (2008) stresses for their part the relevance of fair income distribution and price margins in the food chain. Also part of the CSR approach, Maloni and Brown (2006) included "Fair trade", defined in terms of profit sharing, in their list of issues to cover in the food industry supply chain. Although not specifically focused on the agricultural sector, the recent ISO 26000's Guidance on social responsibility includes likewise "fair operating practices" among the core subjects that should address any organizations concerned by social responsibility (ISO 2010). This broad category encompasses in turn specific issues that overlap those found in the Guidelines' framework i.e. Anti-corruption[35], Responsible political involvement, Fair competition, Promoting social responsibility in the value chain and Respect for property rights.

In sum, given that the concerns found in the literature are similar to those already covered by the Guidelines, there is thus no need to complement the actual framework or to adjust the four impact subcategories proposed.

3. SOCIOECONOMIC INDICATORS

In order to perform a S-LCA – or any other social impact assessment analysis, a list of concrete and measurable indicators related to each of the impact subcategories chosen is required. It is those indicators that allow the estimation and then the comparison, on a common basis, of the results obtained from the assessment. This component of the framework is consequently crucial. As Abbing (2010, p. 16) points out however, there is no universally accepted set of sustainability indicators that

35 Within the Guidelines, this issue is related to the stakeholder category «Society".

could be referred to in order to conduct a social impact assessment. The indicators categorisation's process deserves thus a particular attention.

The reason is that the identification and selection of an indicator set depend on the nature and the scope of the study, as well as on the social impact measurement methods considered. Consequently, although it is possible to identify within the literature a large range of social indicator sets, it is more relevant to discuss in the first place the methodological issues related to the identification and utilisation of those indicators. A classification of generic indicators could then be proposed on the basis of our review in order to complete our normative framework, knowing that, given the focus of our study, it will have to be subsequently adjusted in relation to these methodological issues.

Methodological issue

To discuss the methodological issues related to the identification and selection of social indicators, we refer to the study of Meul & al. (2008), which develops an indicator-based monitoring tool for integrated farm sustainability (MOTIFS) by referring to an extensive set of parameters that are usually discussed in the literature but in a less systematic manner.

Among those parameters, the first discussed is the *criteria for the indicators* that have to be imposed in order to set explicitly the characteristics that the indicators have to fulfill to be included in the study. They selected five criteria in their study that is causality, sensitivity, solidness, use of benchmarks and comprehensibility, but other criteria could be retained, especially in relation to the S-LCA methodology. For example, Kruse & al. (2009) have developed, for their S-LCA applied to salmon production systems, a list of three criteria for indicators identification. These are "relevance, practicability and validity. Paragahawewa & al. (2009) have instead chosen their indicators on the basis of their relevance to the area of protection, i.e. human dignity and well-being.

The second parameter concerns the *indicator design*, that is, the method on which the indicators selection is based. In their study, Meul & al. (2008) referred to three distinct methods namely, existing literature, experts' opinion and fundamental research. Yet, most of the covered studies were rather based upon an experts' opinion method, referred as the "bottom-up" approach, as opposed to the "top-down" approach. Both are however considered complementary since they allow, as Kruse & al. (2009) point out, encompassing broadly recognized societal value, to include specific concerns for the industry/stakeholders and to adjust to data availability (p. 10).

Data availability is moreover considered by Meul & al. (2008) as the third parameter to take into account. Given the lack of publicly available database for social issues and the need to have access to qualitative data and subjective information in order to perform a S-LCA, this issue is even regarded as one of the major challenge related to the conduct of such an assessment and thus, it influences deeply the kind of indicators to be chosen. Indeed, the more aggregated and generic the data are, the less the indicators can measure precisely the corresponding social concerns. On the contrary, site-specific and primary data enable to develop precise indicators able to cope with specific social issues. However, the latter are difficult to obtain, which restricts the list of indicators that can be proposed. In fact, given that it is very costly, time consuming, and not always relevant to collect site-specific or primary data, the Guidelines recommend that the degree of data's precision, and thus the level of detail of indicators, should be function of the sphere of influence of the organization for which the product is being assessed (UNEP/SETAC 2009, p. 57). However, in Meul & al. (2008) as in many studies covered, data availability, rather than scientific soundness and methodological coherence, has determined the list of indicators included in the framework.

The *indicator typology* is another important parameter to consider. Although not widely discussed by Meul & al. (2008), Paragahawewa & al. (2009, p. 14) recall that there are three types of indicators reported in the literature, namely quantitative, semi-quantitative and qualitative indicators. Normally, the choice of one type of indicators is function of the kind of data available, quantitative and qualitative data being usually expressed in a quantitative and qualitative form – or translated into a semi-quantitative indicator. Whilst all types of indicators can be included in a S-LCA according to the Guidelines, the use of qualitative and semi-quantitative indicators raises however a methodological challenge since they can hardly be expressed per functional unit, i.e. the unit of output associated to a standardised function.

The Guidelines considered this issue (p. 40), but do not discuss in detail the question of the *causal relationship* between the indicators and the functional unit of the study. Paragahawewa & al. (2009, p. 11) recall however that there is an ongoing debate in the literature concerning the inclusion of indicators that are not directly related to the product or process, but rather to the conduct of the company. The issue is that, unlike biophysical flows measured in traditional LCA, social impacts induced by the company's conduct often cannot be directly connected to the product/process or, in some cases, easily quantifiable. Yet, these characteristics are essential in order to aggregate and compare the overall social impacts of a given product or process.

Given that a number of widely recognized socioeconomic sustainability concerns do not fit with these criteria but are nonetheless relevant, some authors like Dreyer and al. (2006) have proposed to circumvent this issue by sharing the total amount of impacts created by the company according to the weight that the company is given in the products/process in the whole chain. To avoid arbitrary weighting and reductive quantification, Kruse and al. (2009) suggest rather a categorization of indicators depending on whether they are *additive* or *descriptive*. The former are those indicators that meet two criteria, namely 1) they can be measured quantitatively and 2) they relate to the functional unit. Thereby, the latter are those that can be 1) quantitatively or quantitatively described / measured but 2) cannot be related to functional unit. In order to enable as much as possible comparison, the authors further distinguish the descriptive indicators that are *general*, that is, common to all cases and related to international conventions, from those that are *specific*, i.e. specifically related to the company, product or process of interest.

Unfortunately, since this concern is specific to the LCA methodology, most of the covered studies did not take this issue into consideration, thus limiting the possibility to compare the applicability of these methods. Besides, referring to three the S-LCA studies reviewed, no clear pattern emerges either. Naturally, Kruse and al. (2009) proposed an illustration of their framework in the case of the salmon industry, whereas Paragahawewa & al. (2009) have envisaged using the approach of Dreyer & al. (2006), though in both cases, their analysis ended before reaching the indicators specification step. As for Franze and Ciroth (2011), they defined a functional unit, but their social indicators assessment method, based on hotspots identification, is hardly connected to it.

The last parameter addressed by Meul & al. (2008) is about the *scoring methods*, i.e. the type of benchmark against which are compared the score of indicators in order to assess the relative performance of the product, process or company. Given the diversity of the indicators employed to cover the range of social impacts included in their model, these authors referred to a large number of methods. These are either based on scientific knowledge or legislative standards, comparison to a reference group, Best Available Techniques (BAT), questionnaire, expert judgement or a production possibility curve.

In order to standardise these measures and allow mutual comparison of indicators, Meul & al. (2008) also **quantified** and **rescaled** each indicator using a 0-100 value scale, according to the most relevant benchmark. For example, an economic indicator such as "value added per unit of farm capital" was evaluated using a reference group, the higher note (100) being granted to a farm that was among the 10% best-performing farms. When the indicator focused rather on a more subjective item, a self-evaluation questionnaire was used or an expert judgement was asked, also using the same scoring system. Finally, these authors used a **weighting method** to aggregate all results in order to obtain a unique and final score. To do so, they weighted the indicators according to the assumption that all selected sustainability themes are equally important – unless there was a considerable proof according to experts or the literature that certain indicators were more important than others.

It stems from the applied papers reviewed that the choice of the scoring methods is highly dependent of the scope of the study, especially in regards to its intended purpose, i.e. whether it is to identify hotspots, to assess a particular company/product' social impacts or to obtain results comparable «universally". No clear pattern thus emerges regarding the best method to adopt, although it is relevant to stress that the methodological framework proposed by Meul & al. (2008) is by far the most exhaustive among those reviewed in that matter. As for the sole study reviewed that concretely performed a S-LCA in relation to the agricultural sector, we note that the authors developed an assessment method relying on a five colors system to evaluate the social impacts based on a "intuitive" interpretation of the situation observed compared to international accepted standards (Franze & Ciroth, 2011). Neither quantification nor aggregation of results has thus been proposed, their objective being only of testing the new Guidelines framework and to identify social hotspots.

To sum up, the identification and selection of the right set of indicators to assess the social impacts of one product or activity was one of the main objective pursued in the studies covered by our review, were them intended to develop a conceptual framework or to assess effective social impacts of one case in particular. As discussed previously, a wide range of methodological issues has been considered in each case in order to elaborate a list of social indicators relevant to each corresponding situation. It follows that the sets of social indicators needed to develop a S-LCA framework are inherently case-specific and depends, among other things, of data availability and methodological choices. Accordingly, it is difficult to rely on the existing literature to develop a concrete list of formal indicators.

To develop our own list of socioeconomic indicators, we relied nonetheless on the ones proposed in the reviewed studies, in a top-down perspective to be complemented by a bottom-up adjustment process, given the goal and scope of this particular study.

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Appendix I Description of the Focus Groups

Three focus groups were held with farmers and dairy stakeholders (representatives of federations, experts, etc.) in three different locations across Canada. The objective of these meetings was to complete, refine and validate, based on the stakeholders' understanding of these issues, the list of socioeconomic issues to be assessed in the S-LCA conducted over the milk production sector. Table below presents the list of participants as well as the time and location where these focus groups took place.

Focus groups held

Groups	Participants
Longueuil, (Quebec) September 20th, 15:00	Geneviève Rainville, FPLQ Martine Labonté, FPLQ Marie-Andrée Faucher, CLD d'Autray Claude Corbeil, CLD Hélène Varvaressos, Agricarrières René Roy, Valacta Lisa Beaulieu, Dairy producer (N-B) Denis Morin, Dairy producer Gilbert Rioux, Dairy producer Maurice Montcalm, Dairy producer Pierre Lampron, Dairy producer
Mississauga (Ontario) September 29th, 12:30	Patrice Dubé, Dairy Farmers of Ontario Wes Lane, Dairy Farmers of Ontario Marc Lazenby, Dairy Farmers of Ontario Cindy Whytock, CanWest DHI Ian Rumbles, CanWest DHI Crystal Mackay, AGCare (OFAC) Sid Atkinson, Dairy producer Ralph Dietrich, Dairy producer John Palmer, Dairy producer Paul Vis, Dairy producer Dave Buttenham, Ontario Agri Business Association
Edmonton (Alberta) September 28th, 13:00	Mike Slomp, Alberta Milk Travis Skriver, Alberta Milk Shannon Park, Agriculture and Rural Development Mike Pearson, Agriculture and Rural Development Barry Robinson, Great Northern Livestock Consulting Lorrie Jespersen, Dairy producer Wim Ruysh, Dairy producer Hennie Bos, Dairy producer Albert Kamps, Dairy producer

The discussion were conducted in order first to bring the participants to identify the stakeholders with whom dairy farms are in relation with and to discuss about the socioeconomic issues associated with these various stakeholders. The idea was to take into account the participants' point of view over these issues. These focus groups were also the occasion to discuss with dairy farmers and their Board's representatives about their respective roles and responsibilities towards their stakeholders. The notion of "sphere of influence" was also discussed in order to identify to what extent Canadian dairy farmers and their organisations can influence the behaviours of their partners and stakeholders. Finally, these meetings allowed us to adjust the vocabulary used (and therefore understood) by the participants. The use of an appropriate language in our questionnaire was a key parameter which facilitated the data collection process at the farm level. Given that the three sessions were held in different provinces, it enabled us to observe differences in knowledge, perception and awareness between the groups.

The following sections present the main conclusions reached during these focus groups. This bottom-up process allowed us to adjust, complete and validate the assessment framework initially developed in a top-down approach (see Appendix H).

Identification of stakeholders

Globally, the participants identified in their own words the different stakeholder categories already listed in our framework (farm workers, local community, society, and value chain actors). The "worker" category was the most spontaneously named and discussed, probably because the presence of non-family related workers on farms is a new and growing challenge for dairy farmers. Four main subgroups of workers were identified, namely the regular, temporary, young and occasional workers. While the first category is the most commonly encountered, the other groups are also present and are related to specific issues of concern. Expectedly, family members working or living on the farm were also identified by the dairy farmers among the potentially impacted stakeholders. They have not been included in the framework however for methodological reasons (see Appendix H).

The social issues of concern identification

Based on the discussion guide, the participants were asked to freely list and discuss the issues of concern related to milk production in Canada. A list of issues was also submitted in order to boost the discussion when needed. Interestingly, there were no significant differences between the participants' points of view across regions. This exercise led us to insightful conclusions that allowed us developing the assessment framework presented in section 5.3.3 of the report. The most important issues discussed are listed below per stakeholder category.

A) Farm workers

The salary and workweek length issues were among the most discussed questions. Given the supply management system, dairy farmers consider they have the opportunity of paying good and competitive wages to workers compared to other farmers, but the competition is rough against other economic sectors (industries, mining, etc.). Workweek length is also an important issue which makes it sometime difficult finding and keeping workers. On the other hand, the jobs created are “recession proof” and annual. In regards to social benefits, the participants mentioned work time “flexibility” and “in-kind donations” as two particular practices observed on farms. The discussions showed that “human resource” issues are not yet a priority for dairy farmers.

The presence of young farm workers was also extensively discussed. The participants’ positions were contrasted. For some, “barn babies” grow with this reality which makes them tougher, more responsible and perseverant at school as well as in their future jobs. For others however, these young workers are “cheap labor” whose work on the farm can have a negative impact, especially in regards to their study. This mixed feeling shows the relevance of this specific issue.

Although still relatively marginal in the dairy sector, the presence of temporary foreign workers was also discussed since it is a growing phenomenon, especially in Alberta. Given the rules that supervised the hiring of such workers, dairy producers appear to be relatively well equipped to accommodate these workers and to offer them adequate working conditions.

B) Local communities

The essential character of farming for local and regional communities was also heavily stressed by the participants. The concepts of "occupancy of the territory", "vitality of the community", and economic activity have been raised to stress the importance of agriculture and the maintenance of dairy farms. The involvement of dairy farmers in their local communities has been extensively discussed, as well as their reliability and solidarity.

The negative aspects of agriculture on the environment have appeared relatively minor for the participants. Although there are some inconveniences related to agriculture (odours in particular), these inconveniences are seen as inherent to the rural life. If some "extreme behaviors" are sometime encountered, they are related to a minority and non-representative groups of producers. Producers perceive a major disconnection between what makes the headlines of the news and what they actually do in their daily production.

The participants also considered that their lasting, yet decreasing, presence in rural areas makes them major economic actors whose activities are crucial for the local economy. The role of agriculture for food security was also raised.

C) Society

Dairy farmers acknowledged that there are new and sensitive societal issues related to their activities, such as animal welfare and sustainable development. They are also committed to meet the public's expectations, although they consider that the population does not fully understand the reality and constraints of their activities ("people have no idea of agriculture"). Dairy farmers prefer emphasizing on the evolution of their practices in regards to sustainability (use of fertilizers, pesticides, animal welfare, etc.) than to consider what they could or should do.

The institutional framework in which dairy farmers operate has also been discussed. Expectedly, most participants made the promotion of the supply management system by enumerating its main advantages, but they also listed some of its disadvantages, namely the barrier to entry it creates for young farmers as well as the price of milk, which is becoming a issue both for consumers and politically.

D) Value chain actors

The discussions related to the value chain actors were mainly oriented towards the question of the "sphere of influence". At the farm level, the relation between the farmers and its first-tier suppliers appears very strong and characterized by a high level of trust and confidence. This relation is however limited to the professionals or sales representatives who come on the farm. Producers have no or very few professional relations beyond them. In order words, the sphere of influence of dairy farmers is, on an individual basis, quite small. Furthermore, producers mentioned that "service" and "availability" are the most important criteria to consider in the choice of their suppliers. "Environmental and social stuff" are not necessarily questioned.

In fact, the value chain perspective is still new for individual dairy farmers, probably due to the fact that many business relationships are delegated to their organization (federation). Collectively, dairy farmers and their Boards do seem to have a significant influence. However, they do not necessarily use it presently to modify the practices and behaviours of the sector' suppliers. To date, this issue has not been considered a priority for the sector.

Appendix J Detailed results of the Potential Hotspots Analysis

This Appendix presents the detailed results of the PHA conducted over the Canadian dairy sector's supply chains. Results are presented per supply chain. Each subsection includes:

1- A short description of the supply chain of the considered input or service;
2- A list of the companies included in the sample as proxies to conduct the PHA;
3- A presentation of the results; and
4- A detailed description of the information that justified the result when a risky situation is assessed.

The methodological framework used to conduct this assessment is described in section 5.4.

A) Retail and Wholesale

1- Description of the supply chain

The main agricultural inputs used in milk production, such as fertilizers, pesticides, seeds and animal feed, are generally supplied to farmers through agricultural wholesalers and retailers operating all over the country, often in vertically or horizontally integrated structures. This step, as well as the actors fulfilling this service to dairy farmers, is common for all these inputs. The potential hotspots are consequently assessed at this step regardless of the farm inputs provided to farmers.

2- Companies included in the sample

Crop Protection Services, Thompsons Limited and Cargill are three of the main companies included in the Agricultural Supplies Wholesaler-Distributors sector (NAICS 4183) operating in Canada. They were hence considered as proxies in order to identify potential hotspots related to the social issues under assessment.

- **Crop Protection Services**, a branch of **Agrium**, a Canadian enterprise, supplies pesticides, fertilizers and seeds to farmers mostly in Western provinces but also throughout Ontario;
- **Thompsons Limited**, a Canadian enterprise, supplies "agricultural supplies and services, including seed, fertilizer and crop protectants to farmers throughout Ontario's agricultural regions";[36]
- **Cargill**, an American owned enterprise, is a "producer and marketer of food, agricultural, financial and industrial products and services".[37]

[36] Thompsons' website [http://www.thompsonslimited.com/index.cfm?pagepath=About_Us&id=13988], accessed March 2012.

[37] Cargill's website [http://www.cargill.ca/canada/en/cargill-overview/index.jsp], accessed March 2012.

3- Detailed results

The table below presents the results for the Retail and Wholesale subsystem. Results have been differentiated between regions when possible (West – BC, AL, SK, MB; Central – ON, QC; East – NB, NS, PE, NL).

Results of the PHA of the Retail and Wholesale subsystem

Stakeholders	Subcategories	Distribution (CA)		
		West	Central	East
Workers	Freedom of association and collective bargaining	□ r	□ r	□ r
	Child labour		□ r	
	Fair salary[36]	□ s	□ s	□ s
	Working hours		□ s	
	Forced labour		□ r	
	Equal opportunities/Discrimination		□ c	
	Occupational Health and Safety		▨ s	
	Employment insecurity		▨ c	
Local Community	Access to material or immaterial resources		□ c	
	Safe and healthy living conditions		n/a	
	Respect of indigenous rights		■ c	
	Secure living conditions		□ c	
Society	Involvement in armed conflicts		n/a	
	Corruption		□ c	
	Fair distribution of revenues		▨ c	
Value chain actors	Fair competition		■ w	
	Respect of intellectual property rights		□ c	

CA Canada; c country; r Human rights reports; s Statistical indicator; w Web; n/a Not available

[38] The median salaries of the Agricultural supplies wholesaler-distributors (NAICS: 4183) in Canadian provinces being unavailable, the median salaries of the Trade sector (NAICS: 41, 44-45) in every province have been compared to the median salaries in the different provinces, all sectors included. Data were collected from Statcan (table 282-0072).

4- Detailed justifications

Freedom of association and collective bargaining

The 2012 Annual Survey of violations of Trade Union Rights points out Wal-Mart for violating the right of association in Quebec[39]. This suggests fragility in the protection of those rights in the retail sector in this province. The score for this subcategory is nevertheless rated low as this is a punctual event, while this company does not operate in the agricultural sector.

Child and Forced labour

Cargill has been criticized for buying cocoa from African farms[40,41,42], and cotton from Uzbek fields[43,44], both productions associated to child and forced labour. Cargill's 2010 sustainability report mentions the company's implication in the co-foundation of a certification program for cocoa farms – UTZ Certified certification – a certification however highly criticized by NGOs for not tackling some important sustainability issues[45]. Nevertheless, the score for this subcategory is rated low because this issue is not related to the delivery of inputs to the dairy farms and there is no mention of such violations in the Human rights reports covering the retail sector in Canada.

Occupational Health and Safety

The moderate score is due to a higher rate of non-fatal occupational injuries for the "Wholesale and retail and repair sector" compared to the Canadian average rate in 2008.

Employment insecurity

The moderate score attributed to the subcategory Employment insecurity is based on the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in Canada.

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39 ITUC, CSI, IGB (2012). Annual Survey of violations of Trade Union Rights - Canada, available online [http://survey.ituc-csi.org/Canada.html?lang=en#tabs-5], accessed March 2012.

40 Krebs, A.V. (2005). Monitoring Corporate Agribusiness From a Public Interest Perspective, The Agribusiness Examiner, Issue 414, available on the Organic Consumers Association website [http://www.organicconsumers.org/fair-trade/cocoa072005.cfm], accessed March 2012.

41 International Labour Rights Fund Press Release (2005). Human Rights Watchdog and Civil Rights Firm Sue Nestle, ADM, Cargill, for Using Forced Child Labor, available through the International Labor Rights Forum website [http://www.laborrights.org/stop-child-labor/news/11077], accessed March 2012.

42 Whitehead, J. (2005). Nestle faces négative publicity as child labour case is set for hearing, Brand Republic, available through the Business & Human Rights Ressource Centre website [http://www.business-humanrights.org/Categories/Lawlawsuits/Lawsuitsregulatoryaction/LawsuitsSelectedcases/NestleCargillADMlawsuitreCotedIvoire], accessed March 2012.

43 Environmental Justice Foundation (undated). Trade in Uzbek Cotton, available online [http://www.ejfoundation.org/page147.html], accessed March 2012.

44 Food & Water Europe (2009). Cargill Poses Threat to Consumer Health, the Environment and Human Rights, New Research Finds, available online [http://www.foodandwaterwatch.org/pressreleases/cargill-poses-threat-to-consumer-health-the-environment-and-human-rights-new-research-finds/], accessed March 2012.

45 Wikipedia (undated). UTZ Certified, Section: Criticism, available online [http://en.wikipedia.org/wiki/UTZ_Certified#Criticism], accessed March 2012.

Access to material or immaterial resources

Cargill has been associated to some delocalization, migration and human rights violations issues in Indonesia where its palm oil suppliers are linked to violence and home demolition events affecting community members[46], and to environmental damages[47]. Cargill's 2010 sustainability report says that the company achieved the certification of its palm oil suppliers with the Roundtable on Sustainable Palm Oil (RSPO) – a certification however criticized by NGOs[48]. The above criticisms are, however, neither related to the supply of dairy farms nor to the distribution activity of Cargill in Canada, thus resulting in a low possibility of encountering a hotspot in this subcategory.

Respect of indigenous rights

The high possibility of encountering violation of indigenous rights is based on data collected at the country level from the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011). Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in Canadian economic activities.

Fair distribution of revenues

The moderate score attributed to Canada is based on the Gini coefficient.

Fair competition

The farm's retail sector has been criticized for its rapid concentration[49]. A high possibility of encountering unfair competition is then attributed to the subsystem.

B) Fertilizer industry

1- Description of the supply chain

Fertilizers comprise three main nutrients or minerals: nitrogen (N), phosphate (P) and potash (K). Nitrogen is the mostly used nutrient by the fertilizer industry (62%), followed by phosphate (22%) and potash (16%)[50]. Although they are present in all the provinces, most Canadian fertilizer manufacturers are located in Quebec (36%) and Ontario (26%).

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[46] Schaeffer, A. (undated) Cargill Exposed: A Trail of Human Rights Abuses, Rainforest Action Network, available online [http://understory.ran.org/2011/08/31/cargill-exposed-a-trail-of-human-rights-abuses/], accessed March 2012.

[47] Wikipedia (undated). Critisms of Cargill, available online [http://en.wikipedia.org/wiki/Criticisms_of_Cargill], accessed March 2012.

[48] Wikipedia (undated). Roundtable on Sustainable Palm Oil, Section: Criticism, available online [http://en.wikipedia.org/wiki/Roundtable_on_Sustainable_Palm_Oil#Criticisms], accessed March 2012.

[49] Anderson, M. D. (2009). A Question of Governance: To Protect Agrbusiness Profits or the Right to Food?, Agribusiness Action Initiatives (AAI).

[50] Canadian Fertilizer Institute. Official website: http://www.cfi.ca/

The Canadian fertilizer manufacturers generate revenue of nearly $4.5 billion and a value added of $1.7 billion. They create 2 500 direct employments and provide more than $175 million annually in wages[51].

The production of K-fertilizers first requires extraction of potash. As one of the world major producer (mainly in western provinces), Canada does not import potash. It does however import K-fertilizers, mainly from the US[52]. The production of P-fertilizers also requires extraction of phosphate prior to manufacturing the fertilizer. According to the Canadian Fertilizer Institute, the largest phosphate deposits occur in the United States, North Africa and China[53], with the United States as the main Canadian supplier[54]. Finally, the production of N-fertilizers requires an important input of natural gas, as “nitrogen products are synthesized from the air (78 percent of air is nitrogen) using steam and natural gas”.[55] Nitrogen is produced in Canada and imported, mostly from the US.[56]

Companies involved in the extraction and (or) manufacturing of fertilizers are mostly large companies extracting potash and phosphate and manufacturing K, P and N-fertilizers. As a consequence, the socioeconomic performance of the extraction and manufacturing of fertilizers is not differentiated according to the type of fertilizers produced. However, as the extraction and manufacturing operations involve different economic sectors and can take place in different countries (here Canada and US), their performance is differentiated according to their activities and location.

2- Companies included in the sample

Six large companies involved in the extraction and/or manufacturing of fertilizers in Canada and the US have been selected in the sector’s sample:

1) **PotachCorp**, a Canadian company .responsible for one-fifth of global potash capacity”;[57]
2) **The Mosaic Company**, an American company, the “world's largest producer of finished phosphate product”;[58]
3) **Agrium**, a Canadian business “leading global producer and marketer of agricultural nutrients”;[59]
4) **CF Industries**, an American company, global leader in fertilizer manufacturing and distribution;[60]
5) **Koch Fertilizer**, an American business, one of the world’s largest and most advanced fertilizer company;[61]

.[51] Statistic Canada. Table 301-0006, Fertilizer manufacturers (32531).

[52] Industry Canada, Trade Data Online, Mineral or chemical fertilizers, Potassic (HS 3104), 2011

[53] Canadian Fertilizer Institute (undated). What we do, About Fertilizer, available online [http://www.cfi.ca/whatwedo/aboutfertilizer/], accessed March 2012.

[54] Industry Canada, Trade Data Online, Mineral or chemical fertilizers, Phosphatic (HS 3103), 2011.

[55] PotashCorp’s website, Investors, Segments, Nitrogen, available online [http://www.potashcorp.com/investors/segments/nitrogen/], accessed March 2012.

[56] Industry Canada, Trade Data Online, Mineral or chemical fertilizers, Nitrogenous (HS 3102), 2011.

[57] PotashCorp’s website [http://www.potashcorp.com/about/profile_vision_goals/], accessed March 2012.

[58] The Mosaïc Company’s website [http://www.mosaicco.com/about/company_overview_offices_and_operations.htm], accessed March 2012.

[59] Agrium’s website [http://www.agrium.com/about_us/what_we_do.jsp], accessed March 2012.

[60] CF Industries website [http://www.cfindustries.com/profile_overview.html], accessed March 2012.

[61] Koch Fertilizer’s website [http://www.kochfertilizer.com/locations.asp], accessed March 2012.

6) **Yara International**, a Norwegian company, global firm specializing in agricultural products and environmental protection agents.[62]

The table below shows the type of activities (extraction and/or manufacturing) carried out by those companies, according the location of their operations.

Selected companies in the Fertilizers industry

Companies	Extraction		Manufacturing	
	Canada	United States	Canada	United States
PotashCorp	X	X		X
Mosaic	X	X		X
Agrium	X	X	X	X
CF Industries		X	X	X
Yara			X	X
Koch			X	X

Source: Companies' website.

Since natural gas is required to manufacture N-fertilizers, the production and distribution of this input are also part of that supply chain. To simplify the analysis, only the supply of natural gas is considered in this system – the extraction step is assessed in the Fuel and Diesel system (see below).

As Quebec is the first N-fertilizer producer in Canada[63], gas distribution is assumed to take place in that province. The enterprise Gaz Metro is the only distributor of gas in Quebec and was hence assessed under the PHA.

3- Detailed results

The results of the PHA of the fertilizers industry are presented on below.

62 Yara International's website [http://www.yara.com/about/what_we_do/index.aspx], accessed March 2012.

63 Statistics Canada, Canadian Business Patterns Database, December 2011, available online on the Canadian Industry Statistics (CIS) website [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32531etbe.html], accessed March 2012.

Results of the PHA of the fertilizers industry

Stakeholders	Subcategories	Extraction (P and K)		Gas distribution	Manufacturing	
		CA	US	CA	CA	US
Workers	Freedom of association and collective bargaining	☐ r	▨ c	☐ r	☐ r	▨ c
	Child labour	☐ r	☐ c	☐ r	☐ r	☐ c
	Fair salary	☐ s	☐ s	☐ s	☐ s	☐ s
	Working hours	▨ s	▨ c	☐ s	☐ s	▨ c
	Forced labour	☐ r	☐ c	☐ r	☐ r	☐ c
	Equal opportunities/Discrimination	☐ c	☐ c	■ w	☐ c	☐ c
	Occupational health and safety	■ s	■ s	☐ r	▨ s	▨ s
	Employment insecurity	▨ c	▨ c	▨ c	▨ c	▨ c
Local community	Access to material or immaterial resources	☐ c	☐ c	☐ c	☐ c	☐ c
	Safe and healthy living conditions	▨ w	▨ w	n/a	n/a	n/a
	Respect of indigenous rights	■ c	▨ c	■ c	■ c	▨ c
	Secure living conditions	☐ c	☐ c	☐ c	☐ c	☐ c
Society	Involvement in armed conflicts	n/a	■ w	n/a	n/a	■ w
	Corruption	☐ c	▨ w	☐ c	▨ w	▨ w
	Fair distribution of revenues	▨ c	▨ c	▨ c	▨ c	▨ c
Value chain actors	Fair competition	☐ c	☐ c	☐ w	☐ c	☐ c
	Respect of intellectual property rights	☐ c	☐ c	☐ c	☐ c	☐ c

CA Canada; US United States; s Statistical indicator; r Human rights reports; w Web; c Country; n/a Not available

Fair salary:

As the extraction of potash take mainly place in Saskatchewan in Canada, the hourly median wage of the extractive sector in Saskatchewan (aggregated result: Forestry, fishing, mining, quarrying, oil and gas [NAICS: 21, 113-114, 1153, 2100]) has been used and compared to the provincial median wage; data coming from STATISTICS CANADA (table 282-0072). Concerning the manufacturing process of fertilizers in Canada, the annual average wage in the Fertilizer manufacturing sector (NAICS: 32531) in Canada (CIS, 2010 [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32411sale.html], accessed September 2012) has been compared to the country annual average wage (2011/2012) (Average salary survey, 2011/2012, available online [http://www.averagesalarysurvey.com/article/average-salary-in-canada/19192229.aspx]). Regarding the salaries in the US, data come from the Occupational Employment Stat – available online [http://www.bls.gov/oes/current/oessrci.htm], accessed March 2012 - and are for 2011. The non-metallic mineral mining and quarrying sector (NAICS: 2123) hourly median wage in the US has been compared to the US median wage for all activities. For the Pesticide, Fertilizer and Other Agricultural Chemical Manufacturing sector (NAICS: 3253) the hourly median wage has also been compared to the US median wage of all sectors. For the salaries in the gas distribution sector, the *Ministère de l'Éducation et Commission de la Construction du Québec* (available online [http://www.metiers-quebec.org/batiment/tech_gaz.html], accessed March 2012) published an average hourly wage of 16,25$ in 2010, which is above 60% of the Quebec median wage.

4- Detailed justifications

Freedom of association and collective bargaining

The moderate scores attributed to the US for this subcategory are derived from the country level performance assessed through the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

Working hours

The Canadian extractive sector is characterized by workweek longer than in any other sectors in the country, but agriculture (2006)[64]. The ILO database provides an average of 46.3 worked hours per week in the coalmining industry in Canada (which is used as a proxy for the P and K mining industries).

Regarding the US, the Social Hotspots Database suggests a moderate possibility of excessive working time at the country level. Therefore only activities carried out in the US received a moderate score for this issue.

Equal opportunities/Discrimination

A high possibility of encountering gender discrimination is attributed to the gas distribution since Gaz Métro has been fined, in 2008, for "systemic discrimination" towards women in the second half of the 1990's[65].

Occupational Health and Safety

The mining industry has been subject to concerns related to occupational health and safety[66,67]. Indeed, "mines can be hazardous environments and the possibility of fire, flood, explosion and collapse[68]" can affect workers. According to the statistic collected from the ILO database, rates of fatal occupational injuries are higher in the mining sector than the national average for both Canada and the United States. This leads to a high possibility of encountering health and safety issues in this industry. In regards to fertilizers manufacturing, ILO statistics on non-fatal occupational injuries in Canada and the US (2008) show a higher risk than the national average. This justified the moderate score attributed to the fertilizer manufacturing activities carried out in both countries.

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64 Statistics Canada, Graphique F - Les industries productrices de biens ont de plus longues semaines de travail, available online [http://www.statcan.gc.ca/pub/75-001-x/2008103/charts/10534/5004201-fra.htm], accessed March 2012.

65 Myles, B. (2008). Gaz Métro condamnée pour discrimination envers les femmes. Le Devoir, available online [http://www.ledevoir.com/societe/justice/205943/gaz-metro-condamnee-pour-discrimination-envers-les-femmes], accessed March 2012.

66 CBC news Saskatchewan (2010). Mine safety concerns raised at Sask. Legislature, available online [http://www.cbc.ca/news/canada/saskatchewan/story/2010/04/22/sk-worker-safety-mining-potash-10422.html], accessed March 2012.

67 International Federation of Chemical, Energy, Mine and General Workers' Unions (2006). CEP Mine Safety Teams Rescue Potash Miners, available online [http://www.icem.org/en/97-Sustainable-Development-Health-and-Safety/1644-CEP-Mine-Safety-Teams-Rescue-Potash-Miners], accessed March 2012.

68 Health and Safety Executive, Health and safety in mining, available online [http://www.hse.gov.uk/mining/index.htm], accessed March 2012.

Employment insecurity

The moderate score for employment insecurity is based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in Canada and the US.

Safe and healthy living conditions

Some criticisms related to "safe and healthy living conditions" have been addressed to the mining industry in Canada and the United States. In Canada, citizens have "launched an action against the mine for damages relating to lost wells, subsidence, noise, light and dust pollution as well as anxiety"[69]. Since this action is associated to a single enterprise, the possibility of encountering a hotspot is considered as moderate. Regarding the US, the moderate possibility of encountering mining companies associated to unsafe and unhealthy living conditions issues is based on a controversy around the delivery of a mining permit to the enterprise PotashCorp expected to result in environmental degradation[70]. If Koch fertilizer has not been associated to such issue in our research, some of its subsidiary companies have been associated to environmental negligence in several cases[71].

Respect of indigenous rights

The high possibility of encountering cases of violation of indigenous rights is based on the information collected from the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011). Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in the Canadian economic activities and especially in the mining sector. Regarding the US, the reports mention the poor living conditions of natives without reporting any specific violation, thus leading to a moderate possibility of encountering a social hotspot in this subcategory.

Involvement in armed conflicts

Our review shows that Mosaïc and PotashCrop were associated to phosphate sourcing from a Moroccan company operating in the Western Sahara, recognized as a non-self-governing territory by the United Nations. The NGO Western Sahara Resource Watch[72] claims that investing or buying from the Moroccan company occupying this territory is a form of legitimization. Mosaïc and PotashCrop's supplier doing business in a region with ongoing conflicts and the potential involvement of this organization into the development of an armed conflict are both reasons for considering the possibility of encountering a social hotspot as high. However, as the P-fertilizer industry is located in the US in the subsystem (see section Description of the supply chain), only the US received this score.

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69 Wikipedia, Potash Corporation of Saskatchewan, Section: Criticism, available online [http://en.wikipedia.org/wiki/Potash_Corporation_of_Saskatchewan#Criticism], accessed March 2012.

70 Wikipedia, Potash Corporation of Saskatchewan, Section: Criticism, available online [http://en.wikipedia.org/wiki/Potash_Corporation_of_Saskatchewan#Criticism], accessed March 2012.

71 Wikipedia, Koch Industries, Section: Environmental and safety record, available online [http://en.wikipedia.org/wiki/Koch_Industries#cite_note-42], accessed March 2012.

72 Western Sahara Resource Watch (undated) About western Sahara Resource Watch (WSRW), available online [http://www.wsrw.org/index.php?cat=114&art=515], accessed March 2012.

Corruption

In the US, the moderate possibility of encountering businesses associated to corruption is based on the Corruption Perception Index (2010), which is a measure of the perceived level of corruption in the public sector of a country by business people. The US also received a moderate score based on the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a weakness in the Transparency of government policymaking. In addition to this background performance, major criticisms are made towards the Koch Industry owners, the Koch brothers. They are accused of bankrolling the right wing in the US: "Whether they are contributing millions in campaign contributions, spending millions on lobbying, or investing millions in right-wing think tank and advocacy groups, the Koch brothers' influence is pervasive"[73]. Those criticisms support the moderate possibility of encountering corruption in the sector.

Fair distribution of revenues

The moderate scores attributed to Canada and the US are based on the Gini coefficient.

Fair competition

As the only gas distributor in Quebec[74], Gaz Metro is in a monopolistic situation. However, its activities are supervised by the *Régie de l'énergie du Québec* which minimized the negative effects such monopole could have on the market. The possibility of encountering unfair competition in the sector is therefore considered as low.

C) Pesticides industry

1- Description of the supply chain

Most Canadian pesticide manufacturers are located in Ontario (33%) and Quebec (20%). The rest do mainly operate in Western provinces. The Atlantic province accounts only one manufacturer in New-Brunswick.

Canadian pesticide manufacturers employ 260 people across the country and generate revenues of nearly $1G and a value added of $500G[75].

The value chain of the pesticides includes the production of the active ingredients prior the manufacturing process. Pesticides are produced in Canada as well as imported, mainly from the US. In Canada, agrochemical manufacturing is generally limited to formulation activity where "active ingredients are mixed with other chemicals into usable forms"[76]. Canadian agrochemical manufacturers are commonly subsidiaries of multi-national firms. They access their supplies (active ingredients or formulated products) from parent companies.

[73] Carrk, T. (2011). The Koch Brothers; What you need to know about the financiers of the radical right. Center for American Progress Action Fund, available online [http://www.americanprogressaction.org/issues/2011/04/pdf/koch_brothers.pdf]

[74] Except in Gatineau.

[75] Statistics Canada. Table 301-0006, Fertilizer manufacturers (32532).

[76] AAC. (1997). A Review of Agricultural Pesticide Pricing and Availability in Canada, available online [http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1179942676505], accessed March 2012.

2- Companies included in the sample

Four large pesticide companies having activities in Canada and in the US have been selected as proxies for the pesticides manufacturing sector:

1) **Monsanto** is an American biotechnology company[77];
2) **BASF**, a German company, "is the world's leading chemical company";[78]
3) **Dow AgroSciences** "is a global leader in providing agricultural and plant biotechnology products, pest management".[79] It is a segment of **Dow**, an American chemical company;
4) **Bayer CropScience** is «one of the world's leading innovative cropscience companies in the area of crop protection (Crop Protection), nonagricultural pest-control (Environmental Science), seeds and plant biotechnology (BioScience)".[80] It is a segment of **Bayer**, a chemical and pharmaceutical German company.

Regarding the manufacturing of the active ingredients, they can take place in a large variety of countries as those multinational companies have activities around the world (e.g. Dow has activity in more than 50 countries). Since it was not possible to identify where exactly these manufacturing activities take place, the social issues related to this step of the supply chain were indirectly assessed through the assessment of the companies included in the sample.

3- Detailed results

The results of the PHA of the pesticides industry are presented below.

[77] Monsanto's website [http://www.monsanto.ca/Pages/default.aspx], accessed March 2012.

[78] BASF's website [http://www2.basf.us/basf-canada/abt_overview_e.shtm], accessed March 2012.

[79] DOW's website [http://www.dow.com/about/], accessed March 2012.

[80] Bayer CropScience's website [http://www.bayercropscience.com/bcsweb/cropprotection.nsf/id/EN_Our_Company], accessed March 2012.

Results of the PHA of the Pesticides industry

Stakeholders	Subcategories	Pesticides manufacturing	
		CA	US
Workers	Freedom of association and collective bargaining	□ r	▨ c
	Child labour	□ r	□ c
	Fair salary[79]	□ s	□ s
	Working hours	□ s	▨ c
	Forced labour	□ r	□ c
	Equal opportunities/Discrimination	□ c	□ c
	Occupational health and safety	▨ w	▨ w
	Employment insecurity	▨ c	▨ c
Local Community	Access to material or immaterial resources	□ c	□ c
	Safe and healthy living conditions	n/a	■ w
	Respect of indigenous rights	■ c	▨ c
	Secure living conditions	□ c	□ c
Society	Involvement in armed conflicts	■ w	■ w
	Corruption	n/a	▨ w
	Fair distribution of revenues	▨ c	▨ c
Value chain actors	Fair competition	▨ w	▨ w
	Respect of intellectual property rights	□ c	□ c

CA Canada
US United States
s Statistical indicator
r Human rights reports
w Web
c Country
n/a Not available

[81] Concerning the Pesticides manufacturing in Canada, the annual average wage of the Pesticide and other agricultural chemical manufacturing sector (NAICS: 32532) in Canada (CIS, 2010 [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32411sale.html], accessed September 2012) has been compared to the country annual average wage (2012) (Average salary survey, 2011/2012, available online [http://www.averagesalarysurvey.com/article/average-salary-in-canada/19192229.aspx], accessed March 2012). Regarding the salary in the US, data come from the Occupational Employment Stat – [http://www.bls.gov/oes/current/oessrci.htm], accessed March 2012, and are for 2011. The Pesticide, Fertilizer and Other Agricultural Chemical Manufacturing sector (NAICS: 3253) hourly median wage has been compared to the one of the whole country.

4- Detailed justifications

Freedom of association and collective bargaining

The US score is based on the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

Working hours

The moderate score for this issue in the US comes from the Social Hotspots Database that highlights a moderate probability for the indicator "Risk of population working more than 48h per week".

Occupational Health and Safety

Pesticides are recognized as being potentially dangerous for people manufacturing them[82,83]. However, concerns on the health effects of pesticides are mostly directed towards the use of pesticide and not the manufacturing. In addition, Canada and the United States have monitoring and communication systems to supervise the manipulation of those products[84,85]. Therefore, the possibility of encountering health and safety issues in Canada or the US is rated as moderate.

Employment insecurity

The moderate score for employment insecurity is based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in Canada and the US.

Safe and healthy living conditions

Monsanto has been found guilty of "'outrageous' behavior by releasing tons of PCBs" into an American city[86]. Monsanto and Dow chemical are also responsible for several contaminated sites in the US[87,88]. Dow chemical, owner of Union Carbide Corporation (UCC), is pressed by survivors of the Bhopal major accident in India and human rights groups "to address the ongoing impacts of the disaster, including contamination of water by chemical waste, but the company has consistently

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82 Gilden, R. C., K. Huffling, et al. (2010). «Pesticides and Health Risks." Journal of Obstetric, Gynecologic, & Neonatal Nursing 39(1): 103-110.

83 Ashiru, O. A. and O. O. Odusanya (2009). «Fertility and Occupational hazards: Review of the Literature." African Journal of Reproductive Health 13(1).

84 Health Canada. Workplace Hazardous Materials Information System, available online [http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/about-a_propos-eng.php], accessed March 2012.

85 United States Department of Labor. Occupational Safety & HEalth Administration, available online [http://www.osha.gov/], accessed March 2012.

86 Grunwald, M. (2002). Mosanto Held Liable For PCB Dumping. The Washington Post, available online [http://www.washingtonpost.com/ac2/wp-dyn/A54914-2002Feb22?language=printer], accessed March 2012.

87 Wikipedia. Dow Chemical Company, Section: Environmental record, available online [http://en.wikipedia.org/wiki/Dow_Chemical_Company#Environmental_record], accessed March 2012.

88 Wikipedia. Monsanto, available online [http://en.wikipedia.org/wiki/Monsanto#Environmental_and_health_record], accessed March 2012.

ignored these calls, denying any responsibility for UCC's liabilities in Bhopal".[89] Given those information, it was considered there is a high possibility of encountering issues related to "safe and healthy living conditions" in the pesticides manufacturing industry in the US. No "safe and healthy living conditions" issue related to Canadian pesticides sector has been identified during the data collection phase.

Respect of indigenous rights

The high possibility of encountering violation of indigenous rights is based on the US Department of State Country report on Human Rights (2011)and the State of the World's Human Rights country report of Amnesty International (2011). Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in Canadian economic activities. Regarding the US, the reports are mentioning the poor living conditions of the natives without referring to any specific violation of Indigenous Rights, therefore leading to the moderate score attributed to this subcategory for activities carried out in the US.

Involvement in armed conflicts

Dow has been criticized for selling pesticides to the Sadam Hussein's regime "despite warnings that they could be used to produce chemical weapons"[90]. The sale of Agent Orange during the Vietnam War also suggested involvement in armed conflicts from chemical enterprises, including Monsanto and Dow[91]. A high score is hence attributed to the pesticide manufacturing sectors in both countries since there is a high possibility of encountering enterprises with such involvements.

Corruption

Monsanto was judged guilty of corruption and of falsifying entries into its books and records. Bribing practices have also been highlighted[92]. Their lobby practices and the fact that some politicians terminate their carrier at Monsanto[93] also suggested a possibility of corruption. As issues have only been found for Monsanto in the US, the possibility of encountering such behavior is considered as moderate for the US, but non available in Canada.

Fair distribution of revenues

The moderate scores attributed to Canada and the US are based on the Gini coefficient.

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[89] Amnesty International (2010). Dow cannot run from the legacy of Bhopal by sponsoring 'Run For Water' events, available online [http://www.amnesty.org/en/news-and-updates/dow-cannot-run-legacy-bhopal-sponsoring-run-water-events-2010-04-16], accessed March 2012.

[90] Global Exchange. «Most Wanted" Corporate Human Rights Violators of 2012, available online [http://www.globalexchange.org/corporateHRviolators], accessed March 2012.

[91] Rizo, C. (2009). U.S. Supreme Court declines to hear Agent Orange lawsuits, available online [http://www.legalnewsline.com/news/219697-u.s.-supreme-court-declines-to-hear-agent-orange-lawsuits], accessed March 2012.

[92] BBC News (2005). Monsanto fined $1.5m for bribery, available online [http://news.bbc.co.uk/2/hi/business/4153635.stm], accessed March 2012.

[93] Wikipedia. Monsanto, available online [http://en.wikipedia.org/wiki/Monsanto#Environmental_and_health_record], accessed March 2012.

Fair competition

Six companies (including the four enterprises selected in the sample) hold 85% of the worldwide pesticides sales in 2007[94]. This suggested a high possibility of encountering unfair competition in Canada and the US in the pesticides sector.

D) Seeds industry

1- Description of the supply chain

The Canadian seed industry is made up of approximately 154 seed companies and 4 500 producers of pedigree seeds[95]. The sector generates about $1.9G annually in domestic and export sales and employs more than 14 000 people.

The value chain of the seeds includes a breeding step (R&D) and the growing of the seeds. According to the Canadian Seed Trade Association[96], Canada is an important producer and exporter of seeds which suggests a high probability of having the seeds bought by the Canadian dairy farmers coming from Canada. Both steps of the subsystem are thus considered has being located in Canada. The agricultural activity in Canada is assessed as part of the animal feed supply chain (see below) and, as social issues are not expected to be different whether the crop produces seeds or feed, this step is excluded from the seeds industry's supply chain.

2- Companies included in the sample

Three seed breeding enterprises have been selected in the sample to support the search of social issue associated with that activity:

1) **Pioneer Hi-Bred**[97], an American company subsidiary of **DuPont**;
2) **Syngenta**[98], a Swiss agribusiness; and
3) **Pickseed**[99], a Canadian company.

3- Detailed results

The results of the PHA of the pesticides industry are presented below.

94 *IPS Inter Press Service*, 7 décembre 2007, in Wikipedia: http://fr.wikipedia.org/wiki/Monsanto

95 AAC. Canada's seed industry, http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1174596024742&lang=eng

96 CSTA (2011). Fast Facts, available online [http://cdnseed.org/about-us/fast-facts/], accessed March 2012.

97 Pioneer Hi-Bred's website [http://www.pioneer.com/], accessed April 2012.

98 Syngenta's website [http://www.syngenta.com/], accessed April 2012.

99 Pickseed's website [http://www.pickseed.com/], accessed April 2012.

Results of the PHA of the Seeds subsystem

Stakeholders	Subcategories	Seeds Breeding CA
Workers	Freedom of association and collective bargaining	□ r
	Child labour	□ r
	Fair salary[98]	□ s
	Working hours	□ r
	Forced labour	□ r
	Gender equality	□ c
	Occupational health and safety	n/a[99]
	Employment insecurity	▨ c
Local Community	Access to material or immaterial resources	▨ w
	Delocalization	□ c
	Cultural heritage	▨ w
	Safe and healthy living conditions	▨ w
	Respect of indigenous rights	■ c
	Secure living conditions	▨ w
Society	Involvement in armed conflicts	n/a
	Corruption	□ c
	Fair distribution of revenues	▨ c
Value chain actors	Fair competition	■ w
	Respect of intellectual property rights	□ c

CA Canada · r Human rights reports · w Web
c Country · s Statistical indicator · n/a Not available

[100] The hourly median wage of the sector Professional, Scientific and Technical Services (NAICS: 54) of Canada has been compared to the national median wage. Data come from STATISTICS CANADA (table 282-0072).

[101] Scientific and Technical Services (54) is not covered in the ILO database.

4- Detailed justifications

Employment insecurity

The moderate score attributed to this impact subcategory is based on the World Economic Forum (WEF) annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in Canada.

Access to material or immaterial resources

The food security issue, defined as the capacity of people to have access to a sufficient quantity of food of sufficient quality, is intimately related to this social issue of concern. In this regards, the agribusiness sector is considered liable by many for the food insecurity affecting many regions around the world[102]. These critics are generally related to their control over farm inputs – including seeds, given the patents they own, such as those they hold over genetically modified (GM) seeds. Regardless the property right issue, such control can restrict access to these inputs and create financial burdens to acquire them, especially for small and self-sufficient farm holders.[103].

At the same time, some agribusinesses are also involved in initiatives aiming at guarantying food security in these regions by providing "small farmers with access to finance, guaranteed markets and technical assistance, with (up to hundreds of) agronomists training them to improve their yields and meet international accreditation standards".[104] A social involvement however considered suspiciously by some observers.[105]

This contrasted situation raises a concern regarding the responsibility of the agribusiness sector in general and the seed breeding companies in particular towards the food (in)security issue. Given the significant possibility of encountering companies with risky behaviours related to this issue, a moderate score is given.

Cultural heritage; Safe and healthy living conditions; and Secure living conditions

Wikipedia highlights a case on its Syngenta page suggesting a possibility of encountering issues related to three of the S-LCA guidelines subcategories: Cultural heritage, Safe and healthy living conditions and Secure living conditions:

> "Syngenta was condemned in May 2010 by the Permanent People's Tribunal, Madrid, for human rights violations in Brazil. The case involved the killing of Valmir Mota de Oliveira (aka Keno) and injuries to other workers by private security firm *NF Security*, hired by Syngenta to

102 United Nations (2009). Report of the Special Rapporteur on the right to food, Olivier De Schutter – Agribusiness and the right to food. Human Rights Council, Thirteenth session, Agenda item 3. A/HRC/13/33. 20 pages. Available online: http://www.srfood.org/images/stories/pdf/officialreports/20100305_a-hrc-13-33_agribusiness_en.pdf

103 Kropiwnicka, M (2005). Biotechnology and food security in developing countries: The case for strengthening international environmental regimes. Journal on Science and World Affairs, Vol.1 (1). 45-60 pp. Available online: http://www.scienceandworldaffairs.org/PDFs/Kropiwnicka_Vol1.pdf

104 Deutsche Bank Research (2010). Agribusiness and hunger – Threat to global food security drives collaborative business models. Talking Point. 2 pages. Available online: http://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000253756.pdf

105 GRAIN (2008). Seed aid, agribusiness and the food crisis. Seedling – October 2008. Available online: http://www.grain.org/article/entries/683-seed-aid-agribusiness-and-the-food-crisis

evict approximately 200 rural workers from one of their sites. Protestors had occupied the site in protest against the corporation's violation of Brazilian environmental laws in the Iguaçu National Park region, a UNESCO World Heritage area. A September 2007 Federal Police investigation of NF Security concluded that *»it was established that the company NF Security recruits private security guards who carry out evictions (...) the majority of people contracted by the company have neither the capacity nor the authorization to work as private security guards, and are acting as such illegally."*[106] Although Syngenta denies knowing that security guards were armed, there are clear indications in the police investigation that the company in fact knew they were armed."

As only one case of inappropriate behavior by Syngenta has been documented, the possibility of encountering a hotspot is considered as moderate for the three subcategories.

Respect of indigenous rights

The high possibility of encountering violation of indigenous rights is based on data collected at the country level in the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011). Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in Canadian economic activities.

Fair distribution of revenues

The moderate score attributed to Canada is based on the Gini coefficient.

Fair competition

According to Wikipedia[107], some of the companies involved in seeds breeding suited each other for anti-trust behaviors. The Agribusiness Action Initiatives (AAI)[108] also highlights the fact that the market for crops inputs, including seeds, is increasingly consolidated and centralized which make "real competition […] impossible and small-scale players cannot get fair prices." This suggests a high possibility of unfair competition.

[106] Via Campesina (2008). The case of Syngenta – Human rights violation in Brazil, 2008, available online [http://viacampesina.net/downloads/PDF/The%20Case%20of%20Syngenta%20-%20Human%20Rights%20Violations%20in%20Brazil.pdf], accessed April 2012.

[107] Wikipedia. Syngenta, available online [http://en.wikipedia.org/wiki/Syngenta], accessed in April

[108] Anderson, M. D. (2009). A Question of Governance: To Protect Agrbusiness Profits or the Right to Food?, Agribusiness Action Initiatives (AAI).

E) Animal feed

1- Description of the supply chain

Animal feed, especially purchased feed, is the most important input used in milk production on a cost basis. There are three main types of feed consumed by cows: concentrates (grains and dairy ration, protein supplement and salt and minerals), forages (silage, high moisture grain, haylage, etc.) and other feeds such as straw and by-products.[109]

In Canada, many dairy producers feed their cattle with on-farm grown grains and forages. Many also possess their own feed mills and produce their own dairy ration. However, milk producers rarely grow all the feed they need and need to purchase some. The percentage of feed purchased by dairy producers varies across regions. It amounts for example to 31% in Quebec, 14% in Ontario and 25% in the Atlantic.[110]

Milk producers usually buy feed from farm input suppliers or directly from feed mills. Feed mills are present in every Canadian province. However, most of them are concentrated in Ontario (31%), Quebec (29%) and the Prairies (28%) where most of the animal production is located[111].

Feed producers get their grain from crop producers. Grain comes mainly from the Canadian market. Canada imports soybeans and corn but in small quantities, respectively 9% and 13% of total supplies, mainly from the United States. Soybeans are mostly imported as soybean meal[112]. To frame the PHA, the grain production step has been limited to the production of wheat in the western Canadian provinces and to the production of corn in the eastern provinces[113].

Supplements and additives, which include amino acids, vitamins, minerals and antibiotic and non-antibiotic ingredients, are another major input used in feed production. Since most major feed manufacturers are also involved in the production of such inputs (in Canada or abroad), the two steps have been merged together in this PHA.

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109 AGECO (2011). Enquête annuelle sur les coûts reliés à la production de lait au Québec, en Ontario et dans les Maritimes.

110 AGECO (2011). Enquête annuelle sur les coûts reliés à la production de lait au Québec, en Ontario et dans les Maritimes.

111 Statistics Canada, Canadian Business Patterns Database, Other animal food manufacturing, NAICS 311119, December 2009. Compilation by AGECO, 2011.

112 Statistics Canada. Tables 001-0041 and 001-0042 and Canadian International Merchandise Trade Database, 2009. Compilation by AGECO, 2011.

113 According to the 2006 Statistics Canada (STC) Census of Agriculture, there were 60 743 farmers producing wheat, 73% of which are located in Saskatchewan alone ([http://www.agriculture.gov.sk.ca/Statistics-Farms] accessed April 2012). 63% of the Canadian corn production takes place in Ontario ([http://publications.gc.ca/collections/collection_2009/agr/A118-10-13-2006F.pdf] accessed April 2012).

2- Companies included in the sample

In Canada, feed mills are generally of mid-size and supply mostly local markets. To conduct the PHA, two major companies have nonetheless been selected to be used as proxies for the sector. These businesses are:

1) **Ridley Inc**., a Canadian business manufacturing animal feed mostly in the western provinces[114];
2) **Nutreco**, a Dutch company having animal feed manufacturing plants located in the western and eastern Canadian provinces and supplying the brands Shur-Gain and Landmark Feeds[115].

No sample of businesses has been used at the grain and oilseed production step, since the published commentaries on risky behaviours mainly deal with large companies. No relevant public information could be found at the individual farm level. The social issues related to additives and supplements manufacturers are documented through the information collected at the feed producer company level.

3- Detailed results

The results of the PHA of the Animal feed industry are presented below.

[114] Ridley's website [http://www.ridleyinc.com/companies/caoperations.cfm] accessed April 2012.

[115] Nutreco's website [http://www.nutreco.com/index.php?option=com_content&task=view&id=518&Itemid=536] accessed April 2012

Results of the PHA of the Animal feed industry

Stakeholders	Subcategories	Feed production	Additives and supple-ments manufac-turing	Grain production	
		CA	CA	CA(W)	CA(E)
Workers	Freedom of association and collective bargaining	□ r	□ r	□ r	■ r
	Child labour	□ r	□ r	□ r	□ r
	Fair salary[114]	□ s	□ s	□ s	▨ s
	Working hours	□ r	□ r	▨ s	▨ s
	Forced labour	□ r	□ r	□ r	□ r
	Equal opportunities/Discrimination	□ c	□ c	□ c	□ c
	Occupational health and safety	□ w	▨ w	■ w	■ w
	Employment insecurity	▨ c	▨ c	▨ c	▨ c
Local Community	Access to material or immaterial resources	□ c	□ c	□ c	□ c
	Safe and healthy living conditions	□ w	□ w	□ w	□ w
	Respect of indigenous rights	■ c	■ c	■ c	■ c
	Secure living conditions	□ c	□ c	□ c	□ c
Society	Involvement in armed conflicts	n/a	n/a	n/a	n/a
	Corruption	□ c	□ c	□ c	□ c
	Fair distribution of revenues	▨ c	▨ c	▨ c	▨ c
Value chain actors	Fair competition	■ w	■ w	□ w	□ w
	Respect of intellectual property rights	□ c	□ c	□ c	□ c

CA	Canada	(W)	Western provinces	(E)	Eastern provinces
r	Human rights reports	w	Web	c	Country
s	Statistical indicator	n/a	Not available		

[116] For the Animal feeds manufacturing and the Additives and supplements manufacturing, the annual average wage of the Animal Food Manufacturing sector (NAICS: 3111) in Canada (CIS, 2010 [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32411sale.html], accessed September 2012) has been compared to the country annual average wage (2012) (Average salary survey, 2011/2012, available online [http://www.average salarysurvey.com/article/average-salary-in-canada/19192229.aspx]). Regarding the wheat production, the hourly median wage of the Agricultural sector [NAICS: 111-112, 1100, 1151-1152] in Saskatchewan was compared to the provincial median wage; data come from STATISTICS CANADA (table 282-0072).

4- Detailed justifications

Freedom of association and collective bargaining

The US Department of State Country report on Human Rights in Canada highlights issues of Freedom of association and collective bargaining in farming activities in Quebec and in Ontario. The report states that in Quebec laws restrict the eligibility for unionization to farms with at least three permanent employees, and in Ontario, agricultural workers do not have the right to organize and/or bargain collectively under the provincial law. This suggests a high possibility of encountering impairment of the freedom of association and collective bargaining.

Fair salary

The hourly median wage of the corn production sector in Ontario is represented by the hourly median wage of the Agricultural sector [NAICS: 111-112, 1100, 1151-1152] in that province and is found to fall between 50% and 60% of the provincial median wage[117]. According to the evaluation scale (see section 5.3.3) based on ILO works, this leads to a moderate possibility of encountering unfair salary.

Working hours

The ILO database provides an average of 45 hours of work per week (in 2008) in the Canadian agricultural production sector which suggests a moderate possibility of encountering excessive hours of work.

Occupational health and safety

Regarding the animal feed manufacturing step, the level of exposure to flour dust represents an occupational health and safety issue. It has potential health effect like respiratory diseases, and it is also related to safety issues as dust is susceptible to burn rapidly when ignited[118]. It is however stated that the risk level is "not achievable in any country in the world using state-of-the-art flour milling technology."[119] The possibility of encountering a risky level of exposure to flour dust is therefore considered as low in Canada. However, as recalled by an incident which ended with the death of a worker in Quebec in 2011[120], appropriate health and safety management measures are required in this industry which entails some risks.

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[117] Data comes from STATISTICS CANADA (table 282-0072).

[118] Highbeam Buniness (2012). Flour and Other Grain Mill Products, available online [http://business.highbeam.com/industry-reports/food/flour-other-grain-mill-products], accessed April 2012.

[119] Canadian National Millers Association (undated). Industry Objectives, Section: Occupational Safety and Health – Flour Dust, available online [http://www.canadianmillers.ca/english/issues/#flourdust] accessed April 2012.

[120] CSST (2011). Communiqués: *Décès d'un travailleur après une chute de 5,8 mètres: la CSST identifie des lacunes dans la gestion*, available online [http://www.csst.qc.ca/salle_de_presse/actualites/2011/Pages/9_novembre_trois_rivieres.aspx] accessed April 2012

Regarding the production of additives, there is concern related to activities leading to a high exposure to potentially drug-resistant organisms, which includes workers in the food-manufacturing industry[121]. A moderate score is given to this step.

In the crop production sector, pesticides are recognized as being potentially dangerous to people using them. The risk of health effect depends of both, "the toxicity or hazard of the pesticide and the likelihood of exposure"[122]. The Canadian government is responsible of "registering pest control products, re-evaluating registered products and setting maximum residue limits under the *Food and Drugs Act*."[123] The fact that pesticides sold in Canada are controlled could suggest that health effects are acceptable. However, the Canadian regulation on pesticides is seen as inadequate by some NGO[124]. A review on clinical implications of pesticides use also listed numerous health effects linked to the use of pesticides as cancers and neurological and reproductive effects[125]. All those concerns related to the safety of pesticides suggested a high probability for Occupational health and safety issues for the crop production sector in Canada.

Employment insecurity

The moderate score attributed to the subcategory employment insecurity in Animal feed manufacturing is based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in Canada.

Safe and healthy living conditions

Regarding crop production, impacts on the quality of life of rural communities commonly associated to extensive animal farming are also found in the case of large crop production[126]. Problems related to health, quality of drinking water, dust, bugs, noise and traffic are listed. Our research could not confirm that those nuisances were specifically found encountered in corn production in Quebec or wheat production in Saskatchewan and the risk of safe and healthy living conditions is then considered as low.

Respect of indigenous rights

The country level indicators using the US Department of State Country report on Human Rights (2011)and the State of the World's Human Rights country report of Amnesty International

[121] European gency for Safety and Health at Work (2007). Expert forecast on Emerging Biological Risks related to Occupational Safety and Health, available online [http://osha.europa.eu/en/publications/reports/7606488], accessed April 2012.

[122] Environmental Protection Agency. Pesticides: Health and Safety, Human Health Issues, available online [http://www.epa.gov/pesticides/health/human.htm], accessed April 2012.

[123] Health Canada. Consumer Product Safety, The Regulation of Pesticides in Canada, available online [http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/reg-pesticide/index-eng.php], accessed April 2012.

[124] Sierra Club Canada (undated). Pesticide Reduction, Current fact sheets, available online [http://www.sierraclub.ca/national/programs/health-environment/pesticides/index.shtml], accessed April 2012.

[125] Gilden, R. C., K. Huffling, et al. (2010). «Pesticides and Health Risks." Journal of Obstetric, Gynecologic, & Neonatal Nursing 39(1): 103-110.

[126] Brisson, G., M. Richardson, et al. (2012). Relation entre l'agriculture et la qualité de vie des communautés rurales et périurbaines, Direction de la santé environnementale et de la toxicologie - Institut national de santé publique.

(2011)highlights several violations of indigenous rights suggesting a high possibility of encountering non respect of those rights in Canada.

Fair distribution of revenues

The moderate score attributed to Canada is based on the Gini coefficient.

Fair competition

The animal feed sector has been criticized for being very concentrated which make it difficult the development of new enterprises[127], leading to a high possibility of unfair competition.

F) Medicines and vaccines industry

1- Description of the supply chain

In milk production, medicines and vaccines are used to treat and prevent diseases affecting the cattle. In Canada, most of medicines and vaccines have to be prescribed by a veterinarian who also determines the type of treatment to provide. Dairy producers who give drugs to a cow must respect a withholding period to ensure milk is exempt of drug residues. Withholding times are usually indicated on drug labels. Antibiotics are the most common drugs used in the dairy production.

The pharmaceutical industry is important in Canada. In terms of sales, Canada has the 9th largest world market. The industry is mainly concentrated in Ontario (43%) and Quebec (27%), especially in the metropolitan areas of Montreal and Toronto. In 2009, the top five companies accounted for nearly 45% of pharmaceutical total sales in Canada[128].

While there are many manufacturers processing veterinary products for bovines licensed in Canada, the country imports a significant share of products, mainly from the United States, Europe (France, Switzerland), Australia and New Zealand[129].

Antibiotics come mainly from Switzerland (68%) and France (23%) whereas vaccines for veterinary use are mainly imported from the United States (95%). However, the manufacturing of pharmaceutical products[130] can take place in a variety of countries as the enterprises supplying the Canadian market conduct activities all around the world. For simplification, the manufacturing activities of drugs and medicines are considered to take place in the US and in Switzerland (as the two main sourcing countries).

[127] MAPAQ (2009). Profil sectoriel: Fabrication des aliments pour animaux. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, available online [http://www.aqinac.com/client/publications/Profil_sectoriel.pdf], accessed April 2012.

[128] Statistics Canada, Canadian Business Patterns Database, NAICS 3254, December 2009. Compilation by AGECO, 2011.

[129] Canadian Food Inspection Agency. Importer-Distributors of Licensed Veterinary Biologics, available online [http://www.inspection.gc.ca/animals/veterinary-biologics/licensed-products/importer-distributors/eng/1318465620825/1320717321544], accessed April 2012.

[130] NAICS : 3254.

2- Companies included in the sample

Based on the previous system definition, the sample of businesses is made of the following companies:

1) **Prionics**[131], a Swiss-based company;
2) **Pfizer Animal Health**[132], a division of **Pfizer**, an American pharmaceutical company; and
3) **Novartis Animal Health**[133], a division of **Novartis**, a Swiss-based pharmaceutical company.

When social issues related to the behavior of those three companies are documented in other countries than the US and Switzerland, they are also taken into account in the analysis.

The upstream steps, e.g. the production of active ingredients and R&D, are not considered separately in the PHA as it is assumed they are conducted by the same companies. Therefore, assessing the possibility of encountering organizations with inappropriate behavior in the pharmaceutical and medicines manufacturing sector is considered as being representative of the possibility of encountering such behaviors in these upstream activities.

3- Detailed results

The results of the PHA of the medicines and vaccines sector are presented below.

[131] Prionics' website [http://www.prionics.com/], accessed April 2012.

[132] Pfizer Animal Health's website [https://animalhealth.pfizer.com/sites/PahWeb/US/en/Pages/US.aspx], accessed April 2012.

[133] Novartis' website [http://www.livestock.novartis.com/], accessed April 2012.

Results of the PHA of the Medicines and Vaccines subsystem

Stakeholders	Subcategories	Pharmaceutical and Medicines manufacturing	
		US	CH
Workers	Freedom of association and collective bargaining	▨ c	☐ r
	Child labour	☐ c	☐ r
	Fair salary[132]	☐ s	☐ s
	Working hours	▨ c	☐ r
	Forced labour	☐ c	☐ r
	Equal opportunities/Discrimination	▨ w	☐ c
	Occupational health and safety	☐ w	☐ w
	Employment insecurity	▨ c	▨ c
Local Community	Access to material or immaterial resources	▨ w	▨ w
	Safe and healthy living conditions	■ w	▨ w
	Respect of indigenous rights	▨ c	☐ c
	Secure living conditions	☐ c	☐ c
Society	Involvement in armed conflicts	n/a	n/a
	Corruption	▨ w	☐ c
	Fair distribution of revenues	▨ c	▨ c
Value chain actors	Fair competition	☐ c	▨ c
	Respect of intellectual property rights	☐ c	☐ c

US United States; CH Switzerland; r Human rights reports; w Web
c Country; s Statistical indicator; n/a Not available

[134] The Pharmaceutical and Medicine Manufacturing sector (NAICS: 3254) hourly median wage in the US has been compared to the country hourly median wage. Data for the US in 2011 come from the Occupational Employment Stat – [http://www.bls.gov/oes/current/oessrci.htm], accessed April, 2012. Regarding Switzerland, the average monthly wage in the pharmaceutical industry in Switzerland has been compared to the average monthly wage of the whole country. Data are for 2010 and comes from the *Office fédéral de la statistique de la Confédération Suisse*: [http://www.bfs.admin.ch/bfs/portal/fr/ index/themen/03/04/blank/data/01/06_01.html.] accessed April 2012.

4- Detailed justifications

Freedom of association and collective bargaining

The moderate score for the Freedom of association and collective bargaining subcategory for the US represents the country level performance assessed through the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

Working hours

The moderate score of the subcategory Working hours in the US comes from the Social Hotspots Database that highlights a moderate probability for the indicator "Risk of population working more than 48h per week".

Equal opportunities/Discrimination

In 2010 Novartis was judged guilty by a US Court of discrimination towards pregnant women in terms of pay, promotion and treatment, in the US[135]. As it is the only enterprise for which such behaviour has been identified, a moderate possibility of encountering this social issue is attributed to this life cycle step in the US.

Occupational health and safety

A former Pfizer scientist testified in 2010 in US District Court "that she was removed from a company-sponsored safety committee after pressing complaints about dangerous conditions in [a laboratory of] the pharmaceutical firm"[136]. Regardless the measures taken by the companies to lower the risk of contamination, the Pfizer scientist raises that "scientists today are handling much more dangerous substances than existed a quarter century ago." However, the US Bureau of Labour states that «Working conditions in pharmaceutical plants are better than those in most other manufacturing plants, and work-related injuries are rare. Much emphasis is placed on keeping equipment and work areas clean because of the danger of contamination".[137] The probability of encountering occupational health and safety issues in this industry is then considered moderate in both countries.

Employment insecurity

The moderate score attributed to this subcategory is based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in the US and in Switzerland.

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[135] Wikipedia. Novartis, available online [http://en.wikipedia.org/wiki/Novartis], accessed April 2012.

[136] The day (2010). Pfizer ignored safety matters, former employee testifies in trial, available online [http://www.theday.com/article/20100317/NWS02/303179903/1019&town=], accessed April 2012.

[137] United states International Trade Commission (2010). Products and Chemical Intermediates, Fourth Review: Advice Concerning the Addition of Certain Products to the Pharmaceutical Appendix to the HTS, Investigation No. 332-520.

Access to material or immaterial resources

Pfizer is associated to the pharmaceutical lobby criticized for jeopardizing the efforts provided to make HIV/AIDS related drugs more affordable[138]. Novartis has been criticized for having launched a court case against India's production of generic drugs[139]. These issues, although related to human drugs, are preoccupying and lead to a moderate risk score.

Safe and healthy living conditions

The western pharmaceutical industry is associated to unethical trials on sick people in countries where the legislation is lax and allows important cost savings for such trials[140]. If this social issue is not linked to animal drugs, Pfizer is still associated to such practices. In addition, Pfizer has been recognized guilty of violation of the Clean Air Act in the US (2008)[141], which motivated a high score for that country. Therefore, US received a high score and Switzerland, a moderate one.

Respect of indigenous rights

The moderate probability of encountering violation of indigenous rights in the US is based on information found in the State of the World's Human Rights country report of Amnesty International (2011). There are mentions of poor living conditions of the natives in the US without specific violations of Indigenous Rights leading to a moderated probability of encountering inappropriate businesses' behaviours related to this subcategory.

Corruption

Pfizer is considered as one of the single largest lobbying interest in the US politics. They are associated to lobby against generic drugs on the US market, among others questionable positions[142]. More generally, the important lobby of the pharmaceutical industry raises concerns, especially in the US[143], justifying a moderate score for that country.

Fair distribution of revenues

The moderate scores attributed to the United States and to Switzerland are based on the Gini coefficient.

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[138] Doctors without Borders (2011). Communiqué de presse: Afrique: Sida – Les laboratoires pharmaceutiques suspendent les programmes de reduction du coût des ARV dans les pays à revenu intermédiaire, available online [http://fr.allafrica.com/stories/201107190393.html], accessed April 2012.

[139] Oxfam International (2012). Novartis launch renewed attack on India's right to produce affordable medicines, available online [http://www.oxfam.org/en/pressroom/pressrelease/2012-08-20/novartis-renewed-attack-india-produce-affordable-medicines], accessed August 2012.

[140] Buncombe, A. and Lakhani, N. (2011). Without consent: how drugs companies exploit Indian 'guinea pigs'. The Independent, available online [http://www.independent.co.uk/news/world/asia/without-consent-how-drugs-companies-exploit-indian-guinea-pigs-6261919.html] accessed April 2012.

[141] USA Today (2008). Pfizer pays penalty for pollution violation, available online [http://www.usatoday.com/money/companies/regulation/2008-06-23-pfizer-enviromental-penalty_N.htm] accessed April 2012.

[142] Wikipedia. Pfizer, available online [http://en.wikipedia.org/wiki/Pfizer], accessed April 2012.

[143] Magloire, L. (2008). Le lobbying de l'industrie pharmaceutique aux USA. Opinion watch, available online [http://www.opinion-watch.com/lobbying-de-l-industry-pharmaceutique-aux-usa/], accessed April 2012.

Fair competition

The moderate score for Fair competition is based on the WEF annual Executive Opinion Survey, which highlights that anti-monopoly policy only succeed moderately to promote competition in Switzerland.

G) Bovine semen sector

1- Description of the supply chain

Artificial insemination is an important cost in dairy production. On-farm insemination service is usually offered by artificial insemination centers. These centers also offer services such as embryo transfers, genetic and mating programs, herd management, etc.

Canada is recognized as a leader in terms of dairy genetics. There are 11 artificial insemination centers across the country, most of them located in Ontario. Some of these companies are multinationals (Canadian Dairy Network, 2010). The value chain of bovine semen includes mainly the production of the semen.

2- Companies included in the sample

Three Canadian companies having activities in Ontario and Quebec have been selected as proxies for the PHA.

1) **EastGen**[144], a new company resulting from the merger, in 2011, of *Eastern Breeders Inc*. (EBI) and *Gencor*;
2) **Alta Genetics**[145]; and
3) **Centre d'insémination artificielle du Québec (CIAQ)**[146].

3- Detailed results

The results of the PHA of the bovine semen subsystem are presented below.

[144] Eastgen's website [http://www.eastgen.ca/i?lang=en&page=history.shtml] accessed May 2012.
[145] Alta Genetics' website [http://www2.altagenetics.com/French/CompanyProfile/] accessed May 2012
[146] CIAQ's website [http://www.ciaq.com] accessed May 2012.

Results of the PHA of the Bovine semen subsystem

Stakeholders	Subcategories	Bovine semen production CA
Workers	Freedom of association and collective bargaining	□ r
	Child labour	□ r
	Fair salary[145]	□ s
	Working hours	□ r
	Forced labour	□ r
	Equal opportunities/Discrimination	□ c
	Occupational health and safety	□ w
	Employment insecurity	▨ c
Local Community	Access to material or immaterial resources	□ c
	Safe and healthy living conditions	n/a
	Respect of indigenous rights	■ c
	Secure living conditions	□ c
Society	Involvement in armed conflicts	n/a
	Corruption	□ c
	Fair distribution of revenues	▨ c
Value chain actors	Fair competition	□ c
	Respect of intellectual property rights	□ c

CA Canada   r Human rights reports   w Web
c Country   s Statistical indicator   n/a Not available

147 Data come from Statistic Canada: [http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69a-eng.htm] accessed July 2012. The average hourly wage of employees in «Natural and applied sciences and related occupations" in Canada has been compared to the Canadian average hourly wage.

4- Detailed justifications

Occupational health and safety

A risk of occupational illness related to genetic and biological sciences is recognized as stated in a Council for Responsible Genetics report (2010)[148]: "As a revolution in genetic and other biological sciences has greatly expanded the number of laboratories in the past twenty years, workers in the biological industries have suffered from health and safety regulations that have fallen well behind the times." However, no specific health and safety issue has been found in the specific sector of bovine semen and it does not seem to be a concern in Canada.

Employment insecurity

The moderate score for employment insecurity is based on the World Economic Forum (WEF) annual Executive Opinion Survey, which highlights a relative easiness in hiring and firing practices in Canada.

Respect of indigenous rights

The high possibility of encountering violation of indigenous rights is based on data collected at the country level in the US Department of State Country report on Human Rights (2011)and the State of the World's Human Rights country report of Amnesty International (2011) Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in Canadian economic activities.

Fair distribution of revenues

The moderate score attributed to Canada is based on the Gini coefficient.

H) Machinery industry

1- Description of the supply chain

There are 5 main categories of machinery and equipment on dairy farms: transport and power (tractors, trailers, etc.), general farm equipment (conveyor, air compressor, etc.), land preparation and crop equipment (plow, cultivator, etc.), harvest and crop processing equipment (baler, hay dryer, etc.) and livestock equipment (specialized equipment for dairy production (milking machines, etc.) and for herd (feed mills, watering equipment, etc.)) (AGECO, 2010).

In Canada, businesses specialized in agricultural machinery manufacturing are mostly located in Ontario (28%) and Quebec (18%) as well as in the Western provinces of Saskatchewan (17%), Alberta (15%), Manitoba (13%) and British-Colombia (7%). Atlantic Provinces account only a few manufacturers[149].

[148] Council for Responsible Genetics (2010). Worker safety in biological laboratories – Limitations of PSHA regulations governing bio-laboratory safety, available online [http://www.councilforresponsiblegenetics.org/pagedocuments/j118scxsur.pdf], accessed May 2012.

[149] Statistics Canada, Canadian Business Patterns Database, NAICS 33311, December 2009.

In Canada, agricultural machinery manufacturers create nearly 9,700 jobs generating more than $370 million in salary. In total, revenues generated by those manufacturers account for about $2.9 billion, while value added raises above $1.1 billion[150].

For simplification, the PHA of this sector focuses only on tractors. The value chain of this input includes iron extraction, steel production and tractors manufacturing[151]. The distribution step has been already assessed above.

2- Companies included in the sample

Agricultural machinery sold on the Canadian market mostly comes from the US. Three leading tractors manufacturers with factories in the US have been selected for the sample of enterprises:

1) **AGCO**[152], a leading global manufacturer of agricultural equipment, offering four core brands: Challenger®, Fendt®, Massey Ferguson® and Valtra®;
2) **Deere & Company**[153], manufacturing the brand John Deere; and
3) **CNH Global**[154], a world leader in the agricultural and construction equipment business, manufacturing the brand Case and New Holland.

Although the United States are a net importer of steel, their import reliance as a percentage of domestic production is relatively small, averaging 19% over the last few years. In fact, as one of the main steel producers worldwide with an average production of nearly 90 million metric tons annually, the United States' production is sufficient to cover most of the domestic demand. Therefore, the assessment focuses on the US steel production by the three main players, namely:

1) **United States Steel Corporation**[155], an American company with major production operations in the US, Canada and Central Europe;
2) **Nucor**, an American company claiming to be "the largest producer of steel in the United States"[156]; and
3) **Arcelor Mittal**, the world's leading steel and mining company.

The two main inputs used to produce steel are iron ore and recycled iron and scrap steel. Globally, the United States are self-sufficient both for the production of iron ore and recycled iron and scrap

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[150] Statistics Canada. Table 301-0006, Agricultural Implement Manufacturing (333110).

[151] The LCA database Ecoinvent (2010) identified steel as the main input of tractors manufacturing (Swiss Center for Life Cycle Inventories (SCLCI) (2010) ecoinvent database v2.2. Available at http://www.ecoinvent.org/home/). As the system in SLCA is simplified and only takes into account the main inputs, only this intermediary product is considered upstream from the tractors manufacturing. The same logic is applied for the inclusion of the iron only in the steel production.

[152] AGCO's website [http://www.agcocorp.com/], accessed in May 2012.

[153] Deere & Company's website [http://www.deere.com/], accessed in May 2012.

[154] CHN Global's website [http://www.cnh.com/], accessed in May 2012.

[155] United States Steel Corporation's website [http://www.uss.com/corp/company/profile/about.asp], accessed in May 2012.

[156] Nucor's website [http://www.nucor.com/story/chapter1/], accessed in May 2012.

steel[157]. As the steel and foundry industries have been structured to recycle scrap, they are highly dependent on recycled products[158]. The same enterprises are thus involved in these two life cycle stages. As it is not expected to find any critical social issue specifically related to the recycling processes in the steel production activity, the production of steel and the recycling are considered as one single step in the analysis.

3- Detailed results

The results of the PHA of the machinery sector are presented below.

[157] In 2010, it was estimated that United States produced and consumed only 2% of the world's iron ore output (U.S Geological Survey (2011). Mineral commodity summaries 2011, available online [http://minerals.usgs.gov/minerals/pubs/mcs/2011/mcs2011.pdf], page 84, accessed May 2012. Almost all ore is produced in Michigan and Minnesota from taconite, which is a low-grade ore and almost all of which is in the form of pellets (http://pubs.usgs.gov/of/2001/of01-224/of01-224.pdf) p.2.

[158] U.S Geological Survey (2011). Mineral commodity summaries 2011, available online [http://minerals.usgs.gov/minerals/pubs/mcs/2011/mcs2011.pdf], page 80, accessed May 2012.

Results of the PHA of the Machinery subsystem

Stakeholders	Subcategories	Agricultural machinery Manufacturing	Steel foundries and recycling
		US	US
Workers	Freedom of association and collective bargaining	▨ c	▨ w
	Child labour	□ c	□ c
	Fair salary[157]	□ s	□ s
	Working hours	▨ c	▨ c
	Forced labour	□ w	□ c
	Equal opportunities/Discrimination	□ c	□ c
	Occupational health and safety	▨ s	■ w
	Employment insecurity	▨ c	▨ c
Local Community	Access to material or immaterial resources	□ c	▨ w
	Safe and healthy living conditions	n/a	■ w
	Respect of indigenous rights	▨ c	▨ c
	Secure living conditions	□ c	□ c
Society	Involvement in armed conflicts	n/a	n/a
	Corruption	□ c	□ c
	Fair distribution of revenues	▨ c	▨ c
Value chain actors	Fair competition	□ c	▨ w
	Respect of intellectual property rights	□ c	□ c

US United States
c Country
s Statistical indicator
n/a Not available
w Web

[159] The Agricultural, Construction and Mining Machinery Manufacturing sector (NAICS: 3331) hourly median wage in the US and the Iron and Steel Mills and Ferro-Alloy Manufacturing sector (NAICS: 3311) have been compared to the US median hourly wage. Data for the US in 2011 come from the Occupational Employment Stat – [http://www.bls.gov/oes/current/oessrci.htm], accessed June, 2012.

4- Detailed justifications

Freedom of association and collective bargaining

At the manufacturing level, the moderate score comes from the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

As for the steel foundries and recycling step, the score is based on information gathered from a web search focused on the sample of companies selected for the study. Among them, Arcelor Mittal has been fined several times for discrimination towards union representatives. The Wikipedia French page of the company[160] records nine such fines only in France. As the issue has been raised for only one company, it suggests a moderate score.

Working hours

The moderate scores attributed to Working hours in the US come from the Social Hotspots Database that highlights a moderate probability for the indicator "Risk of population working more than 48h per week" in this country.

Forced labour

In 2006, a company supplying components of John Deere tractors has been associated to forced labour in Brazil[161]. Since the case is isolated and relatively old, a low possibility of encountering forced labour is attributed to the agricultural machinery manufacturing step.

Occupational health and safety

The moderate score attributed to the manufacturing sector in the US for this subcategory is based on the ILO statistic on non-fatal occupational injuries which is higher in this sector compared to the national average (2008).

Regarding the steel production from recycling material, the recycling industry itself recognizes the health and safety risks associated to the sector, as acknowledged by the following statement of the American Institute of Scrap Recycling Industries:

> "Safety is more important today than ever before. The recycling industry is under greater scrutiny by regulators and the cost of accidents—both monetary and human—continues to skyrocket. The need to make our workplaces safer is clear, but getting the old school workers on board with the change and convincing the younger workers they are not invincible can be a daunting challenge. Every day, as safety professionals, we fight the mentality of "this is how we've always done it" and "nothing will happen to me." We strive to overcome this complacency, but it's never easy."[162]

[160] Wikipedia. ArcelorMittal [http://fr.wikipedia.org/wiki/ArcelorMittal], accessed May 2012.

[161] Smith and Voreacos (2006). Slaves in Amazon Forced to Make Material Used in Cars (Update2). Bloomberg, available online [http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a4j1VKZq34TM], accessed May 2012.

[162] Institut of Scrap Recycling Industries. Safety, available online [http://www.isrisafety.org/], accessed May 2012.

This suggests a high possibility of encountering health and safety issues in the foundries and recycling step.

Employment insecurity

The moderate scores for employment insecurity are based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in Hiring and firing practices in the US.

Access to material or immaterial resources

Arcelor Mittal has been involved in an issue of delocalization in India[163]. The company's plan to settle on iron-rich lands encountered resistance from Indian farmers using those lands. While the discord takes place between farmers and the State, the steel industry can be associated to this delocalization issue, which explains a moderate score for the subcategory Access to material or immaterial resources.

Regarding the tractors manufacturing, John Deere has been criticised for moving operations outside the US: "Deere runs the risk of negative response within the US because of the jobs that will be lost as well as the lax labour laws that some of these other countries might have. Firms that have tried to avail of less expensive labour in foreign markets, have in the past faced a lot of erosion in brand value and have had to invest considerably in publicity to restore their image"[164]. The loss of jobs can be considered as a limited access to resources in one country, but can lead to a benefit in another country. The debate on delocalization is far too complex to be comprehensively exposed here. This said, a low possibility of impairing access to resources is still attributed to the agricultural machinery manufacturing sector in the US, based on the country level indicator using the COHRE.

Safe and healthy living conditions

Many steel producers are recorded among the most polluting enterprises of the US[165]. In Bosnia and Herzegovina, a protest was organized in 2011 to denounce high levels of air pollution from Arcelor Mittal plants, and the steel industry is recognized as being an important source of environmental degradation in India[166]. A high score is attributed to this life cycle step.

Respect of indigenous rights

The moderate possibility of encountering violation of indigenous rights is based on country level indicators using the State of the World's Human Rights country report of Amnesty International (2011). In the reports covering the US, there are mentions of some poor living conditions of the

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[163] Shanker, A. (2010). Indian Farmers Fight Billionaire Mittal, Posco for Water Rights. Bloomberg, available online [http://www.bloomberg.com/news/2010-10-04/indian-farmers-fight-billionaire-mittal-posco-for-water-rights.html], accessed May 2012.

[164] Ocanas, Mian, Mishra, Biede, Ilyas (undated). John Derre & Co. Agricultural Operations, Industry analysis. Available online [http://www.angelfire.com/mi/farhadmian/JohnDeere.pdf], accessed May 2012.

[165] Political Economy Research Institute (2010). Toxic 100 Air Polluters. University of Massachusetts Amherst, available online [http://www.peri.umass.edu/toxic_index/], accessed May 2012.

[166] Sahu (2009). Sponge iron industry threatening environment, lives. Merinews, available online [http://www.merinews.com/article/sponge-iron-industry-threatening-environment-lives/15782702.shtml], accessed May 2012.

natives without any specific reference to the violation of Indigenous Rights, thus leading to a moderate possibility of encountering a social hotspot here.

Corruption

The scores for corruption in the US come from the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate transparency in the government policy making, but a high ethic in business behaviours.

Fair distribution of revenues

The moderate score attributed to the United States is based on the Gini coefficient.

Fair competition

A group of steel producers, including Arcelor Mittal, has received an important fine for anti-trust behaviours. This event took place in 2008 in France, where Arcelor Mittal has subsidiaries. Therefore, a moderate possibility of encountering such behaviour is attributed to this life cycle step in the US.

Regarding the farm machinery manufacturing, the country level score proposes a low possibility of unfair competition in this industry. This information is supported by an analysis of the rivalry among existing competitors in the US suggesting that "while there have been mergers and acquisitions within this industry, they have not been as substantive or pervasive as in the plant nutrient and the seed/biotech/crop protection segments"[167].

I) Fuel and Lubricant sector

1- Description of the supply chain

Fuel and lubricants consumed on dairy farms are essentially gasoline, diesel, heating fuel and propane.

Canada produced 158 million cubic meters of crude petroleum in 2009, including 70% coming from Alberta. The rest was mainly produced in Saskatchewan (16%) and in Newfoundland (10%)[168]. Canada accounts 18 refineries across the country. Six of them are located in Ontario, 7 in Western provinces, 2 in Atlantic Provinces and 2 in Quebec. In total, refineries employ 5048 workers across the country. They generate $7.8 billion of revenues and $6.9 billion in value added[169].

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[167] Olson and Boehlje (2010). Theme Overview: Fundamental Forces Affecting Agribusiness Industries. Choices, AAEA, available online [http://www.choicesmagazine.org/magazine/pdf/block_53.pdf], accessed May 2012.

[168] Statistics Canada. Table 126-0001, Supply and disposition of crude oil and equivalent, monthly (cubic metres).

[169] Statistics Canada. Table 301-0006, Petroleum refineries (324110).

The value chain of fuel and lubricants includes the oil extraction, refining and distribution. Regarding the refining and distribution steps, they take place all over the country, mostly in Alberta, Ontario and Quebec[170].

2- Companies included in the sample

Fuel companies are vertically integrated. Therefore, the same three Canadian companies have been selected as proxies for the sample:

1) **Shell Canada**[171], a subsidiary of **Royal Dutch Shell**, a Dutch company;
2) **Suncor**[172]; and
3) **Ultramar**[173].

Regarding the oil extraction activities, their location differs depending on the supplied provinces.

For the Western provinces, crude petroleum input comes from Alberta.

As **Suncor** and **Shell** are major actors in the extraction of oil in Alberta, they are also used as proxies to collect information related to enterprises' behaviors associated to the extractive activity in Canada.

For the Central provinces, crude petroleum mostly comes from Algeria, the United States and Kazakhstan[174]. Three businesses have been selected as proxies for activities taking place in those regions:

1) **Sonatrach**,[175] an Algerian government-owned company;
2) **Exxon Mobil**[176], an American oil company; and
3) **KazMunay gas**[177], a state-owned oil and gas company of Kazakhstan.

When social issues are raised by the selected companies in other countries than the ones where the Milk product system is mostly expected to take place, they are mentioned in the results.

3- Detailed justifications

The results of the PHA of the Fuel and Lubricant subsystem are presented below.

[170] Natural Resources Canada. About Crude Oil and Petroleum Products, available online [http://www.nrcan.gc.ca/energy/sources/petroleum-crude-prices/1225], accessed June 2012.

[171] Shell Canada's website [http://www.shell.ca/], accessed June 2012.

[172] Suncor's website [http://www.suncor.com/], accessed June 2012.

[173] Ultramar's website [http://www.ultramar.ca/fr/notre-entreprise/], accessed June 2012.

[174] Based on the imports of the Oil and Gas Extraction industry in the central provinces (Ontario and Quebec) for 2011 in the Canadian Trade by Industry database.

[175] Sonatrach's website [http://www.sonatrach.com/], accessed June 2012.

[176] ExxonMobil's website [http://www.exxonmobil.com/Corporate/], accessed June 2012.

[177] KazMunayGas's website [http://www.kmgep.kz/], accessed June 2012.

Results of the PHA of the Fuel and Lubricant subsystem

Stakeholders	Subcategories	Fuel distri-bution	Petroleum refining		Oil extraction			
		CA	CA(W)	CA(E)	CA	DZ	US	KZ
Workers	Freedom of association and collective bargaining	□ r	□ r	□ r	□ r	■ r	▨ c	■ r
	Child labour	□ r	□ r	□ r	□ r	□ r	□ c	■ r
	Fair salary[176]	□ s	□ s	□ s	□ s	▨ w	□ s	□ s
	Working hours	□ r	■ s	■ s	■ s	□ r	▨ c	□ r
	Forced labour	□ r	□ r	□ r	□ r	▨ c	□ r	▨ c
	Equal opportunities/ Discrimination	□ c	□ c	□ c	□ c	■ c	□ c	■ c
	Occupational health and safety	▨ s	■ w	■ w	■ s	■ r	■ s	■ r
	Employment insecurity	▨ c	▨ c	▨ c	▨ c	□ c	▨ c	▨ c
Local Community	Access to material or immaterial resources	□ c	□ c	□ c	■ w			
	Safe and healthy living conditions	n/a	■ w	■ w	■ w	▨ w	■ w	▨ w
	Respect of indigenous rights	■ c	■ c	■ c	■ w	□ c	▨ c	□ c
	Secure living conditions	□ c	□ c	□ c	□ c	▨ c	□ c	▨ c

178 The average hourly wage of the Fuel dealer sector was represented by the aggregated sector of trade (41, 44-45); data were collected in STATISTICS CANADA, table 282-0072 (2011). As for the Petroleum Refineries (NAICS: 32411) in Canada (no distinction between the central and western provinces), the annual average wage of this sector (CIS, 2010 [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32411sale.html], accessed September 2012) has been compared to the country annual average wage (Average salary survey, 2011/2012, available online [http://www.averagesalarysurvey.com/article/average-salary-in-canada/19192229.aspx], accessed September 2012). The median salary of the oil and gas extractive sector (NAICS: 211) in Canada was represented by the aggregated sector Forestry, fishing, mining, quarrying, oil and gas [NAICS: 21, 113-114, 1153, 2100] and compared to the Canadian median; data come from STATISTICS CANADA, table 282-0072 (2011). The median wage for the oil and gas extractive industry (NAICS: 211) in the US has been compared to the US median wage (Data for the US in 2011 come from the Occupational Employment Stat – [http://www.bls.gov/oes/current/oessrci.htm], accessed June, 2012). For Kazakhstan, the monthly earning in the aggregated Mining and Quarrying industry was compared to the monthly earning in the whole economy and is found to be higher in 2008; data come from the ILO database Laborsta – [http://laborsta.ilo.org/], accessed June 2012. No statistics have been found on salary in Algeria.

Stakeholders	Subcategories	Fuel distri-bution	Petroleum refining		Oil extraction			
		CA	CA(W)	CA(E)	CA	DZ	US	KZ
Society	Involvement in armed conflicts	n/a	n/a	n/a	■ w			
	Corruption	□ c	□ c	□ c	■ w			
	Fair distribution of revenues	▨ c	▨ c	▨ c	▨ c	▨ c	▨ c	□ c
Value chain actors	Fair competition	□ c	□ c	□ c	□ c	▨ c	□ c	▨ c
	Respect of intellectual property rights	□ c	□ c	□ c	□ c	■ c	□ c	■ c

CA	Canada	CA(W)	Canadian western provinces	CA(E)	Canadian eastern provinces
DZ	Algeria	UK	United Kingdom	US	United States
KZ	Kazakhstan	s	Statistical indicator	w	Web
c	Country	n/a	Not available	r	Human rights reports

4- Detailed justifications

Freedom of association and collective bargaining

Moderate and high possibilities of encountering impairment to the rights of freedom association and of collective bargaining are attributed to the step of oil extraction in Algeria, US and Kazakhstan.

In Algeria, violations of those rights were not explicitly related to the extractive sector per se. However, and as stated in the US Department of State Country report on Human Rights on Algeria (2011), if "the constitution allows workers who are citizens to join unions of their choice […] [and] provides for the right to strike […] [on the condition of] prior authorization […] authorities rarely give permits for public gatherings." Regarding the right to collectively bargain, "the law provides for collective bargaining for all unions, and the government permitted the exercise of this right, in practice, for authorized unions" however, only one union is authorized to negotiate collective bargaining agreement." In addition, the Annual Survey of violations of Trade Union Rights (2011)reports that "Many multinationals operating in the oil-rich south of Algeria continued to show hostility towards workers' demands" and that trade unionism is "forbidden in many oil and gas multinationals". The possibility is therefore considered as high.

In the US, the score for the Freedom of association and collective bargaining represent the country level performances assessed through the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

In the US Department of State Country report on Human Rights on Kazakhstan (2011), "the government continued to restrict the right to organize, and most workers were not able to join or form trade unions of their choice [and] exercised considerable influence on organized labour and favoured state-affiliated unions over independent unions." More closely related to the oil and gas industry, the US Department of State Country report on Human Rights on Kazakhstan (2011) reports the arrest and lay-off of oil and gas companies' workers, including workers of the KazMunaiGas company, for involvement in an illegal strike. In 2009, union activists working for oil companies (again, including KazMunaiGas) have been beat and shoot. The 2011 country report states that there is no more development on this case but that “representatives of the independent labour union community unanimously believed that the shooting directly resulted from […] [the worker’s] activism.” The possibility of encountering violations of the rights of freedom association and collective bargaining is therefore considered as high for this sector in this country.

Child labour

The US Department of State Country report on Human Rights (2011) mentions that “child labour remained a problem in the agriculture and the informal sectors” in Algeria. Regarding Kazakhstan, the US Department of State Country report on Human Rights (2011)reports effort from the government to eradicate the “worst forms of child labour and to develop alternative employment opportunities for children and their families. […] Nevertheless, NGOs contended that the government's efforts were insufficient to address fully the use of child labour.” Closer to the gas extractive industry, gas distribution is explicitly mentioned in the most risky sectors. Based on these findings, a moderate risk is attributed to Algeria where a high risk is attributed to Kazakhstan.

Fair salary

Regarding Algeria, no statistical data on salary were found. However, it has been reported that “thousands of workers threatening to halt production at Algeria’s largest oil and natural-gas facilities ended a protest after state-run Sonatrach agreed to boost their wages, said an official at the oil workers’ union.[179]” This suggested low salaries in this sector leading to a moderate possibility of encountering unfair salary.

Working hours

The ILO database provides an average of 50.4 hours of work per week (in 2008) in the petroleum refineries industry sector in Canada which suggests a high possibility of encountering excessive hours of work. Regarding the extractive step (Crude petroleum and natural gas production), the ILO database suggests an average of 52.6 hours of work per week in Canada. No data are available for Algeria, the US nor Kazakhstan. A moderate score for Working hours can be attributed to the US based on the SHDB that highlights a moderate probability for the indicator “Risk of population working more than 48h per week”. As the human rights reports do not mention excessive hours of work neither in Algeria nor in Kazakhstan for the extractive industry, a low score is attributed to both countries.

Forced labour

The SHDB highlights a moderate risk of Forced labour in Algeria and in Kazakhstan.

[179] Slimani (2011). Oil, Gas Workers in Algeria End Protest After Wage Increase. Bloomberg, available online [http://www.bloomberg.com/news/2011-04-06/oil-gas-workers-in-algeria-end-protest-after-wage-increase.html], accessed June 2012.

Equal opportunities/Discrimination

The high score for Algeria and Kazakhstan comes from the SHDB that attributes a high[180] risk of encountering gender inequality in both countries.

Occupational health and safety

The moderate and high scores respectively attributed to the fuel distribution in Canada and to the oil extraction in the US are based on the rates of non-fatal and fatal occupational injuries found in the ILO database (2008). Canadian statistics on fatal injuries in the Mining and quarrying sector also suggest a high possibility of occupational health and safety issue for this life cycle step in Canada. Regarding the oil extraction in Algeria and Kazakhstan (for which no data are available in the ILO database), according to the US human rights reports, the state of the Health and safety working conditions seems poor in both countries. Giving that the risk seems high in the extractive industry in general and that those countries have poor health and safety working conditions, the possibility of encountering a hotspot is also expected to be high.

Regarding the oil refining step, it is recognized for having "significant occupational health and safety hazards", including: Process Safety, oxygen-deficient atmosphere, chemical hazards and fire and explosions[181]. Health effects like endocrine system disruption are also associated to this industry[182]. Therefore, the possibility of encountering occupational issues is considered as high.

Employment insecurity

The moderate scores attributed to the subcategory employment insecurity in Canada, the US and Kazakhstan are based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in hiring and firing practices in those three countries.

Access to material or immaterial resources

It is expected that new projects development in the gas and oil extraction sector will increase the land pressure. In order to avoid these projects impairing the access to resources (or to compensate for it), the Environmental impact assessments (EIA) should be carried out in a participative way, involving all the stakeholders. An example of the complex interrelation between oil and gas projects development and the impairment to resources access is the concern over the loss of key species (whale and salmon) in the Russian Sea of Okhotsk associated to two projects involving Shell and ExxonMobil, among others[183][184]. The oil extractive industry is therefore associated to a high possibility of encountering issues of access to resources regardless of the country of activity.

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180 More precisely, the SHDB attributed a very High risk of gender inequity in those two countries. As the evaluation scale used here covers a low, moderate and high possibility, the very high risk is presented as a high possibility.

181 International Finance Corporation (2007). Environmental, Health, and Safety Guidelines for Petroleum Refining. World Bank Group, available online [http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_PetroleumRefining/$FILE/Final+-+Petroleum+Refining.pdf], accessed June 2012.

182 Canadian Petroleum Products Institute. Environment, Health and Safety Performance, available online [http://www.cppi.ca/index_e.php?p=20], accessed June 2012.

183 Wikipedia. Sakhalin-I, Section: Environmental controversies, available online [http://en.wikipedia.org/wiki/Sakhalin-I#Environmental_controversies], accessed June 2012.

Safe and healthy living conditions

The oil refining sector is responsible of environmental damages: "The petroleum refining process results in the release of a number of air pollutants, including: sulphur oxides, nitrogen oxides, volatile organic compounds, particulate matter, carbon monoxide, and benzene, as well as many greenhouse gases (GHGs)"[185]. Wikipedia adds that, "aside from air pollution impacts there are also wastewater concerns, risks of industrial accidents such as fire and explosion, and noise health effects due to industrial noise"[186]. A Shell's refinery in the US was pointed at as the cause of a US citizen cancer[187]. Regardless of the result of the lawsuit, the fact that benzene was stored on the refinery – as stated in the case – suggests a risk for safe and healthy living conditions in local communities surrounding petroleum refineries. Other similar cases of lawsuit have been addressed towards Shell and other oil refineries[188] and concerns have also been raised in Canada[189]. A high possibility of encountering health issues seems justified.

Regarding the oil extraction phase of the life cycle, several issues of environmental degradation are related to this industry regardless of the location. In Canada, a special attention is given to oil sands extraction which leads to a large variety of environmental impacts, some being related to public health issues[190]. Suncor has been fined for failing to use pollution control and for dumping untreated wastewater in Alberta[191]. In the US, ExxonMobil has been criticized for several oil spills among which the well-known Exxon Valdez oil spill of 1989[192]. No Safe and healthy living conditions issues have been directly associated to the oil industry in Algeria and Kazakhstan. However, as some local environmental issues seem inherent to the sector, a moderate possibility is still attributed to these countries.

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184 Wikipedia. Sakhalin-II, Section : Environmental Issues, available online [http://en.wikipedia.org/wiki/Sakhalin-II#Environmental_issueshttp://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=1467336C-1], accessed June 2012.

185 Environment Canada. Petroleum Refining, available online [http://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=1467336C-1], accessed June 2012.

186 Wikipedia. Oil refinery, Section: Safety and environmental concerns, available online [http://en.wikipedia.org/wiki/Oil_refinery#Safety_and_environmental_concerns], accessed June 2012.

187 Maher (2011). Shell answers Madison County benzene lawsuit. The Record, available online [http://www.madisonrecord.com/news/239721-shell-answers-madison-county-benzene-lawsuit], accessed June 2012.

188 Writers (2011). Benzene Leukemia Lawsuit Filed by Man Who Grew Up Near Oil Refinery. AboutLawsuits.com, available online [http://www.aboutlawsuits.com/benzene-leukemia-lawsuit-shell-oil-refinery-21220/], accessed June 2012.

189 CBCNews (2010). N.B. refinery dust raises health concerns, available online [http://www.cbc.ca/news/canada/new-brunswick/story/2010/08/24/nb-refinery-dust-health-concerns.html], accessed June 2012.

190 Wikipedia. Oil sands, Section: Environmental issues, available online [http://en.wikipedia.org/wiki/Oil_sands#Environmental_issues], accessed June 2012.

191 Wikipedia. Suncor, Section: Environmental record, available online [http://en.wikipedia.org/wiki/Suncor_Energy#Environmental_record], accessed June 2012.

192 Wikipedia. ExxonMobil, Section: Environmental record, available online [http://en.wikipedia.org/wiki/ExxonMobil#Environmental_record], accessed June 2012.

Respect of indigenous rights

Shell has been sued by the Athabasca Chipewyan First Nation in Canada for non-respect of agreements made in 2003 and 2006 between the two parties[193]. According to Wikipedia, opposition to oil sands extraction within the First Nation concerns mostly environmental stewardship, land rights and health issues[194]. The important use of water from oil sand companies has been pointed at as a problem since it limits the access by Natives to lakes and rivers on their territory[195]. A high possibility of encountering cases of non-respect of indigenous rights is attributed to the extractive industry in Canada, which is supported by the several violations of indigenous rights stated in the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011).

In the US, the two reports mention some poor living conditions of the natives without specific violations of Indigenous Rights, thus leading to a moderate possibility.

In Algeria, natives "receive no benefits from the natural resources found on their territories (water, forests, oil, gas, etc.)" and do not «legal recognition as an indigenous people".[196] In Kazakhstan, several violations of human rights are reported for the religious minorities.[197] A high possibility of encountering non-respect of indigenous rights are then given to those two countries.

Secure living conditions

The moderate scores attributed to this subcategory in Algeria and Kazakhstan are based on the WEF annual Executive Opinion Survey, which highlights a moderate reliability of police services in those countries.

Involvement in armed conflicts

Shell is extracting oil in Nigeria. According to the Canadian Trade by Industry database (2011), this country was the 8th exporting country, in 2011[198], supplying the Canadian central provinces (Ontario and Quebec). Besides the fact oil imports from Nigeria in Canada are less important in volume than from the countries selected in the analysis (Algeria, United States and Kazakhstan), Shell's activities in Nigeria have raised many controversies in the 1990s which worth to be mentioned. Tensions arose between native Nigerian people (the Ogoni) and the company for these formers not benefiting from the economic repercussion of oil activities but suffering from the destruction of the environment (which supports the idea that the extractive industry lead to environmental damage in general). Leaders of the Ogoni people that protested against Shell have been arrested and sentenced to death

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193 Reuters (2011). Canada natives sue Shell over oil sands funding, available online [http://ca.reuters.com/article/businessNews/idCATRE7AT2AR20111130], accessed June 2012.

194 Wikipedia. Athabasca oil sands, Section: Indigenous peoples of the area, available online [http://en.wikipedia.org/wiki/Athabasca_oil_sands#Indigenous_peoples_of_the_area], accessed June 2012.

195 Radio-Canada (2010). Un impact sur les droits ancestraux des Autochtones, available online [http://www.radio-canada.ca/regions/alberta/2010/12/10/001-sables-bitumineux-etude-droits-autochtones.shtml], accessed June 2012.

196 Refworld, The leader in Refugee Decision Support (2010). State of the World's Minorities and Indigenous Peoples 2010 – Kazakhstan. The UN Refugee Agency, available online [http://www.iwgia.org/regions/africa/algeria/841-update-2011-algeria], accessed June 2012.

197 http://www.unhcr.org/refworld/docid/4c33311270.html

198 In amount of money, for the Oil and Gas Extraction Industry (NAICS: 211).

by a specially convened tribunal not being recognized as a fair trial[199]. Shell has been found involved in this repression and agreed to a US$15.5 million settlement in 2009[200]. Since 1993, Shell does not have activity on Ogoni's land anymore but is largely present in south Nigeria and still plans to return to the left area. In 2003, Shell acknowledged that they had inadvertently fuelled corruption in the way they awarded contracts and gained access to land in Nigeria[201]. Some campaigns have claimed to boycott Shell[202]; among them, the call from scientists and professionals around the world asking the Norwegian government to stop investing in Shell for its activities in Nigeria is very recent (2012)[203]. This suggests an on-going irresponsible behaviour from Shell in the area. In July 2011, this company has also been criticized for keeping its activities under the illegitimate regime in Syria[204].

Suncor has also been criticized for its activities in autocratic regime of Libya where investment "can end up supporting a regime that commits human-rights abuses".[205]

If Shell and Suncor are here used to represent activities taking place in Canada, their behaviours suggest a high possibility of involvement in armed conflicts for the extractive step. In order not to associate this possibility to a specific country but to the enterprises, the score is attributed to the extractive step regardless of the country of activity.

Corruption

In a Global Witness report (2012)[206], it is suggested that the increasing demand for oil in a context of decreasing supply and intensification of the competition for resources exacerbates corruption and violent conflicts. As some inherent features of the oil extractive sector exacerbate corruption, a high possibility of encountering such behaviour is attributed to the extractive sector regardless the country of activity. Supporting this score, Shell has been subject to criticisms from NGOs for its lobby against a US act requiring extractive companies to disclose their tax, royalty and other payments to

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199 Virani (2011). Royal Dutch Shell and the tragedy of Nigeria's Ogoni region, The Canadian Council for Democracy, available online [http://thecommons-ccd.com/2011/01/royal-dutch-shell-and-the-tragedy-of-nigerias-ogoni-region/], accessed June 2012.

200 Mattera (2012). Another Supreme Court boost for corporate unaccountability? The Institute for Southern Studies, available online [http://southernstudies.org/2012/03/another-supreme-court-boost-for-corporate-unaccountability.html], accessed June 2012.

201 BBC News (2004). Shell admits fuelling corruption, available online [http://news.bbc.co.uk/2/hi/business/3796375.stm], accessed June 2012.

202 Boycott Shell – Essential Action (undated). Shell in Nigeria: What are the issues? Available online [http://www.essentialaction.org/shell/issues.html], accessed June 2012.

203 Donovan (2012). Call for Norwegian Government Pension Fund disinvestment in Shell. Royal Dutch Shell PLC.com, available online [http://royaldutchshellplc.com/2012/01/30/call-for-norwegian-government-pension-fund-disinvestment-in-shell/], accessed June 2012.

204 Mills (2011). West needs to treat sanctions against Syria with caution. The National, available online [http://www.thenational.ae/thenationalconversation/industry-insights/energy/west-needs-to-treat-sanctions-against-syria-with-caution?pageCount=0], accessed June 2012.

205 York (2012). Canadian companies urged to look at the cost of doing business with despots. The Globe and Mail, available online [http://www.ctv.ca/generic/generated/static/business/article1949364.html], accessed June 2012.

206 Global Witness (2012) Rigged? The scramble for Africa's oil, gas and minerals. Available online [http://www.globalwitness.org/sites/default/files/library/RIGGED%20The%20Scramble%20for%20Africa's%20oil,%20gas%20and%20minerals%20.pdf], accessed June 2012.

governments[207] in order to be less transparent, while the Global Witness report (2012) calls for more transparency in the sector[208]. Also, the human rights report on Algeria from the US Department of State (2010) mentioned a "notable corruption case" involving Sonatrach.

Fair distribution

The moderate scores attributed to all countries, except for Kazakhstan, are based on the Gini coefficient.

Fair competition

The moderate scores attributed to Fair competition in Algeria and Kazakhstan are based on the WEF annual Executive Opinion Survey, which highlights a moderate effectiveness of anti-monopoly policy in those countries.

Respect of intellectual property rights

The high scores attributed to Respect of intellectual property rights in Algeria and Kazakhstan are based on the WEF annual Executive Opinion Survey, which highlights a weak intellectual property protection in those countries.

J) Milk transportation

1- Description of the supply chain

The life cycle of milk transportation includes the transportation service per se, trucks and equipment distribution, truck and equipment manufacturing, components manufacturing and raw material extraction. The step of milk transportation is not covered in the PHA for reasons described in section 5.2. Regarding the trucks and equipment distribution stage, it is not expected to encounter social issues differing from those highlighted for the farm inputs distribution. Finally, regarding the trucks and trailer manufacturing (heavy-duty truck – NAICS 33612 - and truck trailer – NAICS 336212), it mostly takes place in the United States. The Canadian central provinces (QC and ON) are, however, also important players[209].

In Canada, the number of truck trailer manufacturers (271) is important compared to heavy-duty truck manufacturers (44). For both sectors, more than 60% of the manufacturers are located in Quebec and Ontario. In Western provinces, Alberta is the most important producer. The Atlantic Provinces account only a few plants[210].

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207 Business & Human Rights Resource Centre. Available online [http://business-humanrights.org/Documents/Dodd-Frank-2012], accessed June 2012.

208 Global Witness (2012). Oil companies lobby for less transparency as Glocal Witness exposes the need for more, available online [http://www.globalwitness.org/library/oil-companies-lobby-less-transparency-global-witness-exposes-need-more], accessed June 2012.

209 Statistics Canada. Canadian Industry Statistics (CIS), data for 2011, (heavy-duty truck – NAICS 33612 - and truck trailer – NAICS 336212), available online [http://www.ic.gc.ca/], accessed June 2012.

210 Statistics Canada, Canadian Business Patterns Database, Heavy-duty truck manufacturing (33612) and Truck trailer manufacturing (336212), December 2009.

2- Companies included in the sample

To cover truck and trailer manufacturing in the US and in Canada, four companies have been selected as proxies for the PHA:

1) Western Star, an American company subsidiary of **Freightliner**, supplying heavy trucks in every Canadian province[211];

2) Kenworth, a subsidiary of **Paccar**, an American company, manufacturing heavy-trucks in the US and in Canada (QC)[212];

3) Lazer Inox, a Canadian company located in Quebec manufacturing tank milk[213]; and

4) Tremcar, a Canadian company located in Quebec and Ontario manufacturing tank milk and supplying the different Canadian provinces as well as the US[214].

The heavy-trucks manufacturing companies conduct operations in other countries than the United States and Canada. When social issues are encountered in those other countries, they are still included in the analysis.

Regarding the manufacturing of trucks and trailers' components, only the steel is retained in the system analysis for a matter of simplification. The steel life cycle has been assessed in the machinery section and is therefore not presented here.

3- Detailed justifications

The results of the PHA of the trucks subsystem are presented below.

211 WeaternStar's website [http://www.westernstartrucks.com/Dealers/NorthAmerica/], accessed June 2012

212 Wikipedia. Kenworth, available online [http://fr.wikipedia.org/wiki/Kenworth], accessed June 2012.

213 Lazerinox's website [http://www.lazerinox.com/client/page1.asp?page=32&clef=0&Clef2=1], accessed June 2012.

214 Tremcar's website [http://www.tremcar.com/en/sales-contact.php], accessed June 2012.

Results of the PHA of the Trucks subsystem

Stakeholders	Subcategories	Trucks and trailers manufacturing	
		CA	US
Workers	Freedom of association and collective bargaining	☐ r	▨ c
	Child labour	☐ r	☐ c
	Fair salary[213]	☐ s	☐ s
	Working hours	☐ s	▨ c
	Forced labour	☐ r	☐ c
	Equal opportunities/Discrimination	☐ c	☐ c
	Occupational health and safety	▨ s	▨ s
	Employment insecurity	▨ c	▨ c
Local Community	Access to material or immaterial resources	☐ c	☐ c
	Safe and healthy living conditions	n/a	n/a
	Respect of indigenous rights	■ c	▨ c
	Secure living conditions	☐ c	☐ c
Society	Involvement in armed conflicts	n/a	n/a
	Corruption	☐ c	☐ c
	Fair distribution of revenues	▨ c	▨ c
Value chain actors	Fair competition	☐ c	☐ c
	Respect of intellectual property rights	☐ c	☐ c

CA Canada; US United States; s Statistical indicator; r Human rights reports
w Web; c Country; n/a Not available

[215] For the Trucks manufacturing sector and the trailers manufacturing sector (NAICS: 3361 and 3362) in Canada, the annual average wages of these sectors (CIS, 2010 [http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic32411sale.html], accessed September 2012) have been compared to the country annual average wage (Average salary survey, 2011/2012, available online [http://www.averagesalarysurvey.com/article/average-salary-in-canada/19192229.aspx], accessed September 2012). In the US, hourly median wage in the Trucks manufacturing sector and the trailers manufacturing sector (NAICS: 3361 and 3362) have been compared to the US median hourly wage. Data for the US in 2011 come from the Occupational Employment Stat – [http://www.bls.gov/oes/current/oessrci.htm], accessed June 2012.

4- <u>Detailed justifications</u>

Freedom of association and collective bargaining

Scores attributed to the Freedom of association and collective bargaining in the US represent the country level performance assessed through the World Economic Forum's (WEF) annual Executive Opinion Survey, which highlights a moderate cooperation in labour-employer relation in this country.

Working hours

The moderate score for Working hours in the US comes from the Social Hotspots Database that highlights a moderate probability for the indicator "Risk of population working more than 48h per week".

Occupational health and safety

The moderate scores attributed to the manufacturing sector in Canada and the US are based on the ILO statistics on non-fatal occupational injuries which show a higher rate for this sector than the national average in both countries (2008).

Employment insecurity

The moderate scores for employment insecurity are based on the WEF annual Executive Opinion Survey, which highlights a relative easiness in hiring and firing practices in Canada and the US.

Respect of indigenous rights

The high possibility of encountering violation of indigenous rights is based on country level indicators using the US Department of State Country report on Human Rights (2011) and the State of the World's Human Rights country report of Amnesty International (2011). Several violations of indigenous rights in both reports suggest a high possibility of encountering such issues in Canadian economic activities. In the US, the reports mention some poor living conditions of the natives without any specific violations of Indigenous Rights, thus leading to a moderate probability.

Corruption

The scores attributed to Canada and the US are based on the WEF and the Corruption Perception indicators. The subcategory "corruption" is assessed through three indicators: Transparency of government policymaking and Ethical behaviour of firms, both from the WEF, and the Corruption Perception Index. The WEF reports a moderate transparency of government policymaking in the US. The other indicators showing a low possibility of corruption, a low score is attributed to both Canada and the US.

Fair distribution of revenues

The moderate scores attributed to Canada and the United-States are based on the Gini coefficient.