LIFE CYCLE ASSESSMENT IN AGRICULTURE

Potential Applications, Social License and Market Access

Prepared for Alberta Agriculture and Forestry by Nathan Pelletier, PhD of Global Ecologic Environmental Consulting and Management Services, Canada.

March, 2014

Alberta Government

Funding and Disclaimer

The report was prepared as information for Alberta Agriculture and Rural Development. Funding for this project was provided through *Growing Forward 2*, a federal, provincial, territorial initiative. The views and opinions expressed in this report are not necessarily those of Agriculture and Agri-Food Canada or Alberta Agriculture and Forestry (formerly known as Alberta Agriculture and Rural Development (ARD)). For the purposes of this report we refer to it as ARD.

About Nathan Pelletier and Global Ecologic

Nathan Pelletier is an independent sustainability consultant specializing in environmental and social performance measurement and management strategies in food and other industrial systems. His work proceeds from the recognition that sustainability is the first principle of responsible management, whether at the level of private enterprise, regional, national or global governance. For more information, see Appendix A.

www.globalecologic.com

For more information contact Alberta Agriculture and Forestry

Roger Bryan, P.Ag., Manager, Agri-Environmental Innovation Section
roger.bryan@gov.ab.ca
or
Kerrianne Koehler-Munro, P.Ag., Environmental Program Specialist
kerrianne.koehler-munro@gov.ab.ca

“The real problem of food production occurs within a complex, mutually influential relationship of soil, plants, animals, and people. A real solution to that problem will therefore be ecologically, agriculturally, and culturally healthful. ...A good solution improves the balances, symmetries, or harmonies within a pattern - it is a qualitative solution - rather than enlarging or complicating some part of a pattern at the expense or in neglect of the rest.”

Wendell Berry,

Author of Solving for Pattern (1980)

Contents

Life Cycle Assessment in Agriculture: Potential Applications, Social Licence and Market Access

Executive Summary

With increasing attention to sustainability issues in the food sector has come a rising interest in metrics for measuring and comparing the environmental profiles of food production systems and food products. Evidence-based policy, as well as clear and transparent communication of environmental performance between supply chain stakeholders, has underscored the critical role of life cycle thinking and tools in decision-support contexts.

Life Cycle Assessment (LCA) is a formalized methodology (ISO 14040-14044) that provides a quantitative approach to understanding the distribution of resource demands and environmental impacts along food product supply chains, as well as key mitigation levers. The life cycle approach is essential to effective environmental management because important interactions may occur "upstream" or "downstream" along supply chains. This report identifies options for the use of life cycle assessment which might be adopted (or adapted for use) by industry and government regulators in Alberta.

Industry Average Life Cycle Assessment

The most common type of reported agricultural LCAs tend to be generic, industry-level analyses. The purpose of this kind of LCA is to develop a baseline understanding of the magnitude and distribution of resource demands and environmental impacts associated with production of a given commodity at a regional or national scale, along with key levers for mitigation actions. They are also sometimes used for the purpose of comparing impacts between different kinds of commodities available in the marketplace in order to support prioritizing interventions or environmentally informed consumption choices. When multiple analyses are applied to major commodity groups in the same regions, regulators can gain an improved understanding of how different sectors variously contribute to specific environmental concerns, whether at regional scales for issues like eutrophication of water bodies or for global concerns such as greenhouse gas emissions. When an LCA is repeated over time using consistent methodologies, this can also provide a reasonably robust basis for tracking changes in average industry environmental performance, or to assess how an ongoing transition in industry practices (for example, from conventional to conservation tillage) may be changing the average environmental profile, along with any associated trade-offs in key areas of environmental concern.

Producer-level Life Cycle Assessment

In order to better serve the needs of individual producers, a more contextualized approach to LCA can be implemented based on farming system typology. This approach can be useful in identifying beneficial practices in light of specific climatic, geographical, or socio-economic constraints, and with respect to

known, regionalized environmental sensitivities. Certification schemes at the producer-level will be particularly well-served by rigorous, context appropriate models and data.

The most common application is calculator tools that allow end users to enter activity data via a user-friendly interface in order to estimate the environmental footprints associated with products or activities. Such tools may be developed and managed by industry associations, NGOs, or regulatory agencies. Detailed calculators are now available that are specifically intended to help producers of agricultural commodities better understand and manage their activities for a defined subset of environmental objectives. For example, the Sustainable Agriculture Alliance has created the Fieldprint Calculator (http://www.fieldtomarket.org/fieldprint-calculator/) that allows individual farmers to model their specific production systems, and also proposes mitigation strategies and associated emissions reduction potentials for a range of management and technology interventions.

LCA for Certification, Labeling and Communication

The global market for environmentally preferable goods and services is estimated at 5.8 trillion dollars and growing at 4% annually. Competition is becoming increasingly focused on the opportunities in this emerging market space. This is especially true for food, where environmental, health and social issues have sensitized consumers and the food industry. In this context, LCA can be an important tool in support of improving social license to operate, as well as leveraging access to emerging green markets.

Certification and labelling programs based on LCA metrics are increasingly widespread. Effectiveness of these certification and labelling programs, however, depends upon the relevance of the criteria used, the robustness of the certification process, the market share for the products and consumer preferences and preparedness for the labeling.

Life Cycle-Based Certification and Reporting Approaches and Options

Life cycle-based environmental footprint certification initiatives typically correspond to one of three approaches. The first is to award certification on the basis of a third-party verified life cycle assessment of production activities (e.g. Climate Declaration or Environmental Product Declaration). The second is to require a demonstrated level of emission reductions for a given reporting interval or period (for example, the Carbon Trust Carbon Reduction Label). The third approach is to demonstrate lower environmental impacts than a product category benchmark (for example, the Climatop certification system requires a minimum of 20% lower emissions than the benchmark). All three of these options require rigorous producer or company-level assessments (in the case of later food supply chain stages). Sector-level benchmark assessments of the life cycle impacts of key agricultural raw material supply chains may be required to support food company-level assessments and performance claims.

Regulatory Applications for Agricultural Life Cycle Assessment

Conducting LCA provides valuable learning for policy developers, regulators and program design specialists. LCA shows the relative environmental performance of commodity sectors, and indicates relative efficiencies of resource use and impacts. The data from different management scenarios can help design incentives, understand trade-offs, and also identify regulatory needs and Beneficial Management Practices. Since LCA allows for multi-criteria assessment at a specific point or along the entire supply chain, the reduced likelihood of burden-shifting when decisions are informed by life cycle thinking and tools results in better governance and regulatory policy. European experiences have demonstrated the efficacy of policies based on life cycle thinking – in particular, with respect to improving material resource efficiency - and LCA has been used to provide the necessary benchmarks and ranges of efficiencies.

Conclusions

Social license and market access will likely become increasingly contingent on the willingness and ability of producers and commodity groups to measure and communicate their environmental performance, as well as demonstrate a commitment to continuous improvement over time.

Life cycle thinking and related tools like Life Cycle Assessment have become a critical component of effective environmental management. The growth of standardized methods and certification/labeling schemes reveals the emergence of new norms and requirements that agricultural producers will face in order to maintain social license to operate as well as ensure access to current and emerging green markets.

Future options for Alberta include:

1. Undertake additional, industry average life cycle assessment studies of other major Alberta commodities to better understand relative and absolute environmental performance along with priority mitigation areas and BMP options.
2. Use data envelopment analysis to define benchmarks and beneficial-practices for the most recent four commodity LCAs.
3. Apply the lessons garnered from the initial four studies (i.e. the key supply chain hotspots and mitigation levers) to formulate priority industry and regulatory initiatives that are largely relevant for the Alberta agriculture sector as a whole.
4. Develop communication/outreach materials to disseminate the highlights of these studies, and the utility of LCA generally, to Alberta agriculture sector stakeholders.
5. Engage industry stakeholders in developing commodity-specific approaches and tools to enable more rigorous, life cycle assessment studies in support of producer-level mitigation efforts.
6. Assess the extent to which the methods applied in the four studies correspond with existing or emerging international initiatives.
7. Explore the utility of life cycle-based decision support tools for Alberta agricultural producers, such as commodity-specific environmental footprint calculators.

8. Explore options for certification and labeling of Alberta agricultural products, based on new or existing initiatives.
9. Support time-series life cycle assessment studies to demonstrate the evolution of Alberta agricultural practices, resourced demands, and environmental impacts.
10. Support industry stakeholders in establishing life cycle-based environmental performance objectives, along with measurement and reporting protocols.
11. Encourage the incorporation of life cycle-based metrics in Corporate Sustainability Reporting in the Alberta food sector.

Introduction

Since the mid-twentieth century, the development and application of new technologies in agriculture has enabled remarkable increases in food production globally. For example, agricultural innovations in genetic selection and fertilization have resulted in a more than doubling of cereal production, precipitating a price decline exceeding seventy percent in real terms (Tilman et al. 2001). This transformation has been of profound consequence for the least advantaged, who devote a disproportionate share of household income to food purchases. At the same time, the "Green Revolution" has not come without costs. Intensive agricultural practices contribute to a variety of adverse environmental effects. The energy intensity of industrial agriculture also raises concerns vis-à-vis the declining availability of readily accessible fossil energy resources as well as the impacts of extracting and combusting fossil energy. (Pelletier et al. 2011, 2014).

Along with localized impacts on biodiversity, food systems have been identified as a major contributor to regional and global environmental change. It is estimated that food systems alone contribute 15-28% to anthropogenic greenhouse gas emissions in developed countries (EU 2006). Food production is also the primary source of reactive nitrogen mobilization, accounting for roughly 80% of anthropogenic fixation (Socolow 1999, Galloway et al. 2004, 2008) due to enhanced biological nitrogen fixation in agriculture and the production and use of nitrogen fertilizers. Moreover, it is estimated that the food system consumes 12% of global terrestrial net primary productivity. This has non-trivial implications for energy flows within food webs, the composition of the atmosphere, and the provision of important ecosystem services (Imhoff et al. 2004, Pelletier and Tyedmers 2010).

With growing populations, increasing affluence, and an on-going global transition towards diets that are higher in land and resource-intensive sugars, oils and animal products, pressure on agricultural production systems is accelerating. Between 1970 and 2000, global daily per capita caloric intake increased from 2411 to 2789 calories and is anticipated to further increase to 3150 calories per capita by 2050 (FAO 2006). Together, these pressures have brought the concept of food security to the fore of international food system discourse. Food security refers to state of universal ''physical, social and economic access to sufficient, safe and nutritious food that meets dietary needs and food preferences for an active and healthy life'' (FAO 2002). How to provide food security in light of increasing populations and shifting dietary patterns in face of climate change and competition for limited land, water, and other resources figures among the central governance challenges of the modern era.

With increasing attention to sustainability issues in the food sector has come a rising interest in metrics for measuring and comparing the environmental profiles of food production systems and food products. Interested parties include consumers seeking to make environmentally informed consumption choices, regulatory bodies requiring science-based support for developing sustainable food policies, and industry stakeholders wishing to identify effective strategies for improving, differentiating and communicating their environmental performance. The former aspect is fast becoming a priority industry concern both in terms of market access and social license. The frameworks and tools applied towards developing the necessary information base for these applications must therefore enable differentiation of products, production systems and contexts, and both technology and management alternatives via robust quantification of their environmental performance profiles.

Life cycle thinking refers to a sustainability management approach that takes into consideration, to the extent feasible, all relevant interactions associated with a good, service, activity, or entity from a supply chain perspective for the purpose of improved decision-making. In the context of environmental management, the life cycle approach requires attention to material and energy inputs and emissions that occur along the entire "life cycle" of the activities of concern. This includes activities from the level of primary resource extraction through processing, distribution, use, and eventual disposal or reuse phases.

The life cycle approach is essential to effective environmental management because important interactions may occur "upstream" or "downstream" along supply chains, and hence may not be immediately evident at a given focal point. It is also necessary to making transparent any potential trade-offs between different types of impacts associated with specific management interventions to help avoid unintended shifting of burdens – whether between supply chain activities or different kinds of environmental impacts (Pelletier et al. 2012). According to Klöpffer (2003, p. 158) "Life cycle thinking is the prerequisite of any sound sustainability assessment. It does not make any sense at all to improve (environmentally, economically, and socially) one part of the system in one country, in one step of the life cycle or in one environmental compartment, if this 'improvement' has negative consequences for other parts of the system which may outweigh the advantages achieved."

Life Cycle Assessment (LCA) is a formalized methodology for operationalizing life cycle thinking in environmental performance measurement and management. This methodology involves (1) inventorying the material and energy inputs and emissions associated with each stage of a product or service life cycle and (2) applying a suite of peer-reviewed impact assessment methods in order to quantify the associated resource, human health and environmental pressures. The methodology has been standardized in the ISO 14040-14044 series of standards, as well as in numerous private-body and national standards.

LCA allows for identifying life cycle stages that contribute disproportionately to specific areas of environmental concern. Provided that consistent methods are applied to assessing different product or service systems, it is also conducive to comparing the resource efficiency and environmental profiles of alternative production technologies. At an aggregate level, it can be used to estimate the potential impacts of economic activities with respect to sustainability targets or thresholds at relevant geographical scales (Pelletier et al. 2012). A broad variety of published LCA studies of food products have emerged in recent years. Taken together, these studies have provided a wealth of insights as to the distribution of resource demands and environmental impacts along food product supply chains, as well as key mitigation levers.

Alberta Agriculture and Rural Development (ARD) supports environmental stewardship initiatives within the province of Alberta. Beneficial management practices (BMPs) among producers are identified and promoted in order to reduce or eliminate environmental risks and improve competitiveness. In support of developing an improved understanding of the environmental profiles of a subset of key agricultural commodities in Alberta, ARD commissioned the LCA consulting firm, Quantis, to conduct LCA studies of Alberta canola, potato, broiler chicken, and egg production. ARD now seeks to develop next steps in building upon this research in order to further the constructive implementation of life cycle-based environmental management strategies in the Alberta agriculture sector. In particular, ARD wishes to better understand how the results of this research, and the use of life cycle assessment in general, can be effectively used both by government and industry stakeholders in support of improving market access and social license for the Alberta agriculture sector. Within this context, this report is intended to provide an overview of current applications and options for the use of life cycle assessment which might be adopted or adapted for use by industry and government regulators in Alberta.

Life Cycle Assessment in Agriculture – Key Applications and Insights

A perusal of the peer-reviewed and grey literature indicates that hundreds of agricultural LCA's covering a broad range of commodities, production conditions and regions have been reported in recent years (for example, see Roy et al. 2009). These include both industry-level LCA's, which attempt to characterize overall industry average environmental performance in producing a given commodity, as well as more focused LCAs whose ambition is to characterize in detail the life cycle impacts of a specific operation or production technology.

Industry Average Life Cycle Assessment

The most common type of reported agricultural LCAs tend to be generic, industry-level analyses. The purpose of this kind of LCA is to develop a baseline understanding of the magnitude and distribution of resource demands and environmental impacts associated with production of a given commodity at a regional or national scale, along with key levers for mitigation actions. They are also sometimes used for the purpose of comparing impacts between different kinds of commodities available in the marketplace in order to support prioritizing interventions or environmentally informed consumption choices. These comparisons, when undertaken on a robust and consistent methodological basis, enable an understanding as to how a given sector fits into the broader picture of consumption-related environmental impacts, as well as a general understanding of the key variables along the supply chain that are responsible for the greatest proportion of impacts.

For example, some of the "rules of thumb" that have emerged from industry-average LCA modeling in agriculture and food products include:

- the importance of fertilizer production and nutrient management (in particular, with respect to nitrogen) as a key variable in the environmental performance profile of agricultural crop production
- the importance of feed efficiency and sourcing least environmental cost feed inputs in animal production supply chains
- the high degree of variability seen with respect to "average" farm practices and performance, which typically reflects a combination of environmental, technological and social factors
- the importance of energy mix in determining the relevance of processing activities in the environmental profile of food products
- the importance of minimizing food waste to reducing overall, food system resource and environmental impacts

Industry-level life cycle assessment can be usefully applied to define benchmarks of the average environmental performance profile of participants, along with the distribution of impacts that characterize the variety of production practices and conditions within a sector. When multiple analyses are applied to major commodity groups in the same regions, regulators can gain an improved understanding of how different sectors variously contribute to specific environmental concerns, whether at regional scales for issues like eutrophication of water bodies or for global concerns such as greenhouse gas emissions.

Moreover, when analyses are repeated over time using consistent methodologies, this can provide a reasonably robust basis for tracking changes in average industry environmental performance, or to assess how an ongoing transition in industry practices (for example, from conventional to conservation tillage) may be changing the average environmental profile, along with any associated trade-offs in key areas of environmental concern. A number of recently published time-series life cycle assessments demonstrating substantial improvements in resource efficiency and reduced environmental impacts for commodity agricultural products over 30-50 year intervals (for example, see Capper 2009, Capper et al. 2011, Boyd and Cady 2012; and Pelletier et al. 2014) demonstrate the potential of LCA to support industry efforts to communicate their progress and hence leverage improved social license.

One increasingly common and powerful application of industry average LCA is "data envelopment analysis" (DEA). DEA uses the distribution of data for key performance variables in order to identify both benchmarks (production frontiers) and best practice frontiers. The aggregate mitigation potential of shifting industry baselines towards demonstrated best practices is subsequently assessed (Iribarren et al. 2010). Such analyses may be used by industry associations and regulators as a basis for prioritizing interventions, defining and supporting best management practices and tracking progress with respect to defined objectives over time. For regulators, producer-level or industry reporting on performance relative to benchmarks and targets may also be linked to access to subsidies, resources, preferential tax rates, or other voluntary programming tools in support of incentive-based interventions.

Producer-level Life Cycle Assessment

Industry average benchmarks may be useful for participants, industry associations and regulators in terms of building an understanding of current performance, what may be the most important levers for leveraging improved environmental outcomes, as well as the observed distribution in performance across farms. However, high-level, industry-wide analyses also often mask the considerable heterogeneity in farm types, practices, and environmental conditions – each of which may influence the opportunities and constraints that face individual producers in achieving their environmental management objectives.

In order to better serve the needs of individual producers, a more contextualized approach to LCA can be implemented based on farming system typology. This approach differentiates context-specific conditions and norms, data requirements, and impact assessment considerations in order to define sub-populations for analytical purposes. Sub-populations might be defined based on climatic or soil conditions, scale of production, production technology, or other variables. Sensitivity to farm-specific conditions allows for more robust representation of the diversity of farm practices, along with actual production performance profiles, than will a generic, industry-wide average (Pradeleix et al. 2012). This approach can be particularly useful in identifying best practices in light of specific climatic, geographical, or socio-economic constraints, and with respect to known, regionalized environmental sensitivities. Here, processed-based models (for example, with respect to soil carbon or nitrous oxide flux) can be used in order to derive more representative estimations of farm-level impacts than are possible when generic emission factors are applied. Certification schemes at the producer-level will be particularly well-served by rigorous, context appropriate models and data. This approach may be challenging where substantial education and support for producers are necessary in order to enable their participation, or where data reporting, management and analysis requirements create a disproportionate burden for producers or project administrators.

LCA, Social License, and Market Access

The increasing emphasis on evidence-based policy, as well as clear and transparent communication of environmental performance between supply chain stakeholders, has underscored the critical role of life cycle thinking and tools in decision-support contexts. Approaches to make such tools more accessible to user groups have also increased both in number and robustness. As life cycle thinking and tools gradually move into the mainstream, they are also increasingly seen as means to improve social license to operate, as well as leverage access to emerging green markets.

Social license traditionally refers to the extent to which a local community accepts or approves of an entity's presence or activities, regardless of their legal legitimacy. Social license is built over time, through a combination of demonstrated good practice, open and transparent communication, and ethical behavior. Regional and cultural differences underscore that building the social capital required for social license may require attention to the specific needs and customs of the communities in which an entity operates.

Changing demographics and technological conditions in agriculture, along with increased media attention to agriculture's potentially adverse environmental effects, have served to increase the relevance of social license in this sector. The scope of social license that is necessary for agricultural producers has extended beyond the boundaries of traditional farming communities to include communities and stakeholder groups at larger scales that may be impacted by the effects of agricultural practices – for example, downstream communities in watersheds concerned with agricultural run-off. Ultimately, consumers of agricultural products in distant markets have also become stakeholders in the granting of social license to operate, since consumer purchasing decisions and market share can determine the economic viability of specific production norms in specific cultural and geographical contexts. Life cycle thinking and management contributes to this phenomenon, since it makes transparent the concentration of environmental impacts at specific supply chain stages. For agriculture, this is typically at the level of on-farm production. Social license and market access may hence be increasingly contingent on the willingness and ability of agricultural producers to transparently communicate their practices, and to make clear and measurable commitments to improve performance over time. A variety of life cycle-based tools and initiatives to facilitate agricultural producers in measuring and communicating their performance, identifying mitigation opportunities, and differentiating their products in order to improve social license and market access are currently available or under development. Several approaches and examples are discussed in the next section.

User-Friendly, LCA-based Tools for Measuring, Monitoring, and Mitigating Agricultural Activities

In order to enable more widespread use of life cycle-based assessments of food supply chains for decision support, a variety of user-friendly applications targeting different audiences have emerged. In particular, these have focused on GHG emissions, although water, energy, and nitrogen footprints are also becoming increasingly common. The most common application is calculator tools that allow end users to enter activity data via a user-friendly interface in order to estimate the environmental footprints associated with products or activities. Such tools may be developed and managed by industry associations, NGOs, or regulatory agencies.

At the consumer-level, calculators such as the Low Carbon Diet Calculator (developed by Bon Appétit Management Foundation - see www.eatlowcarbon.org/) use a points system based on life cycle assessment studies to help consumers better understand the comparative environmental impacts of different food product consumption choices, including how impacts are distributed along product supply chains. On this basis, consumers can choose low carbon diets, ultimately influencing the relative viability of specific food supply chains on the basis of their carbon intensity.

Industry associations are also increasingly providing life cycle-based calculators targeting both their constituents as well as consumers of their sector's products. SeaFish, a UK-based industry governance body, offers a calculator where users can enter specific or generic data for fish resource supply chains in order to derive estimates of the GHG implications of different sourcing choices (http://seafish.tictocdesign.com/co2emissions/tool/). The tool includes estimated GHG emissions for fishing, processing, and transportation.

Also common are more detailed calculators that are specifically intended to help producers of agricultural commodities better understand and manage their activities for a defined subset of environmental objectives. For example, the Sustainable Agriculture Alliance has created the Fieldprint Calculator (http://www.fieldtomarket.org/fieldprint-calculator/). This tool, which is provided free of cost to corn, cotton, rice, wheat, potato and soybean producers, enables confidential, farm-specific assessments of a suite of environmental performance indicators: Land Use; Conservation; Soil Carbon; Irrigation Water Use; Water Quality; Energy Use; and Greenhouse Gas Emissions. Some of these indicators are calculated using life cycle-based methodologies. The Cool Farm Tool (http://www.coolfarmtool.org/) is another free, life cycle-based online greenhouse gas calculator that assists producers in measuring the carbon footprint of crop and livestock products. The Cool Farm Tool also identifies hotspots, and allows producers to test alternative management scenarios in order to identify those that will have a positive impact on the total net greenhouse gas emissions.

Along similar lines, the European Commission recently developed a farm-level life cycle-based GHG emissions calculator intended to accommodate the diversity of farming systems, climates and soil conditions in the EU-27 (Tuomisto et al. 2013). The calculator was extensively tested in a pilot phase, with the results of the testing subsequently used to improve the underpinning methods and data. The calculator allows individual farmers to model their specific production systems, and also proposes mitigation strategies and associated emissions reduction potentials for a range of management and technology interventions. While currently primarily focused on a single indicator (GHG emissions), the tools also reports farm-level energy use and nitrogen balances. Future work will likely prioritize the incorporation of additional, relevant environmental criteria. The tool provides a reasonable example of an approach that can simultaneously provide both for producer-relevant assessments tailored to context-specific conditions along with industry average benchmarks that are generated by aggregating production-weighted average producer results. However, as with any modeling tool, the quality of input data is of paramount importance.

Life Cycle Assessment for Certification, Labeling and Communication Initiatives

Certification and labeling provide a means of differentiating processes or products within product categories based on specified performance levels or characteristics. They are increasingly applied in the context of private sector, NGO, or government-sponsored initiatives to encourage more sustainable production practices and consumer choices (Borregaard and Dufey 2005). The premise behind such initiatives is that they create opportunities and encourage businesses to capitalize on emerging markets for environmentally sensitive products and practices. In essence, they are intended to harness market forces in creating enabling conditions both for producers and consumers to further sustainability objectives.

The effectiveness of certification and labeling in actually leveraging improved sustainability outcomes depends upon several factors. First is the relevance of the criteria employed, and the robustness of the certification processes in accurately differentiating and communicating performance. Second is the market share for the certified or labeled products. Important here are consumer preferences, as well as consumer confidence in and recognition of the certification schemes and labels in question (Preiss 1997).

A plethora of environmental certification and ecolabeling schemes have emerged in recent years for a diversity of products and services. The market for environmentally preferable goods and services is estimated at 5.8 trillion dollars globally (Department for Business, Innovations and Skills 2012). Growing at an annual rate of 4% annually even through the global economic recession, the “green economy” is thought to be one of the sectors with the greatest job growth potential (Annual Growth Survey 2012). Competition between companies is therefore increasingly focused on gaining market share in this domain.

This is particularly true for the agriculture and food industry, where increased media attention to the environmental impacts of food production, as well as health and social equity issues, has sensitized both industry and consumers to the concept and importance of sustainable food production and consumption. As a result, certified and ecolabeled food products represent one of the fasted growing food markets.

In a review of the extent to which LCA is currently used to inform certification and labeling of seafood products (including fisheries and aquaculture products), Pelletier and Tyedmers (2008) reported very little uptake in life cycle thinking for certification/labeling initiatives in this sector. They underscored the importance of and key opportunities for implementing life cycle assessment principles and practices in order to improve the efficacy of sustainable seafood initiatives, and highlighted key variables for inclusion in certification and labeling schemes. This included organic certification initiatives – in particular for aquaculture supply chains reliant on agricultural feed inputs. In the last half decade, however, life cycle assessment has seemingly become the gold standard for emerging environmental certification and labeling programs. A plethora of schemes based on life cycle criteria have emerged – in particular certification and labeling schemes associated with the greenhouse gas intensity of food products.

Along with the rapid emergence of such schemes have come questions as to the integrity of the supporting methods and data, as well concerns regarding transparency, verification, and potential incidences of greenwashing. Consumers faced with multiple, competing claims based on different certification schemes report challenges in making informed sustainable purchasing decisions. At the same time, industry stakeholders indicate that the existence of multiple reporting schemes, each with differing methods and requirements, presents a major barrier to implementation of more sustainable production strategies (EC 2013). In the European Union, 76% of surveyed companies indicated agreement or strong agreement with the statement that a standardized methodology and supporting guidance would influence their decision to measure and communicate the environmental performance of their products, and 72.5% agreed that lack of consistency (i.e. multiple initiatives and ways of reporting) was one of the most important barriers to benchmarking and communicating environmental performance (EC 2013). However, industry respondents also evinced a lack of confidence in the capacity and quality of available methodological specifications and data to support potential mandatory applications or comparisons between products.

Standardization Initiatives for Life Cycle-Based Methods

In order to reduce market confusion, improve uptake by industry, and promote quality and consistency in life cycle-based certification and labeling schemes, a number of notable methods development and standardization initiatives have emerged. In general, these initiatives take the ISO 14044 standards for life cycle assessment, along with other international and national standards (in particular, GHG accounting standards), as the departure point. The objective is typically to provide more specific, sector-relevant norms and guidance than are provided by existing reference methodology documents.

For example, in support of the sustainable production and consumption objective identified in the European Commissions' "Roadmap to a Resource Efficient Europe", which set as a milestone to provide "the right incentives for citizens and public authorities to choose the most resource efficient products through appropriate price signals and clear environmental information," the EC undertook to develop "a common methodological approach to enable Member States and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life cycle ('environmental footprint')" (European Commission 2011b, Pelletier et al. 2013). The resultant methods and guidance documents were subsequently adopted by the Commission as the reference methods for future voluntary or mandatory applications associated with EU policies (Pelletier et al. 2013). Steps are on-going to develop product and sector-specific category rules for life-cycle based environmental footprinting that are based on the Product and Organization Environmental Footprint methods. Pilot developments include food sector product categories.

Also in Europe, The European Sustainable Food Production and Consumption Round Table (FRT) has similarly developed a reference, life-cycle based protocol for environmental footprinting of food products called the "EnviFood Protocol." Co-chaired by the European Commission, the FRT is comprised of key food and drink industry and supply chain stakeholders, regulatory and standardization bodies, and observer organizations. The FRT method (FRT 2013) satisfies the requirements of both ISO 14044 and the European Commission Product Environmental Footprint standards.

Several other initiatives at the international level are also on-going. For example, the United Nations Food and Agriculture Organization has established working groups in support of developing harmonized methods for environmental accounting in livestock supply chains. Of particular note is the Sustainability Consortium (TSC) – a network of academic, private sector and other stakeholder participants working together to provide robust, life cycle based metrics and data in order to drive sustainable innovation in product supply chains (http://www.sustainabilityconsortium.org/). The Consortium includes over 100 of the world's largest companies, which collectively employ over 8.5 million people and produce a combined revenue of over 2.4 trillion dollars. Within the Sustainability Consortium, the Food, Beverage and Agriculture Sector Working Group is actively involved in developing food system-relevant metrics, data, and reporting protocols. As the Sustainability Consortium includes a variety of major food sector companies who likely source considerable volumes of raw materials from Canadian markets, this initiative may be of particular interest to regulators and industry stakeholders in Alberta.

What is apparent here is that requirements to measure and communicate the environmental performance of food products is fast becoming the new norm in the food industry, and is increasingly possible due to the provision of rigorous and standardized methods. In practice, this means that the supply chain partners and consumers of individual producers and commodity groups will increasingly call upon them to demonstrate a commitment to reducing impacts through measuring and seeking to mitigate the undesirable environmental effects of their activities. The resulting competition between agricultural producers and food sector companies will facilitate shifting baselines towards more efficient and sustainable production practices.

Life Cycle-Based Certification and Reporting Approaches and Options

The implementation of life cycle-based environmental certification schemes (in particular, GHG accounting and labeling schemes) is an increasingly common response to growing concerns regarding resource depletion and environmental change. The overarching motivation for such schemes is to provide both producers and consumers with reliable information regarding the comparative environmental performance of products and services in support of informed choice and improved environmental outcomes. More specifically, such schemes aim to identify, communicate and valorize environmentally preferable practices. Through certification and labeling, producers demonstrate their commitment to sustainability objectives compared to their competitors, and hence leverage both increased market access and social license. Several distinct approaches to certification and labeling may be differentiated, each with its particular strengths and weaknesses.

Environmental Footprint Certification

Life cycle-based environmental footprint certification initiatives typically correspond to one of three approaches. The first is to award certification on the basis of a third-party verified life cycle assessment of production activities (for example, Climate Declaration and other Environmental Product Declarations – see http://www.environdec.com/en/Climate-Declarations/#.UzmXdKIUjDs). Results are not assessed against a prescribed performance level, but rather may be communicated to suppliers or customers in support of informed choice. This approach relies almost entirely on market forces to leverage improved environmental outcomes, and requires a customer base that is relatively informed regarding the environmental impact levels that are typical of the product category in question.

The second approach is to require a demonstrated level of emission reductions for a given reporting interval (for example, the Carbon Trust Carbon Reduction Label – see www.carbontrust.com) as a basis for certification. A potential drawback of this approach is the risk of disincentivizing investments or management changes that bring about substantial, one-time reductions in impacts. This may occur if such investments mean that it will subsequently become more difficult to demonstrate continued improvements and thereby maintain certification. Limits to performance improvement potential must therefore be carefully considered in setting certification requirements. An alternative here is to allow "carry-over" of reductions in excess of the target from one year to the next, or to amortize large reductions over multiple reporting intervals.

The third approach is to demonstrate lower environmental impacts than a product category benchmark (for example, the Climatop certification system requires a minimum of 20% lower emissions than the benchmark – see www.climatop.ch). Compliance with offsetting targets may also be considered (for example, Soil & More – see www.soilandmore.com). This approach has the benefit of promoting a shifting industry benchmark that reflects evolving best practices and improvement potentials. However, ongoing assessments of average industry performance are both time consuming and expensive, creating substantial reporting burdens for producers as well as costs for scheme administrators. It should also be remembered that some farms benefit from favourable conditions including specific soil types, climatic conditions, proximity to sources of inputs and markets, etc. that make it inherently easier to perform well relative to industry benchmarks. Conversely, farms not benefiting from such conditions may be simply unable to even achieve the benchmark let alone superior performance despite substantial improvement efforts and investments. Unrealistic targets may disincentivize some farmers from seeking to participate.

All three of these options require rigorous producer or (in the case of later food supply chain stages) company-level assessments. A key strength of these kinds of certification programs is that they can be based on widely recognized methodological norms for LCA. Such methods are typically publically available or may be purchased under license from the standards body (for example, the ISO standards).

In general, however, few existing farm-level certification schemes actually require a rigorous, individualized process-based quantification of the life cycle impacts of farm products. Rather, producers more often need to demonstrate compliance with certain practices which have been identified as important via prior industry benchmark life cycle assessment studies. This is similarly true of organic agriculture certification schemes, which are typically not based on a life cycle approach, but rather on specific codes of practice. This type of scheme probably presents the lowest barriers in terms of reporting and verification requirements, as they may be developed based on once-off industry average life cycle assessments, or even on the basis of meta-analyses of published LCA literature.

Company Level Monitoring and Reporting

Corporate Sustainability Reporting (CSR) in an increasingly common feature of the most successful food sector companies, as it is a powerful tool in maintaining and improving social license to operate. Some food sector companies may wish to inform consumers or supply chain partners regarding the average environmental profile of different products or product categories in order to support informed choice. They may also be motivated to demonstrate how such information is being used to guide internal goal setting, monitoring and decision making. As the power and importance of life cycle thinking becomes recognized, the frequency of inclusion of life cycle-based sustainability metrics as an integral component of CSR reports is similarly gaining prevalence.

In this context, sector-level benchmark assessments of the life cycle impacts of key agricultural raw material supply chains may be required to support food company-level assessments and performance claims. Here, the individual performance of the individual farms that supply raw materials to food sector companies may not need to be monitored. However, companies may also set life cycle-based sourcing standards that individual farmers must fulfill in order to assist in meeting their overall impact reduction targets, and may use these standards to preferentially choose between producers on the basis of environmental criteria.

Food sector company monitoring and reporting activities have considerable potential for improving overall environmental outcomes in the food sector, in particular where large companies that source and market high volumes of agricultural products are involved. A disadvantage here is that such activities may not be third-party verified, or based on specific, widely endorsed quantification metrics.

Regulatory Applications for Agricultural Life Cycle Assessment

Agricultural life cycle assessments can provide valuable inputs to a variety of regulatory context applications. Foremost is the learning value provided by life cycle assessment activities. Regulators are well-served by life cycle based information regarding the average environmental performance profiles of key commodity sectors, which can help in prioritizing sectors for mandatory or voluntary regulatory initiatives. Since LCA provides insight as to key levers and opportunities for improving resource efficiencies and reducing impacts, regulatory initiatives can be more effectively targeted. Careful attention to data distribution, assessment of alternative production technologies, scenario-modeling and data envelopment analysis of LCA results can help to identify Best Management Practices. These approaches can also contribute to understanding the aggregate mitigation potential that may be achieved through specific regulatory interventions. Because LCA provides for supply chain, multi-criteria measurement, it allows regulators to be attentive to potential trade-offs, hence reducing the likelihood of burden shifting – a fundamental principle of good governance. In sum, LCA-based information can be a valuable decision support resource in regulatory contexts.

Experience in Europe, where life cycle thinking has already become a central component of policy support, underscores a number of valuable insights pertinent to expanding the role of LCA in agriculture and rural develop policy in Alberta. For example, in the recent Sustainable Consumption and Production (SCP) policy review, roughly 70% of respondents indicated that strengthening the requirements on material resource efficiency in existing SCP regulatory instruments would be an effective policy option (EC 2012). In the context of Alberta agriculture, life cycle assessment of agricultural commodities can support identification of material efficiency criteria that can help to achieve multiple environmental objectives. For example, fertilizer production and use is typically the dominant contributor to the life cycle impacts of agricultural products. Where reported fertilizer rates in a given commodity sector are disproportionately higher than recommended rates, material efficiency standards (i.e. fertilizer application rate:yield ratios) as criteria for access to programming, subsidies, or other policy-based incentives may prove particularly efficacious. Here, clear evaluation criteria for resource efficiency would be necessary.

On the “demand side”, stakeholder participants in the SCP review indicated that preferential tax treatment for environmentally superior products, or elimination of subsidies for worst-in-class products could strongly contribute to enabling more sustainable production and consumption (EC 2012). Here, identification of benchmarks and proof of performance must necessarily be based on rigorous, life cycle approaches. At present, in light of the emergent and evolving status of methods and the need for development of more comprehensive data sources in order to enable rigorous comparisons between products, stakeholders seemingly prefer voluntary over mandatory schemes. Such schemes could include, for example, benchmarking and communicating environmental performance on the basis of methodologically compliant life cycle assessments, or agreements with stakeholders to set targets with respect to environmental performance for key commodities. This may require developing product category rules for LCA, beginning with priority products.

Among the key messages garnered from consumer responses to the SCP were “knowing the environmental impact of what I buy is important,” and “there are too many different labels.” This points towards the necessity of regulatory intervention to ensure a common, consistent, and robust basis for environmental product declarations and differentiation.

Conclusions

Agriculture and food systems make non-trivial contributions to environmental change at multiple scales. Social license and market access for agricultural producers will likely become increasingly contingent on the willingness and ability of producers and commodity groups to measure and communicate their environmental performance, as well as demonstrate a commitment to continuous improvement over time.

Life cycle thinking and related tools like Life Cycle Assessment have become a critical component of effective environmental management. They also provide an increasingly prevalent and recognized vehicle for product differentiation. A plethora of standardized methods, decision-support tools, and certification/labeling schemes that are now available or under development for agricultural and food sector applications. This phenomenon points towards the emergence of new norms and requirements that agricultural producers will face in order to maintain social license to operate as well as ensure access to current and emerging green markets.

Regulators and industry stakeholders in Alberta have already taken important first steps towards building an understanding of the life cycle impacts of key agricultural commodities in Alberta via LCA studies. These quantification exercises have also served to increase familiarity with life cycle thinking, generally, and what is required to successfully execute an LCA study. They have similarly contributed to establishing a methodological and data basis for further LCA studies in Alberta.

However, these initial steps represent a starting point only in terms of the potential role and applications of life cycle assessment for Alberta agricultural sector stakeholders. A variety of options and elements should be considered in formulating strategies, along with short and long-term goals. Future options include:

(1) Undertake additional, industry average life cycle assessment studies of other major Alberta commodities. Further studies would serve to better understanding the relative and absolute environmental performance of the major commodity groups, along with priority mitigation areas. Efforts to further improve the methodological and data basis for such studies is desirable. These studies could, in turn, be used to formulate Best Management Practices, along with supporting industry and/or regulatory body programs.

(2) Use data envelopment analysis to define benchmarks and best-practice frontiers for the four commodities. Implement voluntary or mandatory reporting requirements, with incentives linked to implementing best practices, demonstrating continuous improvements, or achieving specific performance levels.

(3) Apply the lessons garnered from the initial four studies (i.e. the key supply chain hotspots and mitigation levers) to formulate priority industry and regulatory initiatives that are largely relevant for the Alberta agriculture sector as a whole. Implement voluntary or mandatory reporting requirements, with incentives linked to implementing best practices, demonstrating continuous improvements, or achieving specific performance levels.

(4) Develop communication/outreach materials to disseminate the highlights of these studies, and the utility of LCA generally, to Alberta agriculture sector stakeholders. Emphasize how LCA can contribute to leveraging social license and market access. Encourage and/or support other commodity groups and stakeholders to undertake and communicate LCA studies on a common methodological basis.

(5) Engage industry stakeholders in developing commodity-specific approaches and tools to enable more rigorous, life cycle assessment studies in support of producer-level mitigation efforts.

(6) Assess the extent to which the methods applied in the four studies correspond with existing or emerging international initiatives. Engage industry stakeholders in developing an Alberta position with respect to these initiatives, taking into account potential implications for future market access for Alberta agricultural products.

(7) Explore the utility of life cycle-based decision support tools for Alberta agricultural producers, such as commodity-specific environmental footprint calculators. Ensure a consistent methodological basis.

(8) Explore options for certification and labeling of Alberta agricultural products, based on new or existing initiatives.

(9) Support time-series life cycle assessment studies to demonstrate the evolution of Alberta agricultural practices, resourced demands, and environmental impacts for key commodities in support of improving social license.

(10) Support industry stakeholders in establishing life cycle-based environmental performance objectives, along with measurement and reporting protocols.

(11) Encourage the incorporation of life cycle-based metrics in Corporate Sustainability Reporting in the Alberta food sector.

Works Cited

Annual Growth Survey. 2013. COM(2012) 750 final, http://ec.europa.eu/europe2020/pdf/ags2013_en.pdf

Borregaard, N., Dufey, A. 2005. Challenging preconceptions about trade in sustainable products. Towards win-win-win for developing countries. International Institute for Environment and Development, London

Boyd, C., Cady. R. 2012. A 50-year comparison of the carbon footprint of the U.S. swine herd: 1959–2009. Camco, London, UK.

Capper, J. 2011. The environmental impact of United States beef production: 1977 compared with 2007. J. Anim. Sci. 89:4249–4261.

Capper, J., R. Cady, Bauman, D. 2009. The environmental impact of dairy production: 1944 compared with 2007. J. Anim. Sci. 87:2160–2167.

Cederberg, C., U. Sonesson, M. Henriksson, V. Sund, Davis, J. 2009. Greenhouse gas emissions from Swedish production of meat, milk and eggs 1990 and 2005. SIK report 793, Swedish Institute for Food and Biotechnology, Gothenberg, Sweden.

Department for Business, Innovations and Skills. 2012. Low Carbon Environmental Goods and Services.

European Commission. 2011. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Roadmap to a resource efficient Europe. European Commission, Brussels

EC. 2012. Synthesis of the stakeholder consultation Delivering more Sustainable Consumption and Production. Technical Report - 2012 – 062. European Commission Directorate General – Environment, Brussels.

EC 2013. Building the single market for green products. Facilitating better information on the environmental performance of products and organizations. COM (2013) 196. European Commission, Brussels.

FAO. 2002. The State of Food Insecurity in the World 2001. Food and Agriculture Organization of the United Nations, http://www.fao.org/docrep/003/y1500e/y1500e00.htm (accessed 18.01.13).

FAO. 2006. World Agriculture Towards 2030-2050. Prospects for Food, Nutrition, Agriculture and Major Commodity Groups. United Nations Food and Agriculture Organization, Rome.

FRT. 2013. Environmental Assessment of Food and Drink (ENVIFood) Protocol. *Drafted by* Camillo De Camillis (European Commission, Joint Research Centre), Christian Bauer (SIG Combibloc), Urs Schenker (Nestec Ltd, Nestlé Research Centre), Nicolas Martin (European Feed Manufacturers Federation -FEFAC), Henry King (Unilever Safety and Environmental Assurance Centre), Coen Blomsma (Fediol), Jean - Christophe Bligny (Danone), Lars Lundquist (Nestec Ltd, Nestlé Research Centre), Øyvind Vessia (European Commission, DG Energy), Anna Papagrigoraki (Comité Européen des Fabricants de Sucre - CEFS), Nicole Unger (Unilever Safety and Environmental Assurance Centre), and Rudi Sueys (Coca - Cola Europe). Laura Draucker (World Resources Institute), Gregory Norris (The Sustainability Consortium), Nathan Pelletier (European Commission, Joint Research Centre), Hans Blonk (Blonk Milieu Advies), Graham Houlder (Flexible Packaging Europe), Oscar Ruiz de Imana (Comité Européen des Fabricants de Sucre - CEFS), Ingo Daniel Klenk (Südzucker), and Andreas Sommer (Bunge). http://www.food-scp.eu/files/ENVIFOOD_Protocol_Vers_1.0.pdf.

Galloway, J., et al. 2008. Recent transformation of the nitrogen cycle: Trends, questions, and potential solutions. Science 320:889–892.

Galloway, J., et al. 2004. Nitrogen cycles: Past, present and future. Biogeochemistry 70(2):153–226.

Garnett, T. 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? Food Policy 36:S23−S32.

Imhoff, M., et al. 2004. Global patterns in human consumption of net primary production. Nature 429:870–873.

Iribarren, D., Vasquez-Rowe, I., Moreira, M., Feijoo, G. 2010. Further potentials in the joint implementation of life cycle assessment and data envelopment analysis. Science of the Total Environment 22:5265-72.

Klöpffer, W. 2003. Life-cycle based methods for sustainable product development. Int. J. Life Cycle Ass. 8(3):157–159.

Pelletier, N., Tyedmers, P. 2008. Life cycle considerations for improving sustainability assessments in seafood awareness campaigns. Environmental Management 42:918-941.

Pelletier, N., Tyedmers, P. 2010. Forecasting potential global environmental costs of livestock production 2000-2050. Proceedings of the National Academy of Sciences USA 107(43):18371-18374.

Pelletier, N., Audsley, E., Brodt, S., Garnett, T., Henrikkson, P., Kendall, A., Kramer, K., Murphy, D. 2011. Nemecek, T. and M. Troell. Energy intensity of agriculture and food systems. Annual Review of Environment and Resources 36:233-246.

Pelletier, N., Maas, R., Goralcyk, M., Wolf, M.-A. 2012. Towards a life-cycle-based European Sustainability Footprint framework: Theory, concepts, applications. Directorate General - Joint Research Centre, European Commission.

Pelletier, N., Allacker, K., Pant, R., Manfredi. S. 2013. The European Commission Organization Environmental Footprint Method: Comparison with Other Methods, and Rationales for Key Requirements. International Journal of Life Cycle Assessment 19:387-404.

Pelletier, N., Ibarbaru-Blanc, M., Xin, H. 2014. Comparison of the U.S. egg industry's environmental footprint in 1960 and 2010. Poultry Science 93:243-255.

Pelletier, N., Andrae, J., Charef, A., Damalas, D., Green, B., Parker, R., Sumaila, R., Thomas, G., Tobin, R., Watson, R. 2014. Energy prices and (sea)food security: Can fisheries and aquaculture adapt? Global Environmental Change 24:30-41.

Pradeleix L., Bellon Maurel, V., Roux, P., Philippon, O., Bouarfa, S. 2012. Life cycle assessment at the regional scale: innovative insights based on the systems approach used for uncertainty characterization. 8th International Conference on LCA in the Agri-Food Sector, Rennes, France. http://hal.archives-ouvertes.fr/docs/00/76/51/78/PDF/mo2012-pub00036280.pdf

Preiss, E. 1997. An eco-label for shrimp: minimizing potential trade barriers. International Environmental Law Clinic, NYU School of Law, New York.

Socolow, R. 1999. Nitrogen management and the future of food: Lessons from the management of energy and carbon. Proc Natl Acad Sci USA 96:6001–6008.

Tilman, D., Farginoe, J., Wolff, B., DoAntonia, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W., Simberloff, D., Swackhamer, D. 2001. Forecasting Agriculturally Driven Global Environmental Change. Science 292:281-284.

Tuomisto, H., Angileri, V., De Camillis, C., Loudjani, P., Nisini, L., Pelletier, N., Haastrup, P. 2013. Certification of low carbon farming practices. European Commission Joint Research Centre, Institute for Environment and Sustainability.

Appendix A. About Nathan Pelletier and Global Ecologic

Understanding and managing the environmental and social costs and benefits of economic activity has become a defining challenge of the modern era. This challenge provides the nucleus for the rapidly evolving field of sustainability measurement and management. Nathan Pelletier, principal of Global Ecologic, is an independent sustainability consultant specializing in environmental and social performance measurement and management strategies in food and other industrial systems. His work proceeds from the recognition that sustainability is the first principle of responsible management, whether at the level of private enterprise, regional, national or global governance.

Pelletier works closely with clients to build an understanding of supply chain environmental and social sustainability performance and mitigation opportunities using a variety of cutting edge modeling frameworks. These include environmental and social life cycle assessment, environmental footprinting, supply-chain greenhouse gas accounting, energy analysis, and ecological footprint analysis. He is dedicated to delivering high-quality, cost-effective consulting services to meet the demands of citizens, firms and organizations committed to furthering sustainability objectives.

Pelletier established Global Ecologic in 2006. He has since continued to expand his broad experience base in food system sustainability consulting services, working with a variety of small and large organizations to further their sustainability initiatives both at home and abroad. Having researched and modeled over 150 agricultural crop, animal husbandry, fisheries and aquaculture production, processing and distribution supply chains using ISO 14044-compliant life cycle assessment (LCA), Pelletier is recognized as an international expert in LCA of food systems, and a leader in the field. Examples of recent and on-going consulting projects include:

- social and environmental life cycle assessment of the Canadian egg industry, including assessment of alternative housing technologies, for Egg Farmers of Canada
- life cycle assessment of greenhouse gas emissions for egg production and processing supply chains in the United States for the American Egg Board
- comparative life cycle assessment of the environmental performance (including GHG emissions) of the US national egg sector in 1960 and 2010 for the American Egg Board, Egg Industry Council, and United Egg Producers
- development of a supply chain ecological footprint and greenhouse gas accounting tool incorporating LCA-based models of agricultural, fisheries and animal husbandry product supply chains for a major international aquafeeds company (EWOS) to facilitate least-environmental-cost feed sourcing (seven projects since 2006)

- life cycle assessment of tilapia aquaculture production in lake and pond-based systems, including processing and transportation to market ports for the leading global tilapia producer, Regal Springs
- development of a supply chain greenhouse gas accounting tool for SeaFish Industry Authority (UK) for profiling high-volume seafood supply chains
- provision of life cycle impact assessment data and advice to support strategic decision making for environmentally preferable product packaging for a microbrewery
- Provision of food product greenhouse gas emissions intensity data for Bon Appétit Management Foundation Company (Compass Food Service), to be used in educating their institutional chefs as well as their on-line food product GHG calculator as part of the Low Carbon Diet Initiative

Pelletier has similarly constructed and published LCA models of US national broiler poultry production, high and low-profitability conventional and niche swine operations in the mid-western United States, as well as three competing mid-western beef production technologies. All of these models are constructed using an ISO 14044-compliant LCA modelling platform developed by Pelletier for the purpose of high-resolution analyses of crop and animal husbandry systems. This includes customized sub-models based on internationally recognized protocols and best-available scientific practice. Because the platform enables the use of identical modelling principles and parameters for context-specific applications, it ensures direct and robust comparability of model results within and across production systems and technologies.

He also recently developed a macroscale screening-level social LCA using 28 social risk categories for trade-based consumption in the European Union (taking into account flows of internationally traded commodities) for the European Commission Joint Research Centre. This model characterized the social risks attributable to the trade-based consumption patterns of the average EU-27 consumer, as well as for EU-27 trade-based consumption in aggregate.

Pelletier similarly recently completed drafting the life cycle-based European Commission Product and Organization Environmental Footprint methods, which will become the reference methods linked to any voluntary or mandatory applications associated with European Commission policy, as well as the European Sustainability Footprint framework.