Environmental Footprinting for Agriculture in Alberta:

Literature Review and Analysis

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All studies and previous research used in this report are listed in the References section of this report.

Abstract

The following is a literature review and analysis of environmental footprinting in Alberta, Canada and internationally, which would be appropriate for the development of an environmental accounting framework and measurement index for assessing the environmental impacts of food and agricultural production in Alberta. The literature review examines the trends, drivers and studies relevant to the subject of environmental footprinting drawing from research, Life Cycle Assessment studies, grey-literature, industry reporting standards, and expert interviews. The term environmental footprinting is a relatively new and generic concept that generally refers to the assessment of energy use, greenhouse gas emissions, nutrients from fertilizers and manure, pesticide use, land use, and water attributes of agriculture and food production. The review concludes that the demand for environmental and social sustainability performance monitoring and reporting are likely going to grow in the 21^{st} century, led by retailers like Wal-Mart. The drivers for environmental performance reporting are varied and come from a number of sources including consumers, retailers and industry certification organizations. This will mean that Alberta's agriculture and food producers and suppliers of agricultural food products, in order to remain vibrant and economically resilient, will need to be prepared to measure and assess the environmental and social attributes of their products. This will likely include a variety of indicators including: a) materials and energy use in agricultural activities and production; b) the GHG emissions associated with these activities; c) the volume and rate of use of pesticides and nutrients; d) eutrophication and acidification; e) water use; f) land use practices that affect biodiversity and soil fertility; g) the possible human and ecological health impacts of their operations, and; h) a deeper knowledge of the product development processes used to create them. These reporting expectations will vary depending on stakeholder reporting demands. Life Cycle Assessment studies of Alberta's key agricultural products would assist Alberta producers in meeting some, but not all, of the data demands to fulfill these growing environmental and social performance reporting. The Alberta Government could play a key role, in partnership with farmers and the agri-food industry, in helping to coordinate a provincial environmental and social monitoring and reporting system, based on common reporting protocols, for assessing the long-term sustainability of agriculture and food production and for baselines and measurement of change.

Executive Summary

The following is a literature review and analysis of environmental footprinting in Alberta, Canada and internationally, which would be appropriate for the development of an environmental accounting framework and measurement index for assessing the environmental impacts of food and agricultural production in Alberta. This literature review and analysis is part of a longer-term, federally funded project on "Environmental Footprinting Opportunities in Agriculture."

The objective of this long-term project is to develop a data baseline for future environmental footprinting, establish a new set of methodologies and tools to evaluate the environmental footprint of Alberta's agricultural industry and help guide and inform policies of Alberta Agriculture and Rural Development. The literature review examines the trends, drivers and studies relevant to the subject of environmental footprinting drawing from research, Life Cycle Assessment studies, grey-literature, industry reporting standards, and expert interviews.

The term **environmental footprinting** is a relative new and generic concept that generally refers to the assessment of energy use, greenhouse gas emissions (CO_2, CH_4 and N_2O), nutrients (fertilizers, manure), pesticide use, land use, (including impacts on biodiversity) and water attributes of agriculture and food production. Life Cycle Assessment (LCA) is one of the tools for conducting environmental footprinting. Lillywhite (2008) used the term, environmental footprint for agriculture, to refer to a hybrid method of incorporating four environmental indicators (pesticides, greenhouse gas emissions, eutrophication, acidification, and water use), drawn from a subset of agricultural LCA data, and presented in a single per hectare metric.

Driving the demand for environmental footprinting and environmental indicator reporting are growing demands for accountability for sustainability accounting and reporting by all sectors: consumers, retailers, industry associations, producers (farmers), and governments. The greatest demand for environmental performance accountability is currently coming from food retailers like Wal-Mart, Marks and Spencer (UK), McDonalds, and Loblaws who have established a set of environmental and social indicators or criterion and performance scorecards for their suppliers that will ultimately extend to the producer and farmer.
Wal-Mart has become the most important leader in demanding environmental and social performance information from their suppliers.

The **Global Reporting Initiative (GRI) guidelines** are the international standard for environmental, social and economic (or sustainability) measurement and reporting used by over 1500 enterprises from all industrial sectors around the world. The GRI guidelines represent the most comprehensive framework for environmental footprinting and have been key to guiding the development of sustainability measurement and reporting by major corporations like Wal-Mart and McDonalds, and their environmental scorecards for their supply chain. More recently GRI produced a set of sustainability reporting guidelines for the food processing industry that is particularly relevant to Alberta's food processing industry, though not directly relevant to farmers. While several major global food producers (farmers) and retailers have used the GRI guidelines to develop CSR and sustainability reports, only a relatively small number of Canadian companies use the GRI guidelines and no Canadian food processor has used the GRI supplement for food processing industries. Unlike other environmental reporting standards like ISO 14000 or certified organic protocols, the use of the GRI guidelines remain voluntary and are not the basis of certification. This makes comparability of GRI-based sustainability indicators and reports difficult. Nor are the GRI guidelines prescriptive in terms of measurement protocols, although GRI has also produced measurement protocols for energy use and water use development that will help standardize reporting on these two key environmental performance variables. These protocols provide detailed and tangible guidelines for how organizations can begin to take a comprehensive life-cycle accounting approach to assessing water use and water discharge impacts.

Notwithstanding these challenges, the GRI guidelines represent a gold-standard for environmental, social and economic sustainability reporting and will likely influence how environmental footprinting and reporting will be conducted in Alberta's and Canada's agricultural and food industries. There is new evidence that companies like Agrium, Loblaws, Wal-Mart, TESCO, Whole Foods Market Inc., and Tyson Foods are beginning to report on some select aspects of environmental and social performance that use the GRI indicator guidelines.

Ecological Footprint (EF) analysis is a biophysical assessment tool that accounts for the environmental impact of consumption. The EF measures how much of nature, expressed in a common unit of bioproductive space (hectares or acres), is used for producing food, energy, transportation needs, housing needs, goods and services, and other materials for a given human population. The estimated EF, expressed as hectares, is compared with the available biocapacity or bioproductive land to a population to assess the sustainability of lifestyles. There have been no studies using the EF methodologies for estimating the biocapacity of Alberta or Alberta agriculture in particular. Ecological Footprint is sometimes mistaken for *environmental footprint*; the EF is a standardized biophysical assessment tool with specific methodological protocols while the *environmental footprint* is a generic term to account for a broad suite of environmental impacts. While the Ecological Footprint Analysis (EFA) can be used to estimate the impact of a given agriculture commodity or class of commodities, there have been few EFA studies focusing specifically on agriculture (e.g. an EF calculation for Israel's grain consumption). While a useful tool for accounting and communicating the overall impact of household consumption on the appropriation of land (for food and materials) and resources (energy), the EF has limitations and is particularly limited for assessing the environmental impacts of agricultural operations.

While water has been traditionally overlooked in the EF biophysical assessments, a number of methods to account for the **water footprint —** defined as the total volume of freshwater that is used to produce the goods and services consumed by a given population — have been under development to illustrate the hidden links between human consumption and water use and between global trade and water resources management.

Life cycle assessment (LCA) is an ISO-standardized analytical framework which evaluates the environmental performance of products, services and activities throughout their entire life history, from "cradle to grave." ISO 14040 and ISO 14044 series, as an example, provides guidance for formal LCA studies including key methodological choices, reporting and application of results). LCA assessments track the flows of matter and energy from the initial extraction of resources, through processing, packaging, transportation and distribution, and finally to the end use of products and disposal or recycling of remaining material. Inputs of resources and outputs of emissions throughout the life cycle are inventoried and translated into contributions to a suite of environmental impact categories of global concern, including global warming, ozone depletion, and energy use. LCA is considered one of the standard quantification tools for assessing environmental impacts and for environmental footprinting and has been used successfully in applications to agriculture and food processing.

Over the past decade, a growing body of research has applied the LCA methodology to products derived from primary agriculture sectors, as well as secondary processing industries producing value-added products. Much of the LCA work on agriculture has been carried out in Europe with a small but growing body of literature examining agricultural production chains in North America. North American LCA studies for grains, beef, dairy, poultry and pork production have focused primarily on energy use and global warming potential from GHG-emissions, and to a lesser degree on acidification potential, eutrophication potential and ozone depletion impacts. LCA has also been employed to compare production practices and model potential benefits of alternative agricultural practices, for example the comparison of organic production methods to conventional methods of agriculture. While there have been a number of proposed methodologies to account for land use impacts and water use impacts, these factors are seldom considered in LCA. The importance of water quality and scarcity and the long-term impacts to soil fertility from land-use practices will require consideration of these factors in future LCA studies of agriculture.

LCA studies that are particularly relevant to Alberta agriculture includes: a) a life cycle assessment of the transition to organic agriculture from conventional production for canola, corn, soy and wheat; b) a life cycle analysis of carbon dioxide equivalents (CO_2e) of Alberta barley, wheat, peas and canola meal used in pork production, slaughter and further processing; c) a life cycle analysis of carbon dioxide equivalents (CO_2e) of Alberta barley, wheat, peas and canola meal used in pork production, slaughter and further processing; d) a life cycle assessment of greenhouse gas emissions from beef production in western Canada; e) environmental performance in the US broiler poultry sector, including life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions, and: f) comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States.

While LCA for agriculture has its strengths for assessing environmental impacts, there are several shortcomings. LCA studies are often difficult to compare across studies, jurisdictions and industries and may not be transferable from one region or country to another jurisdiction. This may be due to differences in methodological assumptions, equivalency factors or coefficients, and the delineation of system boundaries. A critical methodological challenge in agricultural LCAs is the handling of co-product allocation; when a system or process has more than one output, the burden must be allocated among products appropriately without double-counting impacts. There is also a lack of reliable and open-source data and LCA studies can be costly and time consuming. As well, LCA does not typically consider social or economic impacts associated with the system being studied – although there is growing interest in refining the application of LCA-styled tools to these other areas, including life cycle costing (LCC), and social life cycle assessment (S-LCA). Even LCAs of agriculture do not always capture the impacts of the entire life cycle of food products, and often include only those activities up to the "farm gate", and do not consider the potential impacts after the product has changed hands to wholesalers, retailers and consumers.

As a tool for assessing sustainability, LCAs typically do not extend well to aspects of environmental sustainability, such as biodiversity impacts (habitat quality) and land use impacts on soil fertility or health, which are not easily quantified. Examples of land-use impacts not otherwise considered in LCA studies include: degradation of biodiversity; soil erosion; loss of soil fertility; impacts on nutrient cycling; impacts on hydrology; and, one-time habitat loss. Given the importance of soil fertility to long-term food security and agricultural sustainability, measures of soil fertility, even if only qualitative metrics, should be part of a comprehensive environmental footprint assessment framework.

There are important practical issues to consider in agricultural LCA work. According to at least one LCA consultant, most of the data required to conduct agricultural LCAs can be sourced from government agricultural statistics and the publicly available LCA literature. Agricultural LCAs typically run this data through a generic farm model, with coefficients adjusted for variations in operating, soil and growing conditions. However, the generic farm models are assumed to apply to any given agricultural system. Modeling has its limitations, namely that actual farm-level operating statistics are not being collected or used providing a potentially inaccurate accounting of inputs and commensurate environmental impacts.

Other initiatives and tools for assessing the environmental impacts of agriculture and food production were examined including the US-based *Field to Market* **Fieldprint Calculator**. *Field to Market* is the initiative of the Keystone Center, a non-profit organizations dedicated to developing indicators to estimate the environmental, economic, social, and health outcomes of agriculture in the United States. The Calculator allows farmers to better understand how their crop production operations, including land use, water use, energy use, soil loss, as well as climate impact wheat, corn, soybeans, and cotton farming sustainability. The calculator is correlated with national level outcomes used in their environmental indicators report.

The Swiss Federal Office of the Environment has developed the **ecological scarcity method**, a ‘distance to target method’ of life cycle impact assessment, that uses eco-factors, expressed in eco-points per unit of pollutant emission or resource extraction, to rate all Swiss food products. The eco-factors are determined by both the current emissions (to water, air and soils) situation and secondly, by the political targets set by Switzerland or by international policy and supported by Switzerland. The method assesses a number of eco-factors including: CO_2 and energy; air pollutants; heavy metals and arsenic emissions to soil, surface and ground waters; endocrine disruptors in waters; radioactive isotopes in the seas; amount of freshwater consumption impacts of land use on plant biodiversity, and; the assessment of bioreactive landfills. The other factors include the extraction and use of energy resources (non-renewable and renewable), land use, gravel extraction, and freshwater consumption. The selection of these emissions or substances is guided by their ecological and political relevance. The Swiss ecological scarcity method is one of the most rigorous, comprehensive (covering every aspect of emissions to land, water and air, resource use and waste) and pragmatic applications of LCA we reviewed from the literature. The Swiss method shows the potential for using scientifically and politically-based targets (established in law and based on science) as a basis of environmental performance measurement that could be applied to any variety of agricultural products and processes.

Lillywhite (2008), a UK-based academic who has conducted LCA studies in agriculture, proposes the development of the **environmental footprint** index, which incorporates four, weighted environmental indicators (pesticides, greenhouse gas emissions, eutrophication and acidification, and water use) drawn from a subset of agricultural LCA data. Actual environmental data is normalized against a minimum and maximum standard established either from scientific evidence or political/policy targets. The result is a numeric score or index that can be reported on a per hectare basis. Lillywhite suggests that labeling food products with an environmental footprint value is more useful to consumers than simply a carbon footprint value.

Our environmental scan found that major retailers like Wal-Mart, McDonalds, Unilever and Marks & Spencer are leading the demand for environmental and social impact reporting from their suppliers and in turn food producers. Marks & Spencer, for example, wants to become one of the world's most sustainable retailers. According to a recent industry benchmark study of best sustainability practices, Marks and Spencer ranked first ahead of Wal-Mart for innovations that include: a balanced performance scorecard for its suppliers, becoming carbon neutral, sending no waste to landfill, extend sustainable sourcing and a Sustainable Agriculture Program, that will include labeling all of its food items according to food miles giving preference to the 10,000 UK farmers who supply them with fresh meat, dairy and produce. Unilever has made attempts to evaluate its entire value chain from supply through distribution. McDonalds has been using its environmental scorecard to evaluate the environmental performance of its suppliers for several years. Loblaws, Canada's largest retailer, while having adopted some new standards (e.g. sustainable seafood policies) appears to lag these other international retail giants with respect to supply chain environmental monitoring and reporting. Calgary-based Agrium has been working on environmental footprint reduction protocols for farmers and is using their subsidiary called CROP to collect GHG offsets, based on best-management conservation practices, and are developing reporting protocols with industry associations.

Wal-Mart, the world's largest retailer, has emerged as the single-largest driver for environmental and social impact monitoring and reporting. Wal-Mart recently established its own Supplier Sustainability

Assessment Standards for its 60,000 suppliers and a sustainability questionnaire and scorecard for its suppliers. A supplier sustainability index or 'scorecard' considers performance in four key areas: climate and energy, material efficiency, natural resources, and people and community. According to a sustainability and LCA consultant, Wal-Mart is setting the international standard and catalyzing the international market place with what Wal-Mart calls its Productivity Loop or supply chain management expectation of its suppliers. Wal-Mart and other companies are trying to improve the productivity of its supply chain by working directly with producers, manufacturers and distributors to increase the efficiency of the environmental and water footprints of its products. Wal-Mart appears to be motivated by several factors including maintaining its low price competitive advantage; working internally and with other suppliers, Wal-Mart has found cost savings and innovation opportunities by investigating energy use, waste streams and other impacts on natural resources and the community. Wal-Mart sees tremendous potential for driving down costs, reducing environmental impacts of its products, and enhancing quality while helping its suppliers become more sustainable. Another reason is that Wal-Mart is responding to an increasing level of consumer and media consciousness of sustainability issues that include climate change, toxic substances, ethical sourcing and excessive consumption. Some experts believe that Wal-Mart is being strategic by testing the readiness of their suppliers and the market for environmental performance monitoring. Indeed, the list of demands for environmental and social impact reporting of Wal-Mart's suppliers are likely to expand into more challenging areas of measurement, beyond even conventional LCA parameters. One potential area to watch is the growing concern by some retailers of the rising cost of transportation (due to the anticipated rise in fuel costs because of the end of once cheap oil supplies) and thus a potential shift to sourcing food located in closer proximity to retail outlets. As environmental and social reporting begins to mature, indicators will likely become less qualitative and more quantitative.

While there are measurement and reporting challenges faced by Wal-Mart's suppliers, the development and adoption of Wal-Mart's sustainability scorecard and sustainability assessment standards should have significant and lasting impacts in shaping environmental and social indicator measurement and reporting. Environmental reporting pressures on food processors will likely be transferred down the supply-chain to farmers and producers. Wal-Mart may establish its own benchmarks for best environmental performance or best environmental footprint profiles amongst its suppliers. This will likely drive a new kind of competition amongst producers to compete both on price points and most efficient and sustainable environmental and social performance for its products. This will result in new challenges for agricultural producers in meeting these new expectations, both in terms of monitoring and reporting.

A notable benchmark in our literature review was **Nature's Path Foods**, based in Richmond, B.C. Nature's Path is a good example of an organic food producer and processor that buys certified organic grains and produce from farmers and produces and sells their organic products in both Canada and the US through retailers like Wal-Mart. Nature's Path Foods has experienced the challenges of complying with Wal-Marts Sustainability Assessment Standards largely because they source their own grains and inputs to their food production from certified organic producers. Because organically certified products have rigorous environmental standards Natures' Path products may already represent a 'gold-standard' amongst Wal-Mart suppliers. For example, organic products effectively eliminate 100% of pesticide, artificial fertilizers, do not use Genetically Modified Organisms (GMO), and rely only on rainwater for irrigation. Nature's Path Foods is also unique in that they consider the long-term impacts of their production and supply-chain relationship with organic farmers by considering the implications to soil and ecosystem health over time.

Another notable benchmark for certification of environmental performance in agriculture, in addition to certified organic, is **Local Foods Plus** (LFP) an Ontario-based non-profit organization that helps to support demand for local food producers in Ontario by certifying production that meets its local production and sustainability criterion. LFP screens food producers using a series of sustainability criterion that include sustainable production systems that reduce or eliminate synthetic pesticides and fertilizers, avoid the use of hormones, antibiotics, genetic engineering, and conserve soil and water. Other criterion include: a) safe and fair working conditions for on-farm labour; b) healthy and humane care for livestock; c) enhance wildlife habitat and biodiversity on working farm landscapes, and; d) reduce on-farm energy consumption and greenhouse gas emissions. This is a good example of an industry association driving the standards for environmental footprinting and sustainability reporting. In our opinion, the LFP standards might represent the 'LEED Certified Platinum'-equivalent standard for agriculture in Canada if they were to also consider the inclusion of energy, water and waste measurement parameters from the GRI guidelines. At least two Alberta organic farmers have been certified by LFP.

In terms of **data sources** for conducting environmental footprinting analysis, agricultural LCAs, GRI environmental and social indicator guidelines and meeting emerging retailer reporting expectations, we have some concerns. We are unable to comment on the capacity of Alberta farmers and food processors to respond to new environmental and social indicator reporting demands from retailers like Wal-Mart. However, Alberta farmers should have the ability to record and provide large amounts of data necessary to conduct LCA of production processes and meet Wal-Mart supplier sustainability standards. Much of the data, however, is in the private rather than public domain. A cursory assessment of known publically available data sources reveals that there are several sources of public data that may complement farm-acquired data. Notwithstanding, there are apparent data gaps that could be filled with farm-level monitoring and reporting, LCA modeling studies, or with the use of coefficients that could convert production statistics to GHG emission equivalents, pesticide impacts related to eutrophication and acidification, as examples.

In conclusion, the demand for environmental and social sustainability performance rating systems are likely going to grow in the 21st century, led by retailers like Wal-Mart. This will mean that real sustainable product innovation by producers and suppliers of agricultural food products will need to demonstrate a deep understanding of the environmental and social attributes of their products, the materials and energy that go into them, the possible human and ecological health impacts of their operations, and a deeper knowledge of the product development processes used to create them. The role of governments in this new field of environmental and social reporting, vis-à-vis agricultural producers, remains to be defined. We believe governments can play a key supporting role in accounting for the macro-natural capital or environmental conditions at the provincial and regional levels and in assisting producers with sustainability reporting and planning.

The following recommendations are provided for consideration by Alberta Agriculture and Rural Development with respect to developing an environmental footprint model and environmental indicator reporting system for Alberta's agriculture and food processing industries:

Recommendation 1: Develop and support an Alberta environmental and social impact data monitoring, impact assessment and reporting system, as well as measurement guidelines or protocols for Alberta's key agricultural products and processes to meet emerging food retail and food processing environmental accountability demands.

Recommendation 2: Develop a data inventory to support certification and participation in supply chain sustainability programs.

Recommendation 3: Research community-based data collection options including implementing an electronic environmental reporting structure and tracking key data as part of annual farm survey.

Recommendation 4: Assess the Alberta's agriculture biocapacity and soil fertility based on eco-zone specific yield factors.

Recommendation 5: Develop and support a made-in-Alberta environmental and social impact indicator performance reporting system and protocols for agriculture.

Recommendation 6: Explore the possibility of expanding the agricultural protocols established as part of Alberta's offset trading program to quantify environmental benefits beyond CO_2 savings. Other possible impact categories to include are: eutrophication and acidification potential, land impact, and water use.

Recommendation 7: Explore the possibility of offering incentives to encourage farmer participation in an environmental reporting framework.

Other considerations for the development of an environmental footprinting model and sustainability indicator and reporting system for Alberta agriculture are offered including: a) A proposed model needs to be based on scientific protocols and relevant local data and be useful to the agricultural community; b) A robust accounting system needs to be populated with good data, cognizant of data availability, data costs, and reliability of data sources, and; c) Assumptions behind the model should be transparent and data sources open, with users having the capacity to change or modify the assumptions to reflect their unique operating situation or provide feedback to adjust models for future updates.

1. Introduction and Objectives of the Project

The following is a literature review and analysis of environmental footprinting in Alberta, Canada and internationally, which would be appropriate for the development of an environmental accounting framework and measurement index for assessing the environmental impacts of food and agricultural production in Alberta and North America, in general.

This literature review and analysis is part of a longer-term, federally funded project on "Environmental Footprinting Opportunities in Agriculture." This summary of environmental footprinting is to assist Alberta Agriculture and Rural Development determine what kind of environmental footprinting or impact analytic framework would best serve the needs of decision makers at various scales (from the farmer to the Minister responsible for agriculture and rural development).

The ultimate objective of this long-term project is to develop a new set of methodologies and tools to evaluate the environmental footprint of Alberta's agricultural industry, establish baselines and monitor improvements across the supply chain, and help guide and inform policies of Alberta Agriculture and Rural Development.

The main goals of the literature review, environmental scan, and analysis are as follows:

1. Identify and analyze key developments in environmental footprinting methodologies;
2. Summarize national and international environmental footprinting studies and approaches that can guide and inform Alberta Agriculture and Rural Development as well as the agriculture industry on future environmental footprinting project work, and;
3. Evaluate how and why environmental footprinting methods have been used in practice (by government, and non-government organizations and companies) with a particular focus on agricultural crop and livestock production.

2. Background

Demands for accountability for sustainability accounting and reporting, namely the measurement of the triple-bottom line of financial, social and environmental performance, by all sectors in the global economy are growing, including the agriculture and food processing sector and food retail sector. Expectations for sustainability measurement are coming from various sources including:

a) consumers — consciousness of health and food safety issues, as well as environmental issues;

b) retailers (such as Wal-Mart, Loblaws, Marks and Spencers) —concerned with maintaining market share through a commitment to sustainability;
c) industry associations (such as Local Food Plus in Ontario) – with interests in promoting local food production and consumption), and;
d) governments — concerned that the agricultural sector remain resilient and sustainable in the face of these emerging expectations for sustainable agriculture and food production.

Additionally, there is a growing understanding that food security is being compromised by a host of additional risk factors. While the market drivers are most poignant (e.g. the efforts of companies like Wal-Mart and Marks and Spencers to risk-manage their supply chains), there remain additional factors that are influencing the need for a broader set of indicators. Some of these known risks are:

- Loss of arable land and productivity of current acreage in use for agriculture;
- Climate change;
- End of cheap resources ('peak resources') – especially oil, phosphorus and urea for commercial fertilizers;
- Competition for potable water resources;
- Land use and development pressures on agriculture lands;
- Competition for imports and exports, and;
- Seed viability and commercialization.

It can be said that environmental footprinting, along with life-cycle analysis of agriculture production and food processing, is in its infancy. The practice of environmental footprint measurement and reporting has only just begun though the standards and benchmarks for measurement are quickly being defined in part by both retailers, such as Wal-Mart, and industry associations, such as Local Food Plus, who have an interest in food sustainability issues. However, these environmental measurement and reporting efforts by these leading retailers have ultimately been driven and informed by the GRI sustainability accounting and reporting guidelines and initiatives.

This literature review examines the emerging trends, drivers, and methodological approaches to environmental footprint analysis (e.g. life cycle assessment) for measuring environmental impacts of agricultural production. We recognize the term *environmental footprinting* may have several different interpretations and connotations depending; however, in general it refers to the energy use, greenhouse gas emissions (CO_2, CH_4 and N_2O), nutrient impact (fertilizers, manure) pesticide use impacts, land use affects (including impacts on biodiversity) and water attributes of agriculture and food production.

This literature review identifies the current environmental footprint research and measurement tools specific to agriculture and food production systems, including their strengths, weaknesses and challenges. The literature review draws from research (e.g. journals, research articles), LCA studies, grey-literature,[1] industry reporting standards, and interviews with experts and sustainability measurement practitioners in this new emerging field of environmental footprinting for agriculture.

The objective is to understand how these developments in environmental footprinting, analysis and reporting will impact Alberta's agriculture and food production sector, and how to best position Alberta producers to remain economically resilient, innovative, and risk adverse. The results of this study should serve Alberta Agriculture and Rural Development policy makers in designing an environmental footprinting or impact analytic framework that will best serve the needs of decision makers at various scales (from the farmer to the Minister responsible for agriculture and rural development).

The report concludes with recommendations for proceeding to the next stage of developing the analytic framework and tools for assessment.

3. Definitions and Acronyms

Definitions:

Biocapacity:

Biocapacity is the sum of all the bioproductive land types within a jurisdiction expressed in global hectares (gha). Bioproductive land is translated into global hectares by multiplying land types (crop land, forest land, etc.) by the appropriate yield factor and equivalence factor.

Ecological Footprint:

The Ecological Footprint (EF) or Ecological Footprint Analysis (EFA) is a biophysical assessment tool that accounts for the environmental impact of consumption. The ecological footprint provides a snapshot in time of how much nature, expressed in a common unit of bioproductive space, is used exclusively for producing all the resources (food, energy, materials) and absorbing the wastes associated with a given population or with a specific product or activity.

[1] Grey literature is a term used variably by the intelligence community, librarians, and medical and research professionals to refer to a body of materials that cannot be found easily through conventional channels such as publishers, Examples of grey literature include technical reports from government agencies or scientific research groups, working papers from research groups or committees, white papers, or preprints.

Environmental footprint:

Environmental footprint refers to a broad suite of environmental impacts that would generally include energy use, greenhouse gas emissions (CO_2, CH_4 and N_2O), nutrient impact (fertilizers, manure) pesticide use impacts, land use affects (including impacts on biodiversity) and water attributes of agriculture and food production.

Global Hectare:

A global hectare (gha) is a standardized hectare to account for the fact that different land types and different land categories have different productivity or biocapacity potentials. A common unit allows for the meaningful summation of different land types and categories and also allows for meaningful comparisons of footprint results between regions, countries, or products and processes being examined.

Life Cycle Assessment:

Life Cycle Assessment is an ISO-standardized analytical framework, which evaluates the environmental performance of products, services and activities throughout their entire life history, from "cradle to grave."

Social Life Cycle Assessment:

A social impact assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal.

Water Footprint:

The total volume of freshwater that is used to produce the goods and services consumed by a given population. Water footprints are typically calculated for any well-defined population including a household, community, city, province, or nation. Water footprints can also been calculated for businesses or for a specific activity, good or service.

Acronyms:

AP: Acidification Potential

CLI: Canadian Land Inventory

CLUM: Consumption Land Use Matrix

CSR: Corporate Social Responsibility

EF: Ecological Footprint

EFA: Ecological Footprint Analysis

EP: Eutrophication Potential

ES: Environmental Scorecard

EU: Energy Use

FLA: Fair Labor Association

FCM: Federation of Canadian Municipalities

GHA: Global hectares

GHG: Greenhouse gases

GMO: Genetically modified organisms

GPI: Genuine Progress Indicator

GPS: Global Positioning System

GRI: Global Reporting Initiative

GWP: Global Warming Potential

Ha: Hectare

ILO: International Labour Organisation

ISO: International Standards Organization

IUCN: International Union for Conservation of Nature

LCA: Life Cycle Assessment

LCC: Life Cycle Costing

LFP: Local Food Plus

LSRS: Land Suitability Rating System

NDP: Naturalness degradation potential

NPP: Net primary productivity

ODP: Ozone Depletion Potential

REAP: Resource and Energy Analysis Program

SA8000: Social Accountability 8000

SETAC: Society for Environmental Toxicology and Chemistry

S-LCA: Social Life Cycle Assessment

SMEs: Small and medium enterprises

UNEP: United Nations Environment Programme

USLE: Universal Soil Loss Equation

4. Sustainability and Environmental Accounting Methods, Tools and Information Requirements.

4.1 Global Reporting Initiative Sustainability Reporting Guidelines

The Global Reporting Initiative (GRI) produces one of the world's most prevalent standards for sustainability reporting. Sustainability reporting is a broad term considered synonymous with others used to describe reporting on an organization's economic, environmental, and social impacts (e.g. Triple Bottom Line (TBL) reporting, Corporate Social Responsibility (CSR) reporting, ecological footprint reporting, Environmental Social Governance (ESG) reporting).

Virtually every sustainability report or environmental accounting system used by corporations or organizations is using the GRI guidelines as the basis of their reporting. The guidelines, under development since 1997, are being used by more than 1,500 organizations from 60 countries to produce their sustainability reports. The most recent generation of GRI guidelines are defined as "G3" or so-called "Third Generation" launched in October 2006. The G3 Guidelines provide universal guidance for reporting on sustainability performance, applicable to small companies, large multinationals, public sector, NGOs and other types of organizations from all around the world.

The GRI guidelines were derived through a multi-stakeholder process including corporations, accounting firms, non-profit organizations, and others in the spirit of collective entrepreneurship. The goal is to develop a practical, yet voluntary, set of guidelines for sustainability reporting. Individual firms were motivated to participate in the development of these guidelines, in part, to influence their outcome for their best interests. The success of the GRI guidelines demonstrate the capacity for voluntary, multi-stakeholder development for the use of all societal actors who genuinely wish to measure and report on their contribution to the journey of sustainable development.

Major food and beverage product companies who have used the GRI guidelines for their sustainability reporting in 2009 include: Coca Cola, Nestle, Uniliver, Tyson Foods, PACE, Kellogg, and Autogrill. Other companies like Wal-Mart have based their sustainability indicator reporting criterion for suppliers on the GRI guidelines. Of the Canadian corporations using GRI reporting guidelines, there are currently no agriculture, food processing or food retailers using the GRI guidelines. However, it is likely that companies like Agrium and Loblaws have used the GRI guidelines for measuring some aspects of their environmental performance reporting. For example, according to the Bloomberg sustainability reporting data base (available to electronic subscribers to Bloomberg), Agrium has measured energy consumption, water consumption, solid waste and hazardous waste production, GHG emissions, and discharges to water.

GRI seeks to make sustainability reporting by all organizations as routine as, and comparable to, financial reporting. A sustainability report should provide a balanced and reasonable representation of the sustainability performance of a reporting organization – including both positive and negative contributions. It is designed for use by organizations of any size, sector, or location. It takes into account the practical considerations faced by a diverse range of organizations – from small enterprises to those with extensive and geographically dispersed operations. The GRI Reporting Framework contains general and sector-specific content that has been agreed by a wide range of stakeholders around the world to be generally applicable for reporting an organization's sustainability performance.

Indicators: Core Indicators have been developed through GRI's multi-stakeholder processes, which are intended to identify generally applicable indicators and are assumed to be material for most organizations. An organization should report on Core Indicators unless they are deemed not material on the basis of the GRI Reporting Principles. The core GRI environmental indicators appropriate to all industries include:

- Environmental Materials:
    - Materials used by weight or volume;
    - Percentage of materials used that are recycled input materials.
- Energy:
    - Direct energy consumption by primary energy source;
    - Indirect energy consumption by primary source.
- Water:
    - Total water withdrawal by source.
- Biodiversity:
    - Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas;
    - Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.
- Emissions, Effluent and Waste:
    - Total direct and indirect greenhouse gas emissions by weight;
    - Other relevant indirect greenhouse gas emissions by weight;
    - Emissions of ozone-depleting substances by weight;
    - NOx, SOx, and other significant air emissions by type and weight;

  - Total water discharge by quality and destination;
  - Total weight of waste by type and disposal method.
- Products and Services:
  - Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation;
  - Percentage of products sold and their packaging materials that are reclaimed by category.
- Compliance:
  - Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.

Tools for measuring many of these GRI environmental indicators would include the use of life-cycle analysis (LCA) protocols, which are discussed the following sections.

In addition to the GRI environmental indicators, there are also core economic (financial) and social indicators, which are relevant to the agriculture and food processing industries. The core and additional GRI social indicators are listed in Appendix 2 of this report.

To supplement the core indicators, *additional indicators* are also recommended by the GRI guidelines to augment or supplement the core sustainability indicators. These additional indicators represent emerging practice or address topics that may be material for some organizations, but are not material for others.

Furthermore, *Sector Supplements* exist for specific industrial sectors, including a supplement of suggested core indicators for the Food Processing Industries, which are discussed further on in this report.

Why companies and other organizations do sustainability reports?

Reporting on sustainability performance is an important way for organizations to manage their impact on society and the environment. Additionally, addressing these issues has become a response to consumer concerns, licenses to operate, and a data lens to manage limited natural resources availability. Sustainability reporting and the use of the GRI guidelines remains a discretionary option for many companies. Only a relatively small number of Canadian companies use the GRI guidelines to produce sustainability or corporate social responsibility (CSR) report, nor is it yet demanded by the investment community and nor are conventional accounting firms preparing sustainability reports or conducting audits.

Notwithstanding, sustainability monitoring and reporting leads to improved sustainability and risk management outcomes because it allows organizations to measure, track, and improve their performance on specific issues related to their impacts on the environment and communities. In disclosing environmental and social performance indicator information in the public domain, stakeholders can track an organization's performance on broad themes (e.g. environmental performance) or a particular issue (e.g. labor conditions in factories). Performance can be monitored year over year, or can be compared to other similar organizations.

By taking a proactive role to collect, analyze, and report those steps taken by the organization to reduce potential business risk, companies can begin to transparently communicate with their shareholders the risks and benefits of a sustainable existence. Public pressure has also proven to be a successful method for promoting transparency (behavior) and disclosure of greenhouse gas emissions and social responsibilities.

As well as helping organizations manage their impacts, sustainability reporting promotes transparency and accountability. Ultimately, with regular and consistent use of the GRI guidelines and measurement protocols, it will be possible to compare environmental performance across firms within a sector or across sectors. GRI guidelines are thus appropriate for the standardization of environmental footprinting for the agriculture and food processing sectors as well as for the food retail sector.

4.1.1 GRI Guidelines for Food Processing Industries

GRI developed a Sector Supplement in 2009 the food processing sector, which was based, in part, on a 2006 survey of sustainability reporting trends of a sample of 20 food processing companies (e.g. General Mills, Heinz Co.,Kraft Foods Inc., Smithfield Foods Inc., Tyson Foods Inc., and Unilever).[2]

The Food Processing Industries Supplement is meant to cover all companies that are engaged in processing food, as well as food commodity trading related to the processing of products like fish, meat, milk, crops and water, as well as beverage companies. It includes millions of Small & Medium Enterprises (SMEs) worldwide and also some of the largest companies in the world. Companies that

[2] The 2006 GRI study (*Sustainability Reporting in the Food Processing Sector*) found that reporting in this sector was increasing and improving year-over-year making comparability of sustainability reports more likely in future. The most common themes reported by these 20 sample companies included sourcing and supply chain issues (19 or 20), food safety (18 or 20), health and nutrition (16 of 20), transportation (15 of 20), environmental aspects of agriculture (15 of 20), and packaging (15 of 20). Only 6 out of 20 reported on GMOs in their products. The review identified three indicator aspects where fewer than 20 per cent of the companies claimed to have reported on the indicators, including biodiversity, indigenous rights, and labor/management relations.

produce alcohol, tobacco and timber, food retailers and companies that deliver inputs like pesticides and fertilizers to farmers may be able to use parts of the Supplement content but the document was not specifically designed for their use.

The standards are set both on consultation with the food processing industry itself, scientists, accountants and other experts. This is in the spirit of the GRI initiative, which is voluntary and multi-stakeholder in nature. As with other GRI guidelines and protocols, there is the recognition that measuring and reporting is an evolving science and art and will mature through practice.

These GRI food processing industry guidance and the indicators (which are summarized in Appendix 2 in the concordance with the general GRI guidelines) are not aimed at businesses whose principle occupation is farming. However, farming does have many impacts on a large range of food processing sustainability issues and is relevant for all links in the food production chain. In this regard, the Supplement does include activities by the food industry designed to make food production chains (including farming) more sustainable with respect to environmental, social and economic aspects.

These supplement GRI guidelines are meant to address the unique challenges and issues that the food processing industry faces include:

- Helping to make safe, healthy and affordable food available
- Impacts on climate change and risks posed to resource base by climate change
- Involvement in rural areas of developing countries
- Complex, global supply chains
- Vulnerability and capacity of small producers in the food supply chains
- Involvement of governments
- Influence on the health and wellbeing of consumers
- Impacts on natural resource depletion and dependence on natural resources
- Consequences of depletion of scarce natural resources
- Animal welfare, particularly in large-scale or industrial operations
- Fair and ethical trade practices
- Use of packaging and associated impacts on environment and health

Sourcing data for this GRI Supplement is identified as a new issue of critical importance to the sustainability of the food processing sector. The sector depends on primary production, such as agriculture and fisheries, for its raw materials. Obtaining raw materials directly from primary producers, brokers, commodity markets or some combination of these carries inherent material risks (e.g., child labor, water scarcity) that can affect food processing companies and society. Primary production is often outside the direct control of food processing organizations and yet gives rise to major risks for this sector. It is therefore important to emphasize the need for the reporting organization to consider sustainability throughout the organization's supply chain (vertically), while recognizing that its scope for action is primarily through its direct (first tier) suppliers.

In order to address the immense variety of company influences on sourcing chains, any disclosure approach must allow companies and key stakeholders to focus their efforts on the most important issues in the sourcing chain by using the principle of materiality. The purpose of taking this approach is to enable the reporting organization to identify the most significant impacts that its supply chain has on society, the economy and the environment, as well as the significant dependences on ecosystems and social services that may exist within its supply chain.

The following factors, among others, may contribute to increased material risk and could be used by the reporting organization in the materiality assessment of its supply chain.
The suppliers' raw material is:

- Produced in an area of resource constraint;
- Produced in a region of high conservation value;
- Produced in an area of social, political or economic vulnerability.

For each identified material aspect, the reporting organization should provide a concise disclosure of the sourcing management approach taken to the aspects within each category of the G3 guidelines:

- Economic;
- Environment;
- Labor;
- Human Rights;
- Society; and,
- Product Responsibility.

The reporting organization should also provide a disclosure of the sourcing strategy taken to the following sector-specific Sourcing Aspects:

- Protecting natural resources;

- Minimizing toxicity (*Customer health and safety: include the assessment of significant environmental and social impacts across the life-cycle stages of products and services*);
- Community impacts (*Nature, scope and effectiveness of any programs and practices (in-kind contributions, volunteer initiatives, knowledge transfer, partnerships and product development) that promote healthy lifestyles; the prevention of chronic disease; access to healthy, nutritious and affordable food; and improved welfare for communities in need*);
- Fair trade;
- Fair compensation for labor;
- Traceability;
- Products and service labeling (*policies and practices on communication to consumers about ingredients and nutritional information beyond legal requirements*);
- Genetically Modified Organisms (GMO);
- Animal welfare (*breeding and genetics, animal husbandry, transportation, handling, and slaughter*); and
- Biofuels.

The reporting organization should explain how those of the above aspects that are considered material are incorporated into the organization's sourcing strategies and processes. The reporting organization should state how it integrates sustainability considerations throughout its supply chain into its purchasing criteria. The reporting organization should indicate its management approach to data sourcing and quality assurance and quality control measures under each of the elements listed below.

4.1.2 GRI Water Protocols

In 2003, the GRI released its *Water Protocols* that was intended to clarify the measurement expectations for the individual water performance indicators in Section 5 of Part C of the GRI 2002 *Sustainability Reporting Guidelines.* The Water Protocols provide definitions and clarifications of the terms, concepts, and expectations embedded in the indicators with the aim of achieving a greater degree of consistency and comparability in reported information. Consistent with the evolution of the GRI guidelines, the Water Protocols are indeed to follow the cycle of review, testing, and improvement through practice.

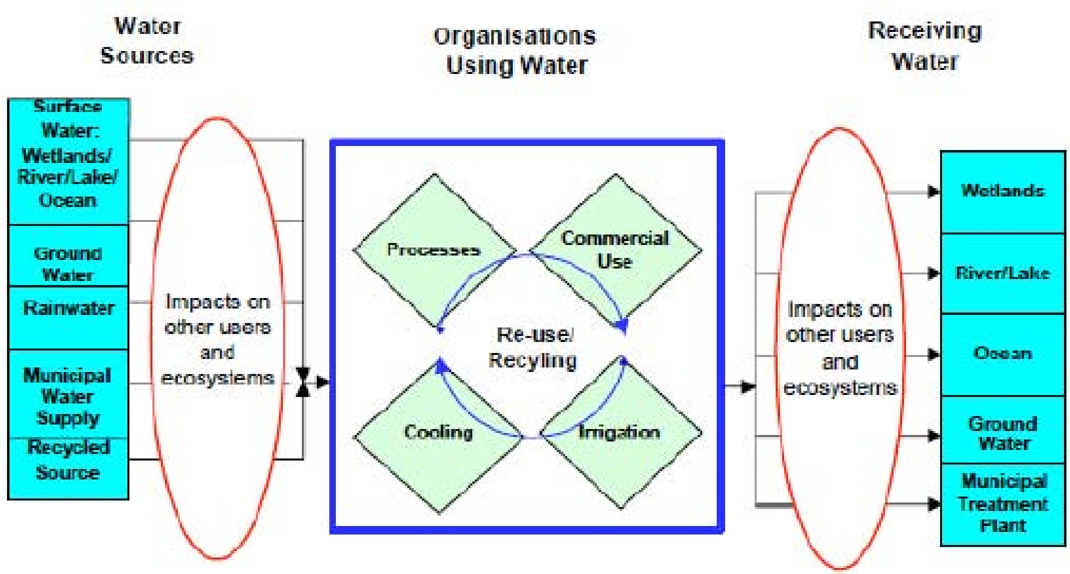
The Protocols assist organisations in reporting on the two core water indicators:

1. total water use;
2. significant discharges to water by type, and;
3. four additional water indicators:

- Water sources and related ecosystems/habitats significantly affected by use of water;
- Annual withdrawals of ground and surface water as a percent of annual renewable quantity of water available from the sources, by region;
- Total recycling and re-use of water. Include wastewater and other used water (e.g., cooling water);
- Water sources and related ecosystems/habitats significantly affected by discharges of water and runoff.

The Protocols provide a useful flow diagram (see Figure 1) to help in providing a complete picture of water use and discharges, and an understanding of how an organization is interacting with the water environment.

Figure 1: Global Reporting Initiative Framework for Water Protocol



Source: Global Reporting Initiative. Water Protocols. February 2003. P. 3

What is unique about the GRI Water Protocol framework is that it encourages organizations to take a comprehensive view of water use that requires looking at the ecological context of water use in the natural water system. The Protocols encourage organizations to consider that any withdrawal from a water source, whether an ocean, river, lake, wetland, or aquifer, will have impacts on other users of water and surrounding ecosystems. Similarly, any discharge of water by an organisation to receiving waters will also have impacts that will be determined both by quantity and quality of that discharge.

The Protocols provide detailed and tangible guidelines for how organizations can begin to take a comprehensive life-cycle accounting approach to assessing water use and water discharge impacts. For example, the Protocols encourages and helps organizations to account for how access to water supplies requires ensuring that the amount withdrawn from a source does not exceed the environment's capacity to renew that quantity. The Protocols also encourage organizations to consider and account for the impacts of returning water to the natural environment, that they not contain pollutants at levels that impair other human or ecosystem uses. Organizations should consider both aspects of water use in their reporting. In addition, because the quality and availability of fresh water is a global, local, and regional concern, organizations that operate multiple facilities should be prepared for stakeholder requests to report on water use at the organizational level, whether their facilities are located within a single watershed or around the world. While the Water Protocols have existed since 2003, we were unaware of any organizations, including agriculture-related, who have used the Protocols particularly in measuring or assessing impacts of operations at the ecosystem or watershed scale.

4.1.3 GRI Energy Protocols and Others

The GRI Energy Protocols were released in December 2002 intended to clarify the measurement expectations for the individual energy performance indicators in Section 5 of Part C of the GRI 2002 Sustainability Reporting Guidelines. The protocols provide definitions and clarifications of the terms, concepts, and expectations embedded in the indicators. Through the protocols, GRI aims to achieve a greater degree of consistency and comparability in reported information. The protocols are meant to serve as a tool for both reporting organisations and report users.

An illustrative application of this protocol is presented in terms of a GRI Energy Balance Sheet to present data on energy use. The methodology adopted in this protocol is based on those employed by the International Energy Agency and the Greenhouse Gas Protocol.[3]

GRI believes that over time all GRI performance indicators will require protocols. The expectation is that these protocols will mostly be organised based on aspects (e.g., energy, child labour, conditions of work), and a single protocol will likely cover several indicators. Once protocols reach a suitable level of maturity based on drafting, pilot testing, review, and revision, reporters will be expected to use the protocols when preparing reports "in accordance" with the GRI Guidelines.

[3] Greenhouse Gas Protocol: a corporate accounting and reporting standard. September 2001. World Business Council for Sustainable Development and World Resources Institute.

4.1.4 GRI Challenges

The GRI initiative is an important success story in multi-stakeholder entrepreneurship according to Brown, H., De Jong, M., and Lessidrenska, T. (2007). However, according to Brown et.al. (2007) the GRI story highlights the fundamental dilemma faced by institutional entrepreneurs who use inclusiveness and multi-stakeholder participation as fuel for affecting social change.

There is little doubt that the GRI guidelines have become the international standard for sustainability reporting used around the world by over 1500 enterprises from virtually every industrial sector, as well as by non-profit organizations and some governments. This is remarkable given that GRI has been operating with limited resources, visibility, and power. The use of the GRI guidelines, even voluntarily, has demonstrated that measuring and communicating sustainability performance systematically and across diverse sectors and contexts is possible.

However, the actual use of the GRI guidelines for environmental performance measurement and reporting has had its challenges. Perhaps the most important criticism of the GRI guidelines is that they are voluntary. They have not become required for accountability to shareholders, accountants, governments or other stakeholders. Because they are discretionary, companies are free to select only those GRI indicators in their CSR and sustainability reports that serve their reporting needs. Nevertheless, the guidelines present a model for optimum sustainability measurement and reporting.

The second challenge or limitation is that GRI guidelines guide the users on what to report but not how. There are no methodological guidelines for consistent measurement of energy, water, and material inputs or environmental impacts, as an example.

A third challenge of the GRI is that corporate sustainability reports or triple-bottom-line reports and indicators are not necessarily comparable between companies within the same sector or across sectors. While GRI has established some measurement protocols (e.g. for energy and water) that should facilitate comparability, there are still variances in how companies inventory, measure and report their financial, economic and social performance. Unlike the ISO 14000 certification protocols or certified organic protocols, the GRI guidelines have not become the basis of certification or verification for sustainability performance.

4.1.4 GRI Summary

In summary, the GRI guidelines and their use in environmental, social and financial reporting will continue to be an evolving practice. The guidelines have been key to influencing sustainability measurement and reporting by major corporations like Wal-Mart and McDonalds, and for its supply chain environmental management system. The GRI guidelines provide the most comprehensive framework for environmental and social reporting for any business enterprise involved in the supply chain of agricultural production, from the farm to the food retailer. They will likely remain as the meta-framework for environmental performance measurement and reporting internationally.

However, the use of these guidelines, which are still voluntary and is still in its infancy internationally and in Canada. The guidelines themselves and the practice of using them for measuring and reporting financial, environmental and social performance is an evolving enterprise. Notwithstanding, the guidelines represent a gold-standard for environmental, social and economic sustainability reporting and will likely influence how environmental footprinting and reporting will be conducted. With the addition of the Food Processing supplement guidelines for sustainability reporting, along with water and energy reporting protocols, the GRI guidelines are particularly relevant to the agriculture and food sector in Alberta and Canada. However, to our knowledge the GRI Food Processing guidelines have not yet been adopted or used by major Canadian agriculture and food sector businesses, though there is new evidence that companies like Agrium, Loblaws, Wal-Mart, TESCO, Whole Foods Market Inc., and Tyson Foods are beginning to report on some select aspects of environmental and social performance that use the GRI indicator guidelines (see Appendix 5, Bloomberg sustainability indicators data list).

4.2 Ecological Footprint

Ecological Footprint Analysis (EFA) is a biophysical assessment tool that accounts for the environmental impact of consumption. EFA usually focuses on the consumption impacts associated with a given population. In these cases, the ecological footprint measures the environmental costs resulting from a given populations' consumption of food, transportation, housing and goods and services, and attributes those costs to the consuming population. While most sustainability models focus on production, the ecological footprint emphasizes consumption highlighting the role of the consumer as an end point or driver of production.

Many Ecological Footprint (EF) practitioners are concerned about the increasing use of the term *environmental footprint* as it can be confused with the EF. The EF is a standardized biophysical assessment tool with specific methodological protocols. The *environmental footprint* is a generic term to account for a broad suite of environmental impacts.

The EF is unique in that it accounts for the costs of consumption regardless of where associated environmental burden falls. For example, through trade, it is possible to enjoy the benefits of consumption without experiencing the impacts in your local region; as the impact is being born by a foreign community. While the ecological footprint is an indicator of consumption, important factors other than consumption habits influence the EF. These include population size, technology, and gains or losses in eco-efficiency. For example, more efficient harvesting techniques, new technology such as zero-emission vehicles, or a reduction in population are factors that could lower the overall ecological footprint.

In more technical terms, the EF provides a snapshot in time and the trajectory over time of how much nature, expressed in a common unit of bioproductive space, is used exclusively for producing all the resources (food, energy, materials) a given population consumes and absorbing the wastes they produce, using prevailing technologies (Chambers et al. 2000). In essence, it is an accounting tool to measure the impact of human activity on the planet. At the macro level, if the human footprint exceeds the productive capacity of the biosphere then consumption patterns are clearly not sustainable.

4.2.1 Land categories

The EF is organized into 6 different land categories: energy land or CO_2 uptake land, crop land, pasture or grazing land, forest land, built up land, and fisheries space. The calculation is relatively straightforward for four of the six categories (crop land, pasture land, forest land, built up land). For crop land, pasture land, forest land, and built up space, the footprint refers to the direct land area with adjustments made to translate the area into global hectares (GHA, described below). Crop land refers to the area of cropland required to produce necessary crops for food and other goods. Pasture land refers to the area of grazing land required to produce the necessary animal products. Forest land refers to the area of forest required to produce the wood and paper. Built up area refers to the area of land occupied by our houses, roads, buildings and other human infrastructure.

Fisheries space or what is sometimes called sea space refers to the area of water fished for the seafood and marine products that we eat. While technically not a land area, sea space is treated similarly to the land categories described above. The different areas fished are adjusted based on the productivity of the different ocean regions and described in global hectares. The EF area summing the crop land, pasture land, forest land, built up land, and fisheries space categories reference direct land use.

Energy land or CO_2 uptake land is different than the other land categories because it does not reference direct land use. Energy land refers to the area of forest that would be required to absorb the CO_2 emissions resulting from a community's energy consumption. Energy land refers to the amount of additional biologically productive area needed to sequester atmospheric CO_2 through afforestation. The EF, therefore, is made up of direct land (crop, pasture, forest, built-up, fisheries space) and theoretical land (forest area required to absorb CO_2 emissions).

In industrialized countries, the dominant land category contributing to a population's EF is energy land. Energy consumption includes direct energy such as personal transportation energy and residential energy. It also includes indirect energy which is the energy embodied in food, goods and services. Embodied energy is the energy needed for production, distribution, operation, and waste disposal of food items, consumer goods or services. Typically, direct energy makes up 60% of a populations' energy footprint and indirect energy makes up 40%. Among wealthier populations' the split becomes closer to fifty-fifty.

4.2.2 Global hectares

The EF expresses results in global hectares. A global hectare is a standardized hectare to account for the fact that different land types and different land categories have different productivity or biocapacity potentials. A common unit allows for the meaningful summation of different land types and categories and also allows for meaningful comparisons of footprint results between regions, countries, or products and processes being examined. Land area is converted into global hectares using yield factors that account for the fact that a land type will have different productivity potential depending on location and equivalence factors that convert the different land categories into a single normalized unit.

4.2.2.1 Yield factors

Land types (for example, agriculture land) will have different productivity potentials depending on the region. Productivity potential can vary both within a country and across countries. For example, a hectare of crop land in Northern Alberta is less productive than a hectare of crop land in the Napa Valley in California. A country or region's yield factor for a respective land type is the ratio of national or regional - to world-average yields for that land type. It is calculated in terms of the annual availability of usable products. As described in the Global Footprint Network Ecological Footprint Standards (2009), a country's yield factor YF_L, for any given land use type L, is given by

$$YF_L = \frac{\sum_{i \in U} A_{W,i}}{\sum_{i \in U} A_{N,i}} \qquad \text{(Eq. 1a)}$$

where U is the set of all usable primary products that a given land use type yields, and $A_{W,i}$ and $A_{N,i}$ are the areas necessary to furnish that country's annually available amount of product i at world and national yields, respectively. These areas are calculated as

$$A_{N,i} = \frac{P_i}{Y_N} \text{ (Eq. 5a) and } \qquad A_{W,i} = \frac{P_i}{Y_W} \qquad \text{(Eq. 1b)}$$

where P_i is the total national annual growth of product i and Y_N and Y_W are national and world yields, respectively. Thus $A_{N,i}$ is always the area that produces i within a given country, while $A_{W,i}$ gives the equivalent area of world-average land yielding i.

4.2.2.2 Equivalence factors

Hectares of the different land categories are converted to a single unit (global hectare) using equivalence factors allowing the different land categories to be summed into a single EF value. For example, cropland in the EF methodology is considered to be more productive than pasture land. The land category equivalence factors are based on global scientific data and updated by the Global Footprint Network (2005). See Table 1 for a list of land category equivalence factors.

Table 1: Global Footprint Network equivalence factors by land category (2005)

Land category	Equivalence factor
Cropland	2.64
Grazing Land	0.50
Other wooded land	0.50
Forest	1.33
Marine	0.40
Inland Water	0.40
Infrastructure	2.64
Hydro	1.00

4.2.3 Alberta Ecological Footprint studies

EFs have been calculated for Alberta, Edmonton, Calgary, Leduc County, and several Census Districts. In addition, the City of Calgary developed a personal EF calculator for Calgary residents. The Calgary Board of Education and University of Calgary have also developed a school EF calculator. Table 2 reviews Alberta EF studies by jurisdiction, base year and source. Due to updates in EF methodology and different base years the studies are not comparable. With the introduction of the 2009 Ecological Footprint Standards and maturity of footprint methodology compatibility and consistency among studies should improve.

Table 2: Alberta Ecological Footprint Studies

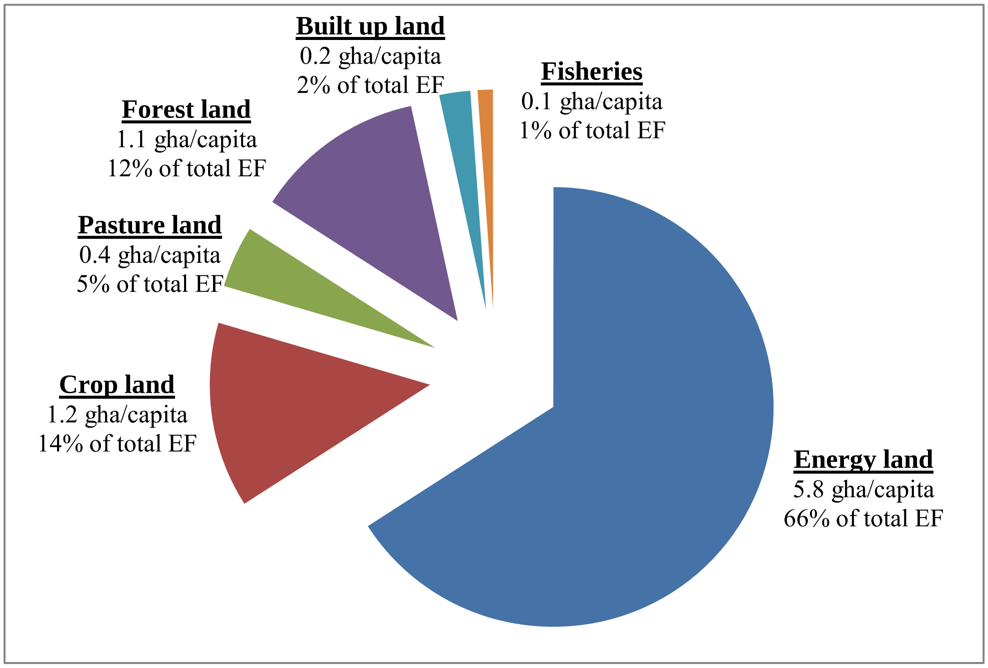
Jurisdiction	Ecological footprint	Source	Comment
Alberta	10.7 gha/capita	Pembina Institute (Wilson, 2001)	Calculated as part of the Alberta GPI, based on personal expenditure approach. The 2001 calculation was updated in 2006.
	9.0 gha/capita	Pembina Institute (Wilson, 2006)	
Alberta	8.8 gha/capita	Alberta Environment (Wilson and Anielski, 2008)	Preliminary analysis conducted for Alberta Environment, unreleased results.
Calgary	9.9 gha/capita	Federation of Canadian Municipalities (Wilson and Anielski, 2004)	Part of Federation of Canadian Municipality study. Of the 18 communities included in the study, Calgary had the highest EF.

Calgary	9.4 gha/capita	(City of Calgary, 2008)	Derived Calgary CLUM based on Canadian CLUM using personal expenditure approach. 2010 update to be released in September.
City of Leduc	8.5 gha/capita	City of Leduc (Anielski and Wilson, 2006)	Part of Leduc Genuine Wealth Study for Leduc. Based on FCM sub national approach. The study also included EF estimates for seven communities within Leduc County.
Edmonton	8.6 gha/capita	City of Edmonton (Wilson, 2010)	Calculated for the Edmonton 2008 GPI Report by Anielski and Johannessen, 2010). Derived from Canadian CLUM (Global Footprint Network) using personal expenditure approach.
12 Census Districts (e.g. Canmore)	Study range: 7.5 –10.3 gha/ capita	(Wilson and Grant, 2009)	Based on Canadian municipal calculation strategy.
Personal calculator (Calgary residents)	Will vary	(City of Calgary, Global Footprint Network, 2009)	Estimates an individual's EF based on a series of questions targeting energy use, diet, consumption of goods and services, household size and transportation patterns.

4.2.3.1 Provincial Ecological Footprint

The most recent analysis conducted for the province in 2007 estimated a provincial EF of 8.8 hectares per person (Wilson and Anielski, 2008). Consistent with previous provincial studies, energy land made up approximately 60% Alberta's total EF. The significant contribution of energy land is similar for other regions in Canada. According to the 2008 study, crop land is the second largest component of the Alberta EF making up 13% of the total. This is closely followed by forest land that makes up 12% of the EF. The remaining land categories include pasture land (5%), built-up area (2%), and fishing area (2%). Figure 2 provides a breakdown of the Alberta EF by land category. While agriculture (crop land and pasture land) represent 18% of the average Albertan's direct footprint, when factoring in the embodied energy associated with food consumption, the total agri-food related EF represents approximately a third of the Average Albertan's footprint. The Alberta agri-food related footprint refers to Alberta consumption of food and agri-goods recognizing that these goods come from a number of different countries. The crop land, pasture land, and energy land embodied in food production and transportation associated with the Alberta EF is not necessarily land in Alberta.

Figure 2: Alberta Ecological Footprint by Land Type (based on 2007 provincial study)



4.2.4 Alberta biocapacity

National Ecological Footprint accounts report a country's EF alongside the country's available biocapacity demonstrating both the demand for biocapacity and supply of biocapacity. There have been no studies; however, using a footprint based methodology estimating the biocapacity of Alberta or Alberta agriculture in particular.

Biocapacity is the sum of all the bioproductive land types within a jurisdiction expressed in global hectares (gha). Bioproductive land is translated into global hectares by multiplying land types (crop land, forest land, etc...) by the appropriate yield factor and equivalence factor (Wackernegal et al., 2005).

Biocapacity (gha) = Area (ha) * Yield Factor * Equivalence Factor [eq.3]

Sustainability at the global level stipulates that global demand not exceed global supply. Table 3 presents Canada biocapacity in national hectares and global hectares. The table demonstrates the yield factors and equivalence factors used to convert national hectares to global hectares for Canada (2008).

Table 3: Canada, biocapacity in global hectares (2008)

Land Use Type	Area (National hectares)	Yield Factors	Equivalence factors	Biocapacity (global hectares)
Cropland	52,110,000	1.14	2.64	157,732,355
Grazing Land	15,390,000	1.09	0.50	8,348,785
Other wooded land	91,951,000	1.09	0.50	49,881,686
Forest	310,134,000	0.73	1.33	300,099,207
Marine	287,762,250	0.81	0.40	92,546,692
Inland Water	89,116,000	1.00	0.40	35,394,571
Infrastructure	945,314	1.14	2.64	2,861,381
Hydro	4,657	1.00	1.00	4,657
TOTAL	**847,413,221**			**646,869,334**

While there are no current estimates of Alberta biocapacity, a 2010 EF study conducted for Ontario included an assessment of provincial biocapacity (Stechbart and Wilson, 2010). Ontario's biocapacity was estimated by categorizing land areas within the province into the EF land categories and multiplying by the appropriate yield factors and equivalence factors. Recognizing different land productivity potentials across the province, yield factors were estimated for three ecozones and Ontario’s portion of the Great Lakes. The crop land yield factor was developed by comparing Ontario crop yields with Canadian crop yields for major crop categories. The pasture or grazing land yield factor was based on the amount of above-ground primary production available in a year. Given uncertainty around data sources, the Ontario study adopted the Canadian grazing land yield factor. Preliminary pasture yield factors were estimated, however, using the Canadian Land Inventory (CLI) classifications and estimates of net primary productivity by Chen (2008) from the University of Toronto. The CLI approach was rejected because the data set is over thirty years old and incomplete for the entire province. The net primary productivity data was not used given that the NPP calculations targeted the productivity potential of forest land as opposed to all land types.

Forest yield factors were calculated based on annual increment of timber per hectare. The approach is similar to the process of calculating a national yield for forest land in the National Footprint Accounts. The approach relies on the assumption that annual increment data accurately accounts for the addition of forest stock each year throughout the forest. The availability of forest land biocapacity is an important consideration for agriculture studies as a potential offset of the energy footprint.

4.2.5 Agriculture Ecological Footprint studies

There have been few EF studies focusing specifically on agriculture. An early EF study conducted by Wada (1993), a student under Dr. Bill Rees at the University of British Columbia, compared the EF of tomatoes grown in heated greenhouses to intensive field agriculture in British Columbia. The study revealed that the energy land required to grow greenhouse tomatoes dramatically exceeds the growing area needed for field tomatoes (in Rees and Wackernagel, 1996). Wada's study highlights the significance of considering energy land in any agriculture footprint analysis. Often the embodied energy impacts have a larger footprint then the actual land area in use.

Frey and Barrett (2006) estimated the EF of different diet profiles comparing several diet profiles to the current average Scottish food footprint. Results indicate that a healthy diet based on Scottish nutrient standards, an organic diet, a diet of 100% local food, and a vegetarian diet all reduce the food footprint by 15% to 35% respectively. Most of the impact associated with the average Scottish person's diet comes from eating meat (2006: p.4). To estimate the food footprints, Frey and Barrett used the Stockholm Environment Institute's Resources and Energy Analysis Programme software (REAP). The REAP software combines material flow accounts and EF accounts by economic sector with monetary input-output analysis. The total material flow and EF are then reallocated to final demand categories based on expenditure data (Wiedmann and Barrett, 2005). In this case, Frey and Barrett matched data from the National Food Survey with Scottish food consumption data and modeled results using the REAP software. The REAP software was developed for the U.K. and is not applicable for Alberta without modification.

Kissinger and Rees (2009) estimated the terrestrial ecosystem area of the Canadian prairies being used to support export demand using a hybrid model combining material flow analysis and EF analysis. The authors attribute the flow of materials and productive ecosystem area 'exported' from Canada to specific importing countries by disaggregating ecological footprint data to estimate the food footprint that individual import-dependent countries impose on Canada. Kissinger and Rees's analysis involved the following steps:

a) Identification and quantification of commodities produced;
b) Quantification of the proportion of commodities exported and identification of their destinations;
c) Documentation of key physical inputs involved in production (i.e., land, water, chemicals and energy);

d) Estimation of the area of terrestrial ecosystem devoted to the production of exported commodities (both the agriculture lands and the area required to sequester carbon dioxide involved in the production).

The authors' analysis included the physical inputs involved in the growing phase. Extra inputs required for supporting activities (e.g., processing, storage and transportation) were not included. Kissinger and Rees's findings indicate that an average of 65% of Canadian prairie cropland was effectively 'exported' on an annual basis over the research period (1989-2007). Of the prairie agricultural land exported, 37% was devoted to the U.S, followed by 26% to Asia and 11% to Latin America. The rest went to the European Union and other countries.

The EF can be used to estimate the impact of a given agriculture commodity or class of commodities. Kissinger and Gottlieb (2010) calculated the EF of Israel's grain consumption using a place oriented approach accounting for the unique production characteristics of each supply region. Kissinger and Gottlieb's analysis documents (specific to each source of supply) the land area to grow the crops and the major components of the energy footprint of grain production including; machinery (diesel and gasoline to operate), fertilizers, and transportation. Their analysis did not include energy for irrigation; seeds and pesticide use, nor the energy embodied in transportation from farm to port. The author's research focused on grain supply and did not include imported processed grain products (e.g. pasta) or the amount of grain embodied in meat imports (feeding grain). While the authors' measured cropland in actual hectares, they measured energy land in global hectares. The energy embodied in producing and transporting the commodity was converted to CO_2 emissions and then translated into area demand using average global sink-capacity of forests for carbon. The land to tonne conversion factor the author's adopted was 0.27 ha for 1 tonne of CO_2. Kissinger and Gottlieb's analysis revealed that changing grain composition, source of grain supply, reducing consumption, and increasing yields are factors that can lower the footprint of grain consumption.

While there are few agriculture specific EF studies, the EF is increasingly reported as a land use indicator in LCA studies. The inclusion of the EF is most common when the product, process, or production method being considered is land based. In these studies, the EF typically refers to direct land only and does not include carbon uptake land. Results are often reported in actual hectares of land as opposed to global hectares. Moreover, unbundling and backcasting the EF calculations to define operational indicators to directly impact EF results have been cumbersome and difficult to quantify.

4.2.6 Water Footprint

Fresh water is not typically considered as an impact category in LCA or EFA. Sea space or marine space is a category in Ecological Footprint analysis and refers to the amount of sea space fished to support the consumption of fish and marine products. It is not a measure of water use, water quality or water availability. While water has been traditionally overlooked in biophysical assessments, a number of methods to account for virtual water or water footprint have been proposed in recent years. The water footprint is generally expressed as freshwater volume (cubic metres per year) used to sustain a population. The Water Footprint concept is primarily rooted in the search to illustrate the hidden links between human consumption and water use and between global trade and water resources management (Hoekstra, 2007).

The Water Footprint is defined as the total volume of freshwater that is used to produce the goods and services consumed by a given population. Similar to the EF, water footprints are typically calculated for any well-defined population including a household, community, city, province, or nation (Hoekstra and Chapagain, 2007). Water footprints have also been calculated for businesses or for a specific activity, good or service. For example, Hoekstra and Chapagain (2007) have calculated the Water Footprint for 285 crop products and 123 livestock products. They have also estimated the Water Footprint for numerous other goods such as a t-shirt, sheet of paper, pair of shoes or microchip (Hoekstra, 2007).

The total Water Footprint of an individual or community breaks down into three components: the blue, green and grey Water Footprint. The blue Water Footprint is the volume of freshwater that evaporated from the global blue water resources (surface water and ground water) to produce the goods and services consumed by the individual or community. The green Water Footprint is the volume of water evaporated from the global green water resources (rainwater stored in the soil as soil moisture). The grey Water Footprint is the volume of polluted water that associates with the production of all goods and services for the individual or community (Hoekstra , 2007: 11). Given that the significance of water is locally dependent, the Water Footprint considers local productivities and does not use global average productivities.

The size of the global Water Footprint is largely determined by the consumption of food and other agricultural products (Hoekstra, 2007: 23). For example, the average global Water Footprint for the period 1997-2001 was is 7,450 billion m^3/yr. Humanity's green Water Footprint is 5,330 billion m^3/yr, while the combined blue-grey Water Footprint amounts to 2,120 billion m^3/yr. The green Water Footprint fully refers to agricultural products. The combined blue-grey Water Footprint refers to agricultural products (50%), industrial products (34%) and domestic water services (16%). Agricultural water use includes both effective rainfall (the portion of the total precipitation which is retained by the soil and used for crop production) and the part of irrigation water used effectively for crop production (Hoekstra and Chapagain, 2007).

Chapagain and Orr (2009), Hoekstra (2007), Chapagain and colleagues (2006), pioneers in Water Footprint and virtual water analysis, have identified a number of challenges when calculating Water Footprints. Several of these challenges are not unique to Water Footprints and are reflective of other biophysical assessment tools.

- The water relationship is complex and hard to meaningfully capture in a standardized model.
- The significance of water is location specific depending on local agro-climatic characteristics, status of water resource, type of production system, and production volumes, all factors making data collection time consuming and interpretation and analysis challenging. Location specific results do not allow for meaningful comparisons between studies and across jurisdictions.
- Identifying the most appropriate scope of boundaries is difficult. For example, processing is a critical component influencing the water footprint but including it adds an additional level of complexity especially in terms of data collection. As a result most studies report at the field level.
- Water footprints can only be calculated by analysing the source of consumer goods and consider the actual water use where production takes place.

Traditional LCA studies have tended to overlook water input, however this is beginning to change particularly with growing concerns about water scarcity (e.g. Australia) and the sustainability of agriculture. Moreover, with the help of the GRI Water Protocols, we should expect to see water indicators appear more regularly in LCA work and in corporate sustainability reporting.

4.2.7 EF Challenges

The strength of the EF metaphor has allowed the tool, or at least the ‘term’, to receive a high level of awareness and use in the scientific community, policy circles, and among lay people. With the popularity, however, general misconceptions about what the EF actually measures and how it should be interpreted and used are commonplace. While the tool is a useful indicator of sustainability, the EF is widely conveyed and used as an overall statement of sustainability, which it is not. The EF is a measure of consumption accounting for flows of material and energy of a given population, project or initiative. Similar to other biophysical measurement tools, EF projects are time consuming and data intensive. Data availability poses a major challenge especially at the community level. Compromised data can jeopardize the quality and veracity of results.

The EF is an additive model compiling complex information into a single, functional score. While we see merits to providing an aggregate result for communication purposes, adding indicators means that information is lost. Relating an aggregated score to specific planning and policy choices is difficult (Wilson and Grant, 2009).

It is important to note that the EF is a very limited indicator system for operations. The footprint calculation merely gives you a single piece of data to identify the overall EF of a myriad of calculations from ones operations. There is no current methodology for unraveling the final calculation to develop a set of operational indicators that can over time have an impact on reducing the EF outcome. The EF, while illustrative, is still not a viable indicator system for day-to-day, month to month drivers for improved performance and reductions in negative EF results. Therefore it is difficult to impact your footprint in any meaningful way. Moreover, it is difficult to monitor changes in consumer behaviour on a go-forward basis.

The EF and biocapacity is usually reported in global hectares. For an assessment of agriculture, however, the results would be more useful if reported in actual hectares, that is, related to a specific geographic location where agricultural production occurs. When using global hectares for local or regional applications, however, valuable information is lost to support policy decisions. For example, the actual size of land is not known and global hectares do not reveal whether the environmental impacts occur regionally or abroad (Turner et al., 2007; Wiedmann, 2008; Moran et al. 2009; Kissinger and Rees 2009, Kissinger and Gottlieb, 2010). Reporting results in actual hectares means that the findings cannot be compared directly with other ecological footprint studies.

The EF measures the impact of consumption and does not capture initiatives to be more sustainable unless they influence consumption patterns. For example, sustainability actions such as protecting wetlands or restricting pesticide use would not be directly captured by the tool. Protected space would be included if an assessment of biocapacity is calculated to demonstrate the supply side of ‘land’ within a given region. Moreover, major factors influencing the ecological footprint are not easily changed. Entrenched consumption patterns, existing infrastructure, established production systems, and existing government policies do not change quickly. Project sponsors and users often want something immediate to lower the ecological footprint, but the reality is significant footprint reductions often require a reorganization of society.

The EF of a given population reflects the amount of bio-productive space used or occupied to support the consumption of goods and services by that population regardless of where in the world the environmental impact incurred. In industrialized countries, which typically rely heavily on imported goods and services, the burden of consumption largely falls outside of local political borders. Communities do not see the negative feedback their consumption may be causing on the supportive ecosystems, which could be half a world away (Rees 2008). Reciprocally, agriculture production in Alberta serves markets all over the world. The reality of export production to serve markets elsewhere is usually discussed in terms of dollars not in terms of lost natural capital.

The EF as a metaphor of human consumption has proved incredibly powerful for education and awareness purposes. The standard EF method, however, has been criticized as not being effective for policy and planning purposes especially at the community level (Wilson and Grant, 2009; Ayres, 2000; Moffat, 2000).

Stoeglehner and Narodoslawsky (2008) argue that the EF can go from an environmental education tool to a decision making tool by reporting results at a finer resolution and drawing on case specific yield factors to ensure situation specific results. The authors also suggest that the EF can be used as an initial screen to prioritize issues for further analysis. Wilson and Grant make a similar suggestion noting that the EF is one tool, which communicates a specific, set of information and ought to be part of a larger agenda to advance sustainability (2009). Using the EF as a screening tool to inform decision making offers an opportunity to direct attention to environmental impacts or issues that should be examined and assessed in further detail. Stoeglehner and Narodoslawsky argue that the EF model increases the efficiency of decision-making processes as it effectively reduces the information load on decision makers' by serving as a filter to identify options (2008).

4.3 Life Cycle Assessment

Life cycle assessment (LCA) is an ISO-standardized analytical framework, which evaluates the environmental performance of products, services and activities throughout their entire life history, from "cradle to grave" (ISO, 2006a). This is achieved by following flows of matter and energy from the initial extraction of resources, through processing, packaging, transportation and distribution, and finally to the end use of products and disposal or recycling of remaining material. Inputs of resources and outputs of emissions throughout the life cycle are inventoried and translated into contributions to a suite of environmental impact categories of global concern, including global warming, ozone depletion, and energy use. Table 4 lists impact categories relevant to agricultural LCAs.

The use of life cycle assessment to evaluate products can be traced back to the late 1960s and early 1970s, when life cycle-styled methods were applied to packaging materials and industrial systems. Interest in life cycle-styled studies emerged out of the oil shocks and energy crisis of the 1970s as well as growing concerns over excess waste and packaging (Baumann & Tillman, 2004). These early studies were commissioned by businesses like the Coca-Cola Company, who wished to know the relative environmental impacts of alternative packaging options – glass or plastic bottles – and wanted to include the entire production chain, examining the packaging production system from the extraction of raw materials to the disposal of waste. In the 1990s, under the leadership of the Society for Environmental Toxicology and Chemistry (SETAC), the LCA methodology was refined and improved, and many elements of the methodology were standardized under the International Organization for Standardization (ISO). At this time, the application of LCA also expanded beyond the manufacturing sectors into other industries, including the food production industry. Today, the rigour associated with this methodology has garnered life cycle assessment the status of a leading methodology to measure emissions-based environmental impacts and make emissions-related product declarations. As a result, standards for greenhouse gas accounting and carbon footprinting, for example, now call for the consideration of the entire life cycle of those products or services being evaluated (BSI, 2008; GFN, 2009).

Table 4. Impact categories relevant to agricultural LCAs

Impact Category	Reference Species	Description	Major Sources in Agriculture [a]
Global Warming Potential	CO_2	Increased radiative forcing in the atmosphere (W/m^2)	Enteric methane, emissions from manure, fertilizer production, field emissions of N_2O [b]
Ozone Depleting Potential	CFC-11	Reduction of stratospheric ozone	On-farm mechanization, transportation [b]

Acidification Potential	SO_2	Deposition of acid precipitation	Ammonia emissions [4] from fields and animal manure [a]
Eutrophication Potential	PO_4	Contributions to nutrient loading in water bodies	Runoff from fertilizer [b]
Photochemical Ozone Creation	C_2H_4	Production of photochemical/ summer smog	Field emissions of N_2O, fertilizer use, energy use, on-farm mechanization [b]
Cumulative Energy Use	MJ	Use of renewable and non-renewable energy resources	On-farm energy, on-farm mechanization [b]
Aquatic Ecotoxicity	1,4-DB[5]	Exposure of the environment to ecologically toxic substances	Pesticide use
Human Toxicity	1,4-DB	Human exposure to substances detrimental to human health	Pesticide use
Land Use[c]	m^2	Direct or indirect occupation of land	Field area for crop production
Biotic Resource Use	NPP	Appropriation of the products of biological productivity	Crop production
Water Use[d]	m^3	Impacts on water availability and quality	Irrigation

a. Major sources listed here only include activities from cradle to farm gate, and do not consider possible emissions from the further processing, packaging, sale, use and disposal of products.

b. For livestock systems, feed production is a leading contributor.

c. Similar impact categories are often used to show the potential impacts of land use, such as habitat loss and impacts on biodiversity associated with the transformation of land.

d. Water use is rarely included in agricultural LCAs although some work has been done to try to develop a standard method of water use indicators (Owens, 2002; Koehler, 2008). Difficulties are encountered in the inclusion of water use as an impact category, arising from the definition of water use, the source of water, the inclusion of water quality indicators, and relationships to other impact categories such as eutrophication.

[4] Ammonia is a common by-product of animal waste due to the often inefficient conversion of feed nitrogen into animal product. A recent study by the National Research Council (NRC. 2003. Air Emissions from Animal Feeding Operations. Washington, D.C.: The National Academies Press) identified ammonia emissions as a major air quality concern at regional, national, and global levels. The potential negative impacts of ammonia are many. Deposition of atmospheric ammonia can cause eutrophication of surface waters, where phosphorus concentrations are sufficient to support harmful algal growth. Nutrient enrichment and eutrophication lead to the decline of aquatic species, including those with commercial value. Sensitive crops such as tomatoes, cucumbers, conifers, and fruit cultures can be damaged by over-fertilization caused by ammonia deposition if they are cultivated near major ammonia sources (van der Eerden et al, 1998). The deposition of ammonia on soils with a low buffering capacity can result in soil acidification or basic cation depletion. And volatilized ammonia can travel hundreds of miles from the site of origin. Source: http://pubs.ext.vt.edu/442/442-110/442-110.html accessed August 30, 2010.

[5] DB stands for dichlorophenoxy butyric acid.

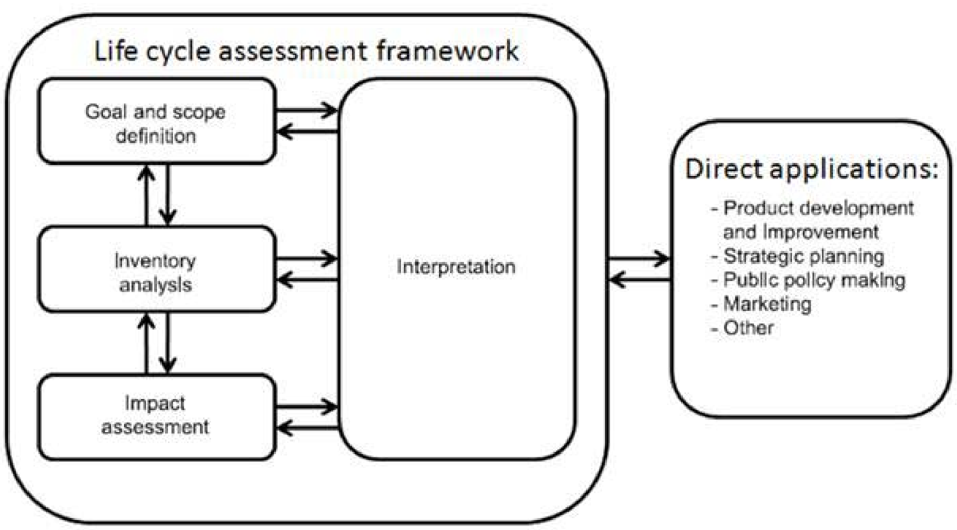
4.3.1 Alignment with GRI indicator guidelines

We have analyzed the alignment of typical LCA impact variables for agricultural LCAs (Table 4) and the GRI guidelines (general and for food processing industry supplement) in Appendix 3. This reveals that many GRI sustainability indicators are not considered in agricultural LCAs while some LCA impact variables are not included in the GRI guidelines. For example, agricultural LCAs consider the impact of pesticide use on eutrophication potential, acidification potential, human toxicity and aquatic eco-toxicity as well as biotic resource use (net primary productivity: NPP) and land use.

4.3.2 ISO 14040 Series

ISO 14040 and ISO 14044 (ISO, 2006a & b) dictate that formal LCA studies include four phases: goal and scope definition, in which the study parameters are established, including basis of measurement ("functional unit"), system boundaries, impact categories and methods of analysis; inventorying of material and energy flows into and out of individual unit processed or stages of production; the classification and characterization of resource use and emission-based impacts following defined characterization models; and the interpretation of results, including sensitivity analyses and checks for completeness and consistency. The ISO standards also provide guidance concerning key methodological choices, interpretation methods, and reporting and application of results, and include examples of data collection sheets, inventory tables, impact assessment results and interpretation checks. Figure 3 provides an overview of the Life cycle assessment framework.

Figure 3: The four-phase structure of formal ISO-compliant LCA studies



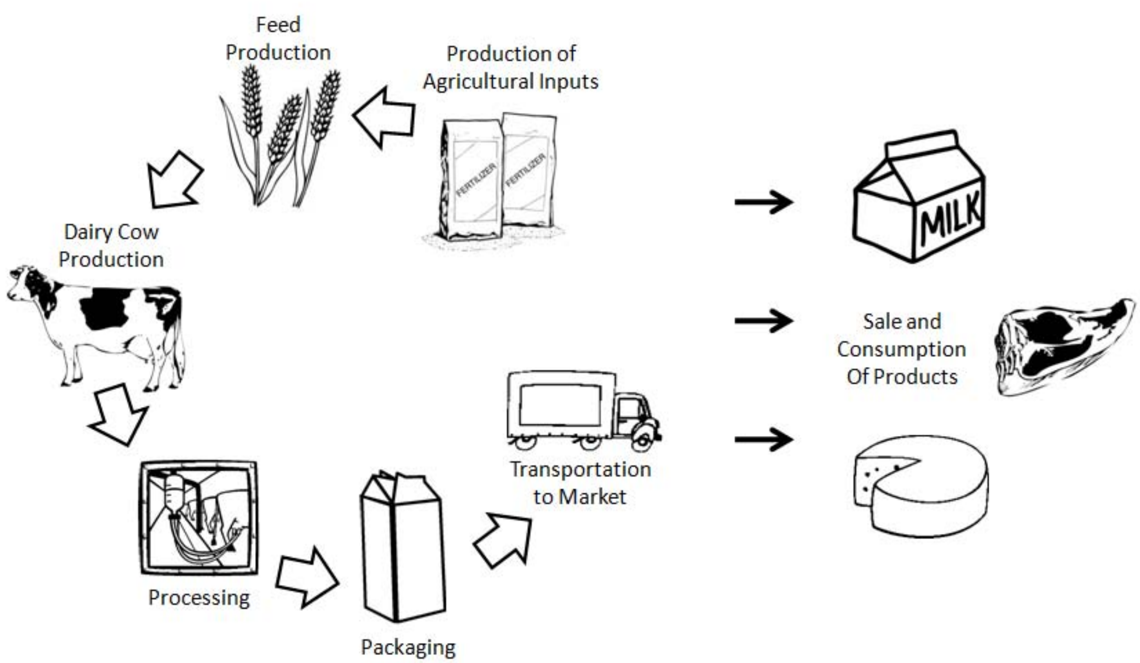
As well as providing quantified measurements of the contribution of production systems to resource use and emissions-related impacts, LCA can be used for a number of applications, including:

- Identifying "hot spots" of environmental impact and areas of potential benefit
- Comparing different products on the basis of certain environmental criteria
- Comparing the relative impact of alternative inputs to the production chain, different methods of production, and different management practices
- Modeling scenarios to predict the impact (positive and negative) of potential changes made to the system
- Identifying trade-offs between impact categories or production stages as a result of modeled changes
- Providing a baseline against which future performance can be measured

4.3.3 Application of LCA to Agricultural Systems

Over the past decade, a growing body of research has applied the LCA methodology to products derived from primary agriculture sectors, as well as secondary processing industries producing value-added products. An example of the full life cycle of agricultural products can be seen in Figure 4.

Figure 4: Simple life cycle diagram of a dairy production chain



The growing use of LCA to examine agricultural systems has come from the recognition that on-farm activities alone fail to account for the total emissions associated with food production, as upstream and downstream activities often contribute as heavily if not more so to total impacts. These up- and downstream activities include the production of fertilizers and pesticides, the provision of electricity and fuel inputs, and transportation of intermediate and final goods (especially if goods are transported significant distances or by fuel-heavy modes such as air freight). Even LCAs of agriculture do not always capture the impacts of the entire life cycle of food products, and often include only those activities up to the "farm gate," while excluding the potential impacts after the product has changed hands to wholesalers, retailers and ultimately consumers.

Globally, primary industries examined have included grains (Katajajuuri et al., 2003; Pelletier et al., 2008; Meisterling et al., 2009), beef (Casey & Holden, 2006; Pelletier et al., 2010; Beauchemin et al., 2010), dairy (Cederberg & Mattsson, 2000; Haas et al., 2001; Eide, 2002; Hospido et al., 2003; Arsenault et al., 2009); poultry (Pelletier, 2008); pork (Basset-Mens & van der Werf, 2005; Pelletier et al., in press; SNC-Lavalin Agro, 2009), sugar beet (Brentrup et al., 2001), apples (Stadig, 1997; Milà i Canals et al., 2006), and field vegetables (Carlsson-Kanyama, 1998). Studies have also examined secondary sectors and value-added products such as cheese (Berlin, 2002), bread (Andersson & Ohlsson, 1999) and tomato ketchup (Andersson et al., 1998). While much of the LCA work on agriculture has been carried out in Europe and focused on European production systems, there is a small but growing body of literature examining agricultural production chains in North America (Table 5).

Table 5. North American LCAs of Primary Agriculture Sectors

Sector	Study	Purpose	Impact Categories [a]
Grains and legumes	Canadian canola, corn, soy and wheat *Pelletier et al., 2008*	Explored the potential impacts (positive/negative) of a nation-wide transition to organic production	EU, GWP, ODP, AP
	US wheat *Meisterling et al., 2009*	Compared conventional and organic production; analyzed scenarios based on distance product was transported	GWP, EU
Beef	US Beef *Pelletier et al., 2010*	Compared beef produced using pasture and feedlot systems	EU, EF, GWP, EP
	Western Canada Beef *Bauchemin et al., 2010*	Compared contributions of cow-calf and feedlot phases of production	GWP
Dairy	Nova Scotia dairies *Arsenault et al., 2009*	Compared pasture-based and confinement-based systems	GWP, ODP, AP, EP, EU, others
Poultry	US broilers *Pelletier, 2008*	Characterized emissions from broiler production	GWP, ODP, AP, EP, EU
Pork	US swine *Pelletier et al., In Press*	Compared high- and low-profit commodity and niche production systems	EU, GWP, EP, EF
	Alberta pork *SNC-Lavalin Agro, 2009*	Quantified GHG emissions throughout the entire life cycle of Alberta pork production	GWP

a. EU = Energy Use; GWP = Global Warming Potential; ODP = Ozone Depletion Potential; AP = Acidification Potential; EP = Eutrophication Potential; EF = Ecological Footprint

Agricultural LCAs have been effective in identifying those areas of the agricultural production chain, which contribute greatest to certain impact categories, as well as comparing different products, management practices or production scenarios. Specifically, the production and use of fertilizer has been shown to contribute heavily to the energy use, global warming, eutrophying and acidifying emissions associated with Canadian crop production (Pelletier *et al*., 2008), on-farm mechanization has been identified as a driver of energy in New Zealand apple production (Milà i Canals *et al*., 2006) and enteric methane has continually been identified as a significant source of greenhouse gases in beef production systems (Pelletier *et al*., 2010; Beauchemin *et al*., 2010). A particularly consistent observation of livestock systems has been the importance of feed production as a contributor to numerous impact categories. Poultry feed production, for example, accounted for between 80 and 97% of the impact category contributions examined by Pelletier (2008) for U.S. broiler systems. Likewise, the energy demands of beef production are also dominated by feed production, although enteric methane from beef cows accounts for a higher portion of greenhouse gas emissions than the production of beef feed (Pelletier *et al*., 2010).

LCA has also been employed to compare production practices and model potential benefits of alternative agricultural practices. One of the more common comparative applications has been the comparison of organic production methods to conventional methods. The primary differences in impact seen between these systems is typically the use of green manure nitrogen versus synthetic nitrogen fertilizers, and so potential decreases in impact by transitioning to organic production are limited by the degree to which fertilizer dominates the impacts of the system. Results of these kind of LCAs have demonstrated that, for certain systems such as canola and wheat production, the transition to organic practices can significantly reduce total energy demand and ozone depletion potential (Pelletier *et al*., 2008), although differences in greenhouse gas emissions are more slight, and other stages of the product life cycle, for example long transportation distances, may play a larger role in determining the system's contributions to global warming (Meisterling *et al*., 2009).

An extensive review of life cycle assessment of food products by Poritosh et al., (2009) recommend the introduction of land and water in agri-food analyzes. While there have been a number of proposed methodologies to account for land use impacts (see section below), water resources are seldom considered in LCA. Indeed, for the most part, North American LCA studies into agriculture have not considered water use and land use impacts. LCA studies that do report water usually focus on reporting total input of water used while neglecting the impacts of water outputs (Koehler, 2008). In order to overcome methodological challenges, a project group was funded under the auspices of the United Nations Environment Programme/Society of Environmental Toxicology and Chemistry Life Cycle Initiative to develop an integrative inventory scheme for the assessment of freshwater use. In addition, several academic institutions in Europe are beginning to examine the inclusion of water resources as an impact category suggesting further development of how water is handled in LCA methodology. Water has also been raised as an issue for discussion at the upcoming International Conference on LCA in Food to be held in Italy in September 2010.

4.3.4 Functional unit

The functional unit is the amount of product against which impacts are measured forming the basis of comparison when examining multiple products. A number of functional units have been used to analyze agricultural systems, including product-specific units (e.g. a given mass or volume of product), and operation-specific units such as crop-farming on one hectare of land or an entire farm (Haas *et al.*, 2000). For product-specific functional units, mass has been the typical choice for food products, although other measures (protein, energy content) are increasingly used. When deciding upon an appropriate functional unit for an LCA, questions that need to be considered include:

- What is the goal of the study? (e.g. if the objective is to examine the possibility of making emissions-based product declarations, a product-specific functional would be appropriate using a functional unit which corresponds to the typical unit of the product);
- Who is the intended audience of the study and how are results expected to be used? (e.g. if consumers are intended to be the audience, a product-based functional unit makes sense; if the intended audience is a farmer, it may make sense to use a whole farm functional unit to provide a basis for improvement);
- What is the actual function of the product (e.g. if the function of meat products is considered to be provision of protein, a protein-based rather than mass-based functional unit would be appropriate); and
- Will different products from different systems, which may provide slightly different functions (e.g. one product may provide more energy but less protein) be compared? The use of different functional units in comparative studies may result in different outcomes, and so in these cases particular attention needs to be paid to this important methodological decision.

Other new measurement opportunities and challenges may be emerging that include consideration for the nutritional functional units of food (e.g. kcal. contained in food, protein or other nutrient content). This would suggest consideration be given to start reporting in multiple attributes and functional units for food in addition to accounting for conventional LCA inputs and impacts.

4.3.5 Key Agriculture LCA studies with relevance to Alberta

The following studies are evaluated given their relevance to Alberta's agriculture sector. The goals, scope and major findings are highlighted for each of the studies.

Pelletier *et al*., 2008. Scenario modeling potential eco-efficiency gains from a transition to organic agriculture: Life cycle perspectives on Canadian canola, corn, soy, and wheat production

Goal: Modeled a hypothetical nation-wide transition from conventional to organic practices in four agricultural sectors and measured the effects (positive and negative) on environmental performance including contributions to global warming, ozone depletion, acidification and energy use.

Scope: Included the use of farm machinery, the production of fertilizers, seeds, soil amendments and pesticides, and field-level nitrogen emissions. Excluded production and maintenance of machinery and infrastructure, and transportation.

Major findings: The simulated transition showed significant decreases in energy use and ozone depletion for all four crops examined, slight decreases in global warming potential and negligible change in acidification potential. While fuel use was actually higher for organic production practices, the use of green manure as a nitrogen source rather than chemical fertilizers was the major driver of a decline in energy use. The change in global warming potential was not as drastic, because a larger portion of greenhouse gas emissions were found to be the result of field emissions rather than fertilizer production.

SNC-Lavalin Agro, 2009. A life cycle analysis of carbon dioxide equivalents (CO_2e) of Alberta barley, wheat, peas and canola meal used in pork production, slaughter and further processing.

Goal: Measured the carbon footprint of Alberta pork to provide a basis for emissions-based product declarations to investigate possible market advantages, as well as to identify mitigation opportunities.

Scope: Followed the pork life cycle from production to slaughtering, processing and distribution. Included consideration of fertilizer production, feed production and processing, and transport throughout the life cycle. While global warming was the primary focus, numerous other impact categories were consideration to identify possible impacts that may otherwise be overlooked.

Major findings: The hog production stage was found to contribute 60% of GHG emissions, with the largest share being methane emissions from manure. Upstream activities (fertilizer production, grain production and feed production) accounted for 26% of emissions, while downstream processing of meat and distribution accounted for 13%.

Beauchemin *et al*., 2010. Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study.

Goal: To compare cow-calf and feedlot phases of beef production and to assess the role of enteric methane in contributing to total greenhouse gases.

Scope: Modeled a simulation farm to reflect beef production practices in western Canada, including both a cow-calf operation and a feedlot, as well as cropland to supply feed and bedding. Followed animals from birth to slaughter and accounted for methane emissions from cows and manure, nitrous oxide emissions from manure, soils, from N leaching, run-off and volatilization, and carbon dioxide emissions from energy use associated with on-farm activities as well as the supply of fertilizer and pesticides.

Major findings: Estimated a greenhouse gas intensity of 22 kg CO_2e per kg beef produced. Enteric methane accounted for 63% of GHG emissions, while methane from manure, nitrous oxide from soil, and carbon dioxide from energy use each accounted for only 4-5%. The cow-calf system was found to produce 80% of GHG gases, while the feedlot produced the remaining 20%, mostly as a result of enteric methane being heavily associated (84%) with the cow-calf phase of production.

Pelletier, 2008. Environmental performance in the US broiler poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions.

Goal: To measure to the environmental impacts of poultry production along the entire supply chain and identify those processes that contribute most to the life cycle environmental impacts of poultry products.

Scope: Included all inputs and emissions associated with feed production (including on-farm activities and all inputs to fertilizer and pesticide production, etc.; as well as inputs of fish meal from reduction fisheries), feed milling, hatchery, on-farm energy use, litter management and transportation throughout the life cycle. Excluded the provision of infrastructure, feed additives, maintenance of breeder flocks, hatchery wastes, and disposal of mortalities.

Major findings: Feed provision accounted the large majority of all environmental impacts measures. When feed production is examined more closely, it becomes evident that fertilizer use dominates the energy use impact category while field-level N_2O emissions and N and P leaching are major contributors to the global warming impact category.

Pelletier et al., 2010. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States.

Goal: To measure and compare the environmental impacts of three beef production systems: feedlot system, out of state pasture/ finished feedlot system, and a pasture system.

Scope: Impact categories considered: cumulative energy use, ecological footprint, greenhouse gas emissions, and eutrophying models.

Major findings: The pasture system had the highest impacts for all categories. The feedlot finished system had the lowest impacts for all categories. Feed production contributed most to the energy use and ecological footprint categories. Nutrient losses from manure contributed most to eutrophying emissions, and enteric methane contributed most to greenhouse gas emissions. The cow-calf phase is the dominant contributor to impact categories regardless of finishing strategy.

Beef production (regardless of system) generates lower edible resource returns on material/energy investment relative to other food production strategies. Edible energy return (i.e. units of nutrition such as calories or protein value, in animal production) on industrial energy investment:

Beef (grass finishing): 4.1%

Beef (feedlot finished): 5.2%

Broiler poultry: 16%

Pork production systems: 27%

4.3.6 LCA challenges

While LCA provides a rigorous framework to measure the biophysical burden of products and services, there are a number of challenges inherent in LCA applications that need to be considered when using the tool. Box 1 reviews general challenges that relate directly to agricultural applications and supply chain considerations.

An immediate challenge when using LCA to assess sustainability is that the tool does not extend well to aspects of environmental sustainability, which are not easily quantified, such as biodiversity impacts (habitat quality) and land use impacts on soil fertility or health. As well, LCA does not typically incorporate non-biophysical elements of sustainability and so does not consider social or economic impacts associated with the system being studied – although there is growing interest in refining the application of LCA-styled tools to these other areas, including life cycle costing (LCC), and social life cycle assessment (S-LCA) (Jørgensen *et al*., 2008; Hauschild *et al*., 2008).

Box 1: LCA challenges (agricultural applications and supply chain considerations)

Challenges – overview

- Does not apply well to aspects of environmental sustainability (e.g. soil fertility, biodiversity) that are not easily quantifiable
- Does not typically consider social or economic sustainability
- Difficult to compare results across studies, jurisdictions, industries or to make generalized conclusions
    - Complexity of systems
    - Variability in methodological assumptions
    - Setting study boundaries
    - Selecting a functional unit
    - Selecting impact categories
    - How to handle co-production allocation
- The lack of reliable and open source data
- Costly and time consuming

Because of the specificity of an LCA study reflecting the significant variation in the practices and production methods within industrial systems results are not easily generalized to an entire sector or industry. These shortcomings can be largely overcome by being transparent about methodological decisions and assumptions and interpreting and communicating results clearly.

A number of key factors will influence LCA results making it difficult to compare studies and may allow room for bias. Notable factors include: methodological assumptions underlying characterization and equivalency factors, the delineation of system boundaries, identification of a functional unit, and impact category selection. It is critical for studies to be transparent about assumptions and methodological decisions underlying the model. In terms of systems boundaries, generally, the expansion of the system to include more upstream and downstream activities results in a more comprehensive understanding of environmental burden, but also requires additional time and resources. Historically, agricultural LCA has focused on the farm-gate as the boundary for energy accounting but increasingly it is the post-dock impacts that are greater (e.g. lobster post-dock storage). Thus the consistent delineation of the system boundary is very important to ensure that LCAs are genuinely comprehensive and comparable

Streamlined LCAs, which target particular stages of elements of production, previously identified as key drivers of impact are often useful when time and resource are scarce, but may result in some impacts being overlooked. Similarly, the inclusion of multiple impact categories, beyond the typical consideration of GHG emissions, requires additional data collection and the often the use of inventory databases and software specifically designed for life cycle impact assessment which can be costly. The benefit of including a wider range of impact categories, however, is that it may highlight otherwise overlooked impacts and clarify trade-offs between different impacts (e.g. a comparison of two systems may show one to contribute greater to global warming potential, but less to eutrophication or another impact category).

Another critical methodological challenge in agricultural LCAs is the handling of co-product allocation. When a system or process has more than one output, burden must be allocated among products appropriately without double-counting impacts. For example, a dairy farm may produce milk as well as meat from culled calves and cheese from further processing. In some cases, it is possible to avoid allocation by expanding the boundaries of the system or examining processes in more detail. The emissions associated with cheese processing, for example, can be quantified and allocated completely to the cheese product. It is more difficult to allocate the burden from other stages of the production chain, such as feed production, which contributes to all of the products. In these cases where allocation is necessary, it is recommended by ISO 14044 that allocation reflects biophysical relationships between inputs and outputs. Burden from feed production may be allocated, then, between the products based on the energy content of the products as having a direct relationship to the energy content of the feed inputs.

Burden in LCAs has also been allocated between co-products on the basis of mass or economic value, and results of these studies often vary depending on the allocation method used. As is the case with other methodological considerations, the choice of allocation methods not only affects the outcome of the study, but also affects the comparability of different studies if they allocate using different methods.

There are important practical issues to consider in the practice of agricultural LCA, as it pertains to data sources for conducting LCAs. According to Nuno da Silva, a LCA consultant and practitioner for PE International based in Boston, most of the data required to conduct agricultural LCAs comes extensively from public data sources.[6] Most of the data that is inputted into LCA models can be sourced from government statistics and other literature. LCA consultants typically begin with a generic farm model which is assumed to be applicable in any given agricultural system. Coefficients are then used to account for variations in soil types, rain fall conditions, differences in rates of fertilizer and pesticide application, and different yields that reflect unique geographical and operating conditions. In theory, LCA analysis can be customized and applied to any given agricultural operation.

Data is not sourced at the farm level or point of production, rather, data generally comes from public (i.e. government) agricultural statistics. These macro-statistics are then run through the generic farm model and calibrating using respective coefficients for various operating conditions. The public data may be complimented or adjusted according to crop specific conditions (e.g. spray irrigation). According to da Silva, it is possible to create an LCA data inventory for most common crops out of existing LCA literature. Da Silva notes that while traditional LCAs have been applied to industrial settings, which are linear (e.g. mass translated to energy), the application of LCAs to farm systems differ in that they require an open systems approach. That is, agricultural LCA recognize the variability in farm operations where, for example, a farmer might apply a certain amount of fertilizer to generate a certain yield while in another year yields change, due to changes in growing conditions, and so too will the rate of fertilizer applied.

The key observation in the experience of da Silva as an agricultural LCA practitioner is that the analysis is not based on actual farm-level operating statistics, rather the inputs and thus impacts are modeled using a generic farm model coupled with macro-level agricultural statistics. The result is that the LCA results may not actually reflect the true level of inputs and thus environmental impacts of various livestock, crop or produce production. This demonstrates the inherent challenges of relying on modeling versus the more

[6] Personal communication with Nuno da Silva on August 23, 2010.

time-consuming practice of collecting data from the source of operations, namely the farm or the processing facility. These challenges are similar to EF analysis where the footprint of the average household or person is calculated or modeled based on macro-level energy use, food consumption and household expenditure data (derived from surveys) as opposed to using data from actual household consumption volumes and experience.

4.4 Land use impact category

LCAs have typically focused on the resources and inputs or associated pollutants and wastes emitted from how land is being used but not on the direct impacts to land resulting from land use itself. With the increasing use of LCA as a tool to quantify the environmental impacts of agriculture and food production systems the impacts associated with how land is used has received more attention. Using LCA to measure the environmental impacts of land based production systems highlighted the importance of land health and quality in supporting production outputs and long-term system yields. The increased focus on land also brought attention to the important role that land plays in providing life support functions and biodiversity.

The land use impact category attempts to capture impacts on the land caused by "intensive human activities, aiming at exclusive use of land for certain purposes and adapting the properties of land areas in view of these purposes" (Lindeijer et al., 2002). More simply put, the land use category tries to quantify the impacts on 'land' caused by land transformation and occupancy associated with land that is being used for growing crops, pasture, mines, buildings, highways, and other forms of human infrastructure.

While land use was adopted as an impact category back in the 1990s, it was largely perceived as a subsidiary category or omitted from LCAs altogether (Hertwich et al., 2000; Lindeijer et al., 2002; Mila i Canals et al., 2006). As LCA was designed to assess the environmental impacts of industrial production processes, land use traditionally was treated as a function of land output efficiency. Land-use impacts were expressed in terms of area of land used and time in relation to output. In this case:

Land-use impact = area X time/units of output[7]

[7] The unit out output is implied – area x time per functional unit. If our functional unit was, for example, a liter of milk it would be the area of land impacted (hectares) in a given time period (year) per liter of milk.

A land-use impact value determined by output efficiency, however, reveals nothing about the impact on the quality of land, the life support functions of the land, or the impact on the potential future productivity of the land. Furthermore it does not distinguish that different types of land use have different impacts on the environment (Müller-Wenk, 1998; Brentrup et al., 2002).

To better account for the impact of human activities on land quality, LCA practitioners began relating output productivity to a land quality measure to illustrate the degree of impact that a land-use change or occupation has on the land (Lindeijer, 2000). The concept of land quality became accepted as a critical component of the land-use impact category. In the 1996 The Society of Environmental Toxicology and Chemistry (SETAC) Working Group on Impact Assessment (Finnveden) the land-use impact category was formally proposed as:

Land occupation impacts = area X time X quality

Land change impacts: area X quality difference[8]

4.4.1 Measuring land quality

Two prevalent approaches have emerged to measure land quality: developing a scoring system based on land classes and identifying key indicators.

4.4.1.1 Land use classes:

Land-use classes are a means to distinguish land-use quality. The different land use classes correspond to a different level of quality, which are assigned a score and factored into the land-use impact equation. While several different classification schemes have been suggested, there is very little consensus in the LCA community on a 'best' classification system. Using a land categorization approach has been criticized as being too cumbersome. Detailed classification requires local knowledge and data of the land area(s) being impacted. Applying land-use classes to distinguish land quality is also criticized, because results from different sites cannot be compared. Land use can only be meaningfully compared to other ecologically homogenous land units (Brentrup et al., 2002).

Heijungs and colleagues (1992) proposed using the International Union for Conservation of Nature (IUCN) ecosystem classifications (1991) as standardized approach to classify land-use impacts. The five classes, expressed as the extent of human interference, are:

[8] Land change impacts factors in a quality factor. We describe those in 4.4.1. The typical approach is to define change is based on an assessment of differences in land quality. We reference to the IUCN classification system as an example.

- natural systems;
- modified systems;
- cultivated systems;
- systems dominated by human buildings, and;
- systems degraded by pollution and loss of soil and vegetation.

The IUCN classification system was based on Vitousek and colleagues (1986) concept of net primary production. Lindeijer (2000) critiques the IUCN classification noting that no physical data is used to score the land in the various classes and there is no weighting of class characterizations. Early efforts to adopt the IUCN classification system have been set aside.

Classifying land based hemerobic levels has emerged as potentially useful methodological approach to assess land quality.[9] Hemeroby describes the intensity of human influence on land as a means of characterizing different land-use impacts. It distinguishes categories based on the remaining naturalness of the land under use (Klöpffer and Renner, 1995; Brentrup et al., 2002). Brentrup and colleagues (2002) proposed using the hemerobic levels to identify a naturalness degradation potential (NDP) of different land uses. The NDP of the various land-use types can be multiplied by the area and time (typically m^2 X year) of a given land-use type, offering a simple means for aggregating the land impact into a land-use indicator. While the locality of land-use impacts and data collection continue to present a challenge using this approach, the NDP values integrate well into the LCA methodology as land-use impact characterization factors.

4.4.1.2 Key indicators:

Another approach to account for land use impacts has been to measure critical impact indicators. A fundamental challenge, however, with land use is that the main impacts are not readily apparent. Unlike the other LCA impact categories, land use is multi-functional and many land functions are not well understood. In addition, neither the relationship among the different functions of land, nor how those various functions respond to change, is clear. Furthermore, the functions of land operate at different scales (Lindeijer et al., 2002).

Proposed land use indicators have typically focused on trying to account for biodiversity, soil quality, ecosystem integrity or quality, and landscape integrity. Table 6 reviews select indicators included in studies under the land-use impact category.

[9] See Lindeijer (2000) for examples of different LCAs using classification schemes.

Table 6: Key Indicators under land-use impact category

Indicator	Source
Soil	
Soil erosion	- Baitz, 1998 - Matteson et al., 2000 - Bauer, 2006 - Romanyà, et al., 2006
Soil organic matter	- Matteson et al., 2000 - Cowell and Clift, 2000 - Milà I Canals et al.,2006 - Romanyà, et al., 2006
Soil compaction	- Cowell and Clift, 2000 - Romanyà, et al., 2006
Soil structure	- Matteson et al., 2000 - Cowell and Clift, 2000
Soil pH	- Matteson et al., 2000 - Romanyà, et al., 2006
Phosphorus and potassium status on the soil	- Matteson et al., 2000
Trace substances/ contamination	- Cowell and Clift, 2000 - Romanyà et al., 2006
Non-living matter	- Cowell and Clift, 2000
Salinization	- Romanyà, et al., 2006
Plant Productivity	- Romanyà, et al., 2006
Reduction of ground water recharge	- Bauer, 2006
Landscape	
Landscape/ Aesthetic impact	- Weidema et al., 1996 - Haas et al., 2000
Layout of farmstead	- Haas et al., 2001
Biodiversity	
Species diversity (select keystone species, e.g. grassland species)	- Auhagen et al., 1992 - Cowell, 1998 - Haas et al., 2001 - Jeanneret et al., 2006 - Treweek and Bubb, 2006
Rare/ threatened species	- Cowell, 1998 - Schenck, 2006
Species Density	- Auhagen et al., 1992
Rareness of biotopes	- Auhagen, 1992 - Blümer, 1998 - Ryedgren, 2006
Wildlife habitats	- Haas et al., 2000
Land in natural vs. anthropogenic use	- Schenck, 2006
“Natural” landcover dominated by non-native coverage	- Schenck, 2006
Length of land/water interface with buffer zone	- Schenck, 2006
Fragmentation/Integrity of “natural” land	- Schenck, 2006
Ecosystem integrity	
Vascular plant species density	- Lindeijer et al, 1996 - Lindeijer, 2000 - Lindeijer, 2001 - Weidema & Lindeijer, 2001 - Vogtländer et al., 2004 - Müller-Wenk, 2006
Naturalness	- Auhagen,1992 - Brentrup et al., 2002 - Brentrup et al., 2004 - Bauer, 2006

Ecosystem type	- Cowell, 1998 - Vogtländer et al., 2004
Degree of biological accumulation	- Knoepfel, I. et al., 1995
Net primary production (NPP)	- Lindeijer et al., 1996 - Cowell, 1998 - Lindeijer, 2000 - Lindeijer, 2001 - Bauer, 2006

4.4.2 Establishing a standardized framework

SETAC-Europe Second Working Group (WIA-2) proposed degradation of biodiversity and the degradation of life support functions as the two main impact areas of the land-use impact category (Udo de Haes et al., 2002).

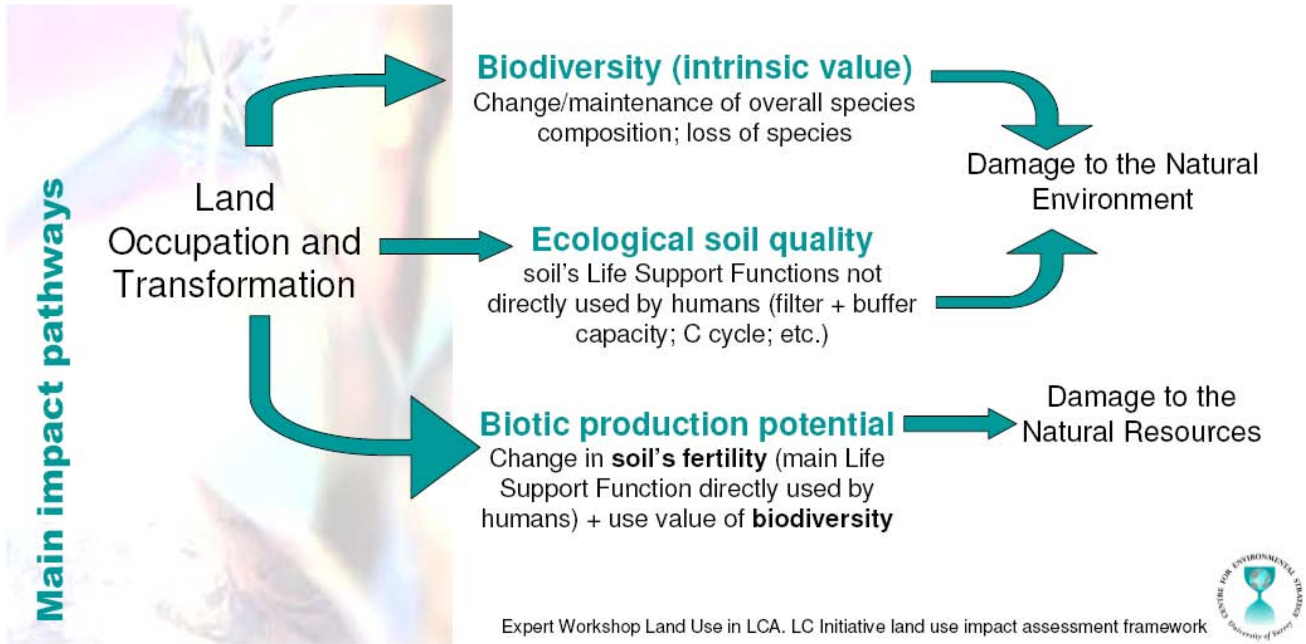
Degradation of life support functions: This category captures the potential impact of land use on life support functions of the land such as nutrient cycling, soil fertility, and water discharge functions. This category accounts for land-use impacts on the current health of the land and is telling of the future productivity of the land.

Biodiversity degradation: This category captures the impact on species diversity.

While the SETAC-Europe WIA-2 guide does not propose a 'best available' methods, it does put forth principles, definitions, distinctions, and objectives, offering more structured guidance in how to assess the impacts of land use.

UNEP/SETAC Life Cycle Initiative (Milà i Canals et al, 2006) advanced the following sub-categories to included as part of the land use impact category: biodiversity (existence value); biotic production potential (including soil fertility and use value of biodiversity), and ecological soil quality (including life support functions of soil other than biotic production potential). While the suggested sub-categories are largely a reiteration of the impacts introduced by SETAC Europe WIA-2, they do distinguish between life support functions, which support biotic production, and other life support functions. Figure 5 highlights the impact pathways of land occupation and transformation as articulated by Milà i Canals (2006).

Figure 5: Main impact pathways of land occupation and transformation



The framework proposed by Milà i Canals and colleagues (2006) is an attempt to adopt a standardized land-use impact framework for inclusion in LCA. While the framework symbolically acknowledges some success in gathering consensus for a path forward, there is still concern within the LCA community around the refinements proposed by Milà i Canals and colleagues, and more generally regarding the direction of how land-use impacts should be approached. Given the multiple functions of land and the different types and scope of land impacts, depending on the system being assessed, many LCA practitioners are hesitant to endorse a formal set of categories and indicators (Mattsson et al., 2000; Lindeijer et al., 2002; Udo de Haes, 2006).

4.4.3 Challenges

Accounting for impacts such as the degradation of biodiversity, the degradation life support functions, and the degradation of ecological soil function, involves assessment methods and indicators that often require site specific analysis, local or at least regional data, expert knowledge, and multi scale perspectives. Udo de Haes (2006: p. 220) identifies four factors: quantitative character, clear relation to functional unit, generic regarding space, and steady state analysis which limit the effectiveness of the LCA method to adequately account for land use impacts.

Quantitative character:

A strength of the LCA as a measurement tool is its ability to simplify complex information in a quantitative fashion to facilitate decision making. Several land-use impacts, however, are difficult to express quantitatively. While some studies have discussed integrating qualitative descriptions to describe land-use impacts in LCA results (Mattsson et al., 2000; Schenck, 2006), Haes (2006) and Guinee (2006) suggest that qualitative results get lost in the decision making process and that methodologically they do not fit. Integrating a qualitative component is counter intuitive to the design of the tool.

Clear relation to functional unit:

The structure of LCA requires quantification in relation to a functional unit. Impacts with a flow character with clear input or output characteristics are more easily evaluated using the tool, as opposed to non-flow related issues such as logging a forest for agriculture purposes (Guinée et al., 2006). In addition, many land-use impacts do not relate well to a uniform functional unit. For example, the relationship of biodiversity degradation and soil erosion to per tonne of wheat grain is not as intuitive as kilogram of CO_2 or kilogram SO_2 emitted to per tonne of wheat grain.

Generic regarding space:

Traditional LCA assumes a spatially generic impact assessment. This reflects the life cycle nature of the tool, which implies potential impacts in multiple regions of the world. For land-use impacts, such as biodiversity and soil quality site, specific data are required if the results are to be meaningful. This adds a data dimension and resource demand, which reduces the practicability of the tool. It also limits the ability of cross assessment comparisons and the extrapolation of results for other assessments (Lindeijer and colleagues, 2002: 39).

Steady state analysis:

LCA methodology assumes a steady state analysis, recognizing the need to integrate processes with different time characteristics. The assessment of dynamic systems such as ecosystems and land require a level of detailed analyses, which are not well suited to the model.

The conditions discussed above suggest that many land-use impacts are inherently problematic to integrate into the LCA structure. What we observed is that the land-use impacts on soil health are largely absent from current agricultural LCAs. Examples of land-use impacts which have not been considered in the LCA structure include: degradation of biodiversity; soil erosion; loss of soil fertility; impacts on nutrient cycling; impacts on hydrology; and, one-time habitat loss (Udo de Haes, 2006). Notwithstanding these challenges, the critical nature of soil fertility to long-term food and agricultural sustainability will ultimately require some measure of soil fertility as it relates to agricultural land-use, even if it is limited to a qualitative assessment that compliments conventional agricultural LCA results.

4.4.4 The assessment of biologically based production systems

LCA methodology does not easily extend to production systems, which are also biological systems. They are directly dependent on the functions of 'land' for which impacts are not easily measured and more generally not well understood. While management and use of the land is critical, for land-based systems, nature provides many of the factors of production. How and what impacts influence these factors of production are difficult to capture in LCA. In addition, capturing the impacts of how land is used on the larger life support functions of land generally is very difficult to measure. We do not fully understand the complexity of the relationships between the different functions and services of land. LCA is also not well suited to accommodate the inherent uncertainty in our understanding of how land works. How land is used has impacts at different scales and will vary depending on the environment in which the land is being used. It is critical to understand the resistance, resilience, and vulnerability of the land being impacted. These aspects, however, are not easily modeled let alone captured by LCA.

4.5 Social Indicators

Social impact considerations are increasingly included as part of more traditional environmental measurement tools and reporting frameworks such as LCA and the EF. An initiative led by the United Nations Environment programme (UNEP) and Society of Environmental Toxicology and Chemistry (SETAC) has produced a set of Guidelines for Social Life Cycle Assessment (S-LCA) of Products. The guidelines describe the context, the key concepts, the broader field in which tools and techniques are getting developed and their scope of application. The framework detailed in the S-LCA guidelines corresponds with the ISO 14040 and 14044 standards for Life Cycle Assessment (Benoit et al., 2009).

The guidelines define S-LCA as:
"a social impact (and potential impact) assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use;

maintenance; recycling; and final disposal. S-LCA complements E-LCA with social and socio-economic aspects. It can either be applied on its own or in combination with E-LCA."
(Benoit et al., 2009:37)

The S-LCA guidelines recommend the inclusion of six impact categories: worker's human rights, working conditions, health and safety, cultural heritage, governance, and socio-economic repercussions.

The ecological footprint does not include social impact categories. The tool, however, is increasingly reported as part of broader sustainability frameworks, which include socio-economic indicators. The environmental sustainability index, for example, includes the ecological footprint as one indicator. Similarly Genuine Progress Indicator accounting and Genuine Wealth well-being assessment model[10] include the ecological footprint as one component among many.

Given the emphasis on social impact categories being included within supply chain sustainability requirements, the province will want to monitor impact categories being considered and potential implications to the Alberta agriculture sector. From a global perspective, the inclusion of social impact categories in reporting requirements should benefit Alberta. Provincial and federal labour, health and safety and human rights regulations position Alberta and Canada well ahead of any minimum standards likely to be included as part of any global supply chain sustainability requirements. The inclusion of social impact categories becomes relevant if production sources are being compared within Canada or between Canada and the United States where there are relatively high social standards continent-wide.

The GRI social indicators, the impact sub-categories listed in the S-LCA guidelines, the Social Accountability 8000 Standard, and the Fair Labor Association Compliance Benchmarks offer a comprehensive list of social indicators currently considered in assessment protocols offering a useful starting point, if choosing to include a social dimension as part of an environmental footprint model. In addition, any supply chain social indicator reporting requirements will likely be based on the above sources.

4.5.1 S-LCA guidelines

The guidelines identify a list of potential sub-impact categories or indicators to consider which they recommend organizing by the relevant stakeholder group for which they apply. All social and socio-

10 http://www.anielski.com/Services.htm accessed August 30, 2010.

economic subcategories have been defined according to international agreements (conventions, treaties etc) (Benoit et al. 2009: 49). Social indicators suggested in the S-LCA guidelines have been developed around the worker, the consumer, local community, society, and value chain actors. Table 7 lists the indicators by category. Many of these social indicators are difficult to measure on a consistent basis making comparability difficult.

Table 7: S-LCA indicators by stakeholder category

Worker

- Freedom of association and collective bargaining
- Child labour
- Fair salary
- Working hours
- Forced labour
- Equal opportunities/ discrimination
- Health and safety
- Social benefits/social security

Consumer

- Health & safety
- Feedback mechanism
- Consumer privacy
- Transparency
- End of life responsibility

Local community

- Access to material resources
- Access to immaterial resources
- Delocalization and Migration
- Cultural heritage
- Safe & healthy living conditions
- Respect of indigenous rights
- Community engagement
- Local employment

Secure living conditions

Society

- Public commitments to sustainability issues
- Contribution to economic development
- Prevention & mitigation of armed conflicts
- Technology development
- Corruption

Value chain actors
(not including consumers)

- Fair competition
- Promoting social responsibility
- Supplier relationships
- Respect of intellectual property rights

4.5.2 The Social Accountability 8000 (SA8000) Standard

The Social Accountability 8000 (SA8000) Standard is a worldwide accepted certification standard based on international workplace norms of International Labour Organisation (ILO) conventions, the Universal Declaration of Human Rights and the UN Convention on the Rights of the Child. The SA8000 presents a set of criteria and a specific monitoring system that an enterprise needs to comply with in order to be certified. The nine elements included in the Standard: child labour, forced labour, health and safety, Freedom of association and right collective bargaining, discrimination, discipline, working hours, compensation and management systems are listed in the Social Accountability 8000 standards as follows:

- Child Labor: No workers under the age of 15; minimum lowered to 14 for countries operating under the ILO Convention 138 developing-country exception; remediation of any child found to be working

- Forced Labor: No forced labor, including prison or debt bondage labor; no lodging of deposits or identity papers by employers or outside recruiters

- Health and Safety: Provide a safe and healthy work environment; take steps to prevent injuries; regular health and safety worker training; system to detect threats to health and safety; access to bathrooms and potable water

- Freedom of Association and Right to Collective Bargaining: Respect the right to form and join trade unions and bargain collectively; where law prohibits these freedoms, facilitate parallel means of association and bargaining

- Discrimination: No discrimination based on race, caste, origin, religion, disability, gender, sexual orientation, union or political affiliation, or age; no sexual harassment

- Discipline: No corporal punishment, mental or physical coercion or verbal abuse

- Working Hours: Comply with the applicable law but, in any event, no more than 48 hours per week with at least one day off for every seven day period; voluntary overtime paid at a premium rate and not to exceed 12 hours per week on a regular basis; overtime may be mandatory if part of a collective bargaining agreement

- Compensation: Wages paid for a standard work week must meet the legal and industry standards and be sufficient to meet the basic need of workers and their families; no disciplinary deductions

- Management Systems: Facilities seeking to gain and maintain certification must go beyond simple compliance to integrate the standard into their management systems and practices.

4.4.3 Social Indicators from the Global Reporting Initiative (GRI)

Four of the seven Global Reporting Initiative performance indicator domains are social domains: labour practices and decent work, human rights, society, and product responsibility. Labour practices and decent work indicator categories include: employment; labour/management relations; occupation health and safety; training and education; diversity; and equal opportunity. Human rights indicator categories include: investment and procurement practices; non-discrimination; freedom of association and collective bargaining; child labour; forced and compulsory labour; security practices; and indigenous rights. Society indicator categories include: community; corruption; public policy; anti competitive behaviour; and compliance. Product responsibility indicator categories include: customer health and safety; products and service labeling; marketing communications; customer privacy; and compliance. Given the extensive list of indicators for each category a detailed list is included in Appendix 2.

4.4.4 Fair Labor Association

The Fair Labor Association (FLA) provides accreditation to organizations that meet their monitoring guidance and compliance standards. The standards pertain to each element of the FLA's Code of Conduct. The code elements are as follows:

- Forced labour;
- Child labour;
- Harassment or abuse;
- Non-discrimination;
- Health and safety;
- Freedom of association and collective bargaining;
- Hours of work, and;
- Wages, benefits and overtime compensation.

4.6 Other Agriculture tools and indicators

4.6.1 Agriculture indicators

Gerbens-Leenes and colleagues (2003:238) conducted a detailed global literature review of frequently used indicators for environmental sustainability in food production at the local level, regional level, and global level. Table 8 summarizes their findings.

Table 8: Indicators for environmental sustainability in food production (Gerbens-Leenes, 2003)

Local level	Regional level	Global level
(Pollution based indicators)	(Depletion of resources)	(Depletion of resources)
o NH_4	o ecological structures	o phosphorus use
o NO_x	o unsprayed area	o land use
o SO_x	o uncultivated area	o energy use
o pesticides	o land use	
o nitrogen	o water use	(Climate change)
o phosphorus	o crop diversity	o CO_2
o heavy metals		o CH_4
		o N_2O

4.6.2 Field to Market – The Keystone Alliance for Sustainable Agriculture

Field to Market,[11] an initiative of the Keystone Center, a non-profit organizations dedicated to developing collaborative solutions to societal issues, is developing indicators to estimate the environmental, economic, social, and health outcomes of agriculture in the United States. In 2009, *Field to Market*, released its first report focusing on environmental indicators. The report evaluated national-scale metrics over the past two decades for land use, water use, energy use, soil loss, and climate impact in corn, soy, cotton and wheat production. The report is supported online by a Fieldprint Calculator. The calculator allows farmers to better understand how their crop production operations impact farm sustainability. The calculator is correlated with national level outcomes used in their environmental indicators report. The report is available online at http://www.fieldtomarket.org/fieldprint-calculator/

The *Field to Market* environmental indicators address land use, irrigation water use, soil loss, energy use, and climate change.

Land use:

The indicator is crop productivity or yield in units of production per acre. For example, crop productivity for corn is bushels per acre.[12]

[11] http://www.keystone.org/spp/environment/sustainability/field-to-market

[12] Crop yields is not the only meaningful measure of land use productivity. Other measures of the arability and health of the soil will be required, in addition to considering crop yields.

Irrigation water use:

The irrigation water use indicator is calculated by dividing the difference in irrigated and non-irrigated yields, in productivity per acre units, by the amount in inches, feet or gallons of irrigation applied per acre.

Soil loss:

Soil loss considers both the water and wind erosion of soil. Soil loss is estimated using the Universal Soil Loss Equation (USLE). The soil loss indicators are reported in units of tons loss per acre.

In the supporting Fieldprint Calculator, water erosion and wind erosion indicators are estimated based on a series of questions, which account for:

- rainfall erosivity;
- soil erodibility;
- slope length;
- slope steepness;
- crop management factor;
- erosion control practice factor, and;
- wind severity.

Energy use:

Energy use considers two kinds of energy expended for crop production, transportation (including energy required to move water from a source to an irrigated field) and the embedded energy in fertilizers and pesticides applied to a field. Transportation energy is reported in gallon diesel equivalents. The embedded energy associated with fertilizers, pesticides, and manure applications are reported in BTU/Ac.

Climate change:

Energy consumption is reported in terms of carbon dioxide emission equivalents and reflects carbon content of energy sources. Field to Market believes that their calculator is a starting point for developing outcome metrics for agriculture for a variety of crops using a variety of technologies and land use practices. Their reporting system does not define or prescribe a level for sustainability nor does it represent all dimensions of sustainability. They hope to continue to develop other environmental (including water quality and biodiversity), social, and economic indicators.

In 2009 Field to Market released its Environmental Resource Indicators Report that indicated that production agriculture in the US has been increasing its efficiency over time; relying on fewer inputs to produce more yields (e.g. soil loss trends improved by 30 to 70% for four crops evaluated[13]). Using available data, the report evaluated national-scale metrics from 1987 to 2007 for land use, water use, energy use, soil loss, and climate impact and generated initial benchmarks for corn, soybean, cotton and wheat production. The study evaluated both overall resource use, as well as resource efficiency to demonstrate the positive change in each crop's "fieldprint" over the past two decades. The report looked at the outcomes that have resulted in farmers implementing a variety of production practices, versus studying the practices themselves.

The US-based Fieldprint calculator may be a useful benchmark tool for Alberta producers to consider using, in lieu of a similar calculator for Alberta and Canada. The tool was developed to help accelerate the gains made inside the farm gate and explain those practices outside the farm gate. The tool could help both farmers and food companies explain what growers are doing voluntarily to manage natural resources and pursue sustainability. The calculator can help farmers assess the efficiency of their operations and improve their management of natural resources. The tool helps growers evaluate their operations against an industry-wide index to manage natural resources while producing crops more efficiently and profitably. The tool also provide direct links to resources that can help growers learn more about practice options to help them make informed natural resource management decisions. By building awareness on these issues and sharing best practices, *Field to Market* believes they can document accelerated improvements throughout the agriculture supply chain and future generations can enjoy the vital products of agriculture and an ever improving environment.

4.6.3 Ecological Scarcity Method

The 'ecological scarcity' method (first published in 1990) is a 'distance to target method' of life cycle impact assessment developed in Switzerland by the Federal Office of the Environment (2009) that uses eco-factors, expressed in eco-points per unit of pollutant emission or resource extraction, to rate all Swiss food products. The eco-factors are determined by both the current emissions (to water, air and soils)

[13] For wheat production, the study found that while productivity (yield per acre) increased 19 percent, the total annual energy use and total irrigation water use were similar in 1987 and 2007. The average trends showed an 18 percent decrease in total energy use and an 11 percent decrease in total water use. Total soil loss decreased 54 percent. Total climate impact increased an average of five percent over the study period, with a more significant increase over the past decade.

situation and secondly, by the political targets set by Switzerland or by international policy and supported by Switzerland.

The method assesses a number of eco-factors including: CO_2 and energy, air pollutants (including benzene, dioxin and diesel soot); heavy metals (lead, cadmium, mercury, zinc) and arsenic emissions; emissions to soil (heavy metals, plant protection products (herbicides, insecticides, fungicides); emissions to surface and ground waters (nitrogen, phosphorus, organic matter); endocrine disruptors (measured as oestrogen activity) in waters; radioactive isotopes in the seas; amount of freshwater consumption impacts of land use on plant biodiversity, and; the assessment of bioreactive landfills (carbon in materials consigned to landfills; hazardous wastes in underground repositories; radioactive wastes in final repositories). The other factors include the extraction and use of certain resources from nature, including: energy resources (non-renewable and renewable); land use (by type); gravel extraction; and freshwater consumption. The selection of these emissions or substances is guided by their ecological and political relevance.

These many eco-factors are first assessed based on today's emissions then a 'normalized flow' is defined and scored; these become the reference points. The current flow or current consumption/emissions by product are then compared to these normalized flow scores. A third 'critical flow', based on political consumption/emissions targets are considered as another benchmark against the current flow. Thus current flows can be assessed against critical flow targets to determine the sustainability of products being produced in Switzerland. The eco-factors are then weighted where weighting expresses the relationship between the current pollutant emission or resource consumption (current flow) and the politically determined emission or consumption targets (critical flow). Weighting is primarily based on environmental protection targets set at a national level in Switzerland. The more the overall load of a substance exceeds the politically determined critical flow, the more eco-points are assigned per unit (e.g. gram) to a substance.

The method converts the various environmental impacts into points, so that these values can be added and compared. The eco-factors thus have the formal nature of a utility value analysis, whereby they can be determined from the current environmental situation (current flow), the target situation aimed at by environmental policy (critical flow) and the calculation algorithm. The eco-factor substances are inventoried at the point of passage from the technosphere (point of production or emission) to the eco-sphere.

The Swiss ecological scarcity method is one of the most rigorous, comprehensive (covering virtually every aspect of emissions to land, water and air, resource use and waste) and pragmatic application of LCA we reviewed from the literature. The Swiss method shows the potential for using scientifically and politically-based targets (established in law and based on science) as a basis of environmental performance measurement that could be applied to any variety of agricultural products and processes.

A key benefit of this method of assigning scores is that it has the potential to make eco-labeling relatively easy to understand. The higher the eco-points per unit of food product, the larger its environmental impact. One of the applications of the eco-scarcity method has been the experiment of converting the eco-points into ecological time units, measured in hours. Doublet and Jungbluth (2009) estimated that in 2005 the total environmental burden caused by the consumption of goods and services per Swiss capita per year was about 20 million eco-points based on the ecological scarcity 2006 method; this includes all imports to Switzerland. The Swiss Ecological Time Unit (SETU) is a concept that calculates the environmental impacts of a product in relation to an annual target for environmental impacts. The method has been developed as a possible unit for Environmental Product Information and was used to assess the environmental burden or impacts of 41 beverages, snacks and meals. For example, the ecological scarcity eco-points for a cup of coffee was assessed at 846 and converted to 36 minutes and 7 seconds of eco-hours; this compares with 156 eco-points for tea or 6 minutes and 40 seconds. The difference between coffee and tea is due to the high amount of pesticides used during the production of coffee; it leads to severe emissions into the top soil. A benefit of using eco-hours or SETU is that it is relatively straightforward and not time-consuming when comparing the environmental impacts of different products. It is less ambiguous than the use of qualitative values or too abstract quantitative ones like ecological scarcity points. Showing the eco-time for food products could help consumers adopt a more sustainable behavior while becoming familiar with their annual sustainable time budget.

This is one example of what is possible in aggregating a number of environmental impact factors into a composite index or score for purposes of labeling and consumer awareness of the environmental footprint of food.

4.6.4 Environmental footprint

Lillywhite (2008) proposes the development of a hybrid method, the environmental footprint, which incorporates four environmental indicators (pesticides, greenhouse gas emissions, eutrophication and acidification, and water use) drawn from a subset of agricultural LCA data and presents the result as a single figure on a per hectare basis. Lillywhite proposes reporting the normalized environmental footprint value on food products in lieu of reporting the carbon footprint only. Lilywhite sets the study boundaries as the farm gate.

The environmental indicators proposed by Lillywhite are a subset of common LCA agricultural study impact categories and reported in similar fashion, with exception of pesticide use. GHG emissions are reported in carbon dioxide equivalents (CO_2e) per hectare and are calculated by multiplying the emissions of respective greenhouse gases by their global warming potentials. Eutrophication and acidification are estimated by quantifying the eutrophication and acidification potential of different nutrients. Results are reported in phosphate equivalents and sulphate equivalents per hectare. Water impact is calculated as the use of non-rainfall water in litres per hectare per year. Pesticide impact is calculated by quantifying the environmental impact of all pesticide applications using a formula where impact equals toxicity multiplied by exposure. The equation considers a farm worker component, ecological component and consumer component. Results are reported as an environmental impact field value per hectare.

Lillywhite normalizes the results of each indicator and merges them into a single index value reported per hectare. To normalize results Lillywhite determines a minimum value and max value for each indicator. The minimum value is always zero. The maximum value is not fixed and set approximately 25% above the highest result found in the study.

Lillywhite recommends reporting a normalized environmental footprint value based on four indicators: pesticides; greenhouse gas emissions; eutrophication and acidification; and water use. Lillywhite argues that reporting an environmental footprint value on food products is more useful than just reporting the carbon footprint value.

Krajnc and Glavic (2005) in a paper discussing sustainability indicators argue that it is very difficult to evaluate the performance of a company when faced with too many impact indicators. They suggest normalizing the GRI indicators into a composite sustainability index. The composite score can be used to measure progress over time and for comparisons between institutions.

Gerbens-Leenes et al (2003) in a literature review of indicators for environmental sustainability in food production similarly argue that the enormous number of indicators found in the literature generates too much data that often provide no additional knowledge on the environmental sustainability of a system. They suggest selecting a few indicators reflective of overall system sustainability instead of trying to measure too many indicators. To measure the environmental sustainability of food production systems, the authors propose an energy indicator, land indicator and water indicator expressing the results in kilograms of food equivalent.

5. Supply Chain Standards, Certification and Retailer Sustainability Reporting Expectations

Supply chain standards are beginning to emerge and be driven by major retailers including Wal-Mart, McDonald's, Marks and Spencer (UK, with their Plan A) and Uniliver. According to one Canadian expert on sustainability reporting, Wal-Mart, Unilever and Marks & Spencer lead the way in terms of sustainability standards and expectations for their suppliers. Marks & Spencer, for example, wants to become one of the world's most sustainable retailers. Unilever has made attempts to evaluate its entire value chain from supply through distribution (the multiplier effect) and analysis of its impacts of at the macro-economic level, including employment impacts. Wal-Mart has established supply chain sustainability assessment standards for its suppliers.

Canadian retailers like Loblaws, Canada's largest retailer, seem to lag these other industry leaders with respect to supply chain management monitoring and reporting standards. Wal-Mart appears to be the leader internationally in driving demand of it's suppliers to meet its sustainability criterion, many of which could benefit from monitoring of energy use, GHG emissions, water use and waste management, but could also benefit from LCA.

Calgary-based Agrium — a major retail supplier of agricultural products, including fertilizer, seeds, herbicide in North and South America — is another example of the growing consciousness amongst business about the importance of sustainability. According to our interview with an expert in sustainability reporting, Agrium is working on environmental footprint reduction protocols for farmers. Agrium is using their subsidiary called CROP to collect GHG offsets, based on best-management conservation practices, and are developing reporting protocols with industry associations.

While the development and adoption of standards such as Wal-Mart's sustainability scorecard and sustainability assessment standards for its suppliers and McDonald's Environmental Scorecard are in their infancy, there will likely be growing pressure on producers across North America to comply with these standards in order to maintain a sustainable supplier relationship. Through experience in monitoring and reporting, Wal-Mart, for example, will be in a stronger position to establish its own benchmarks for best environmental performance or best environmental footprint profiles amongst its suppliers. This will likely drive a new kind of competition amongst producers to compete both on price points and most efficient and sustainable environmental and social performance for its products. This will result in new challenges for agricultural producers in meeting these new expectations, both in terms of monitoring and reporting. An environmental footprinting tool offers the capacity to meet the retailer expectations and certification requirements.

5.1 Retailer Sustainability Reporting Standards

5.1.1 Wal-Mart Supplier Sustainability Assessment Standards

Perhaps surprisingly, Wal-Mart, the world's largest retailer, is having the most significant impact in defining environmental and social sustainability measurement and reporting standards for food producers and suppliers of any other retailer. Wal-Mart's recently released sustainability scorecard has become the new baseline of information for all other companies, including its suppliers, concerned with environment and social performance. Wal-Mart's scorecard assesses its supplier's performance in four key environmental areas: greenhouse gas emissions; waste and water use; natural resources; and responsible and ethical production. Wal-Mart's sustainability scorecard and assessment standards for its suppliers is a sign of things to come.

Wal-Mart strategically engaged an "army of NGO's, academics, leading suppliers and government regulators" to develop it's own sustainability standards and is now leading the retail sector in designing and implementing a system for rating supplier's sustainability performance.[14] Wal-Mart, like IKEA (another leader in retail sustainability), believes it is possible that low cost, quality and sustainability can go hand-in-hand. According to Five Winds International, 'smart companies know they will have to go beyond simply responding to Wal-Mart's latest efforts'; in other words, expectations for sustainability measurement and reporting from retailer down to the producer are likely here to stay.

[14] Five Winds International. 2010. A Pivot Point for Sustainability.

Wal-Mart has established its own Supplier Sustainability Assessment Standards for its 60,000 suppliers. A supplier sustainability index or 'scorecard' considers performance in four key areas: climate and energy (40%), material efficiency (20%), natural resources (20%) and people and community (20%). While not yet mandatory for all of its suppliers, the top tier suppliers to Wal-Mart are now expected to complete its Sustainability Assessment questionnaire (Table 9) that results in a scoring by Wal-Mart and the eventual labeling of food and products for consumer discretion. The assessment includes measures of Energy (GJ of energy input), GHG emissions (mass balance/value-added approach,), GHG emission reduction targets, solid waste (whole waste stream analysis) and water use (volume and quality).[15] The Wal-Mart standards are consistent with the core GRI environmental indicators although limited to only a few measurement requirements of its suppliers.

Table 9: Wal-Mart Sustainability Index Questionnaire for Suppliers

	YES/NO Response	Measurement Requirement and Unit of Measure
Energy and Climate		
Reduce energy costs and greenhouse gas emissions		
1. Have you measured and taken steps to reduce your corporate greenhouse gas emissions (Y/N)	X	
2. Have you opted to report your greenhouse gas emissions and climate change strategy to the	X	
3. What are your **total annual greenhouse gas emissions** in the most recent year measured? (Enter total metric tons CO2e, e.g. CDP 2009 Questionnaire, Questions 7-11, Scope 1 and 2 emissions)		X (metric tons CO_2e)
4. Have you set publicly available **greenhouse gas reduction targets**? If yes, what are those targets? (Enter total metric tons and target date, e.g. CDP 2009 Questionnaire, Question 23)		X (metric tonnes/target)
(Enter total metric tons and target date, e.g. CDP 2009 Questionnaire, Question 23) Carbon Disclosure Project (CDP)? (Y/N)	X	
Nature and Resources		
High quality, responsibly sourced raw materials		
5. If measured, please report total amount of **solid waste generated** from the facilities that produce your product(s) for Wal-Mart for the most recent year measured. (Enter total lbs)		X (lbs)
6. Have you set publicly available solid waste reduction targets? If yes, what are those targets?(Enter total lbs and target date)	X	
7. If measured, please report **total water use** from the facilities that produce your product(s) for Wal-Mart for the most recent year measured. (Enter total gallons)		X (gallons)
8. Have you set publically available water use reduction targets? If yes, what are those targets? (Enter total gallons and target date)	X	
Material Efficiency		
Reduce waste and enhance quality		

[15] According to Catherine Greener, water footprinting would be ideal but isn't happening yet amongst producers.

9. Have you established publicly available sustainability purchasing guidelines for your direct suppliers that address issues such as environmental compliance, employment practices, and product/ingredient safety? (Y/N)	X
10. Have you obtained 3rd party certifications for any of the products that you sell to Wal-Mart? If so, from the list of certifications below, please select those for which any of your products are, or utilize materials that are, currently certified.	X
People and Community	
Vibrant, productive workplaces and communities utilize materials that are, currently certified.	
11. Do you know the location of 100% of the facilities that produce your product(s)? (Y/N)	X
12. Before beginning a business relationship with a manufacturing facility, do you evaluate their quality of production and capacity for production? (Y/N)	X
13. Do you have a process for managing social compliance at the manufacturing level? (Y/N)	X
14. Do you work with your supply base to resolve issues found during social compliance evaluations and also document specific corrections and improvements? (Y/N)	X
15. Do you invest in community development activities in the markets you source from and/or operate within? (Y/N)	X

According to Catherine Greener, an industrial engineer and consultant to Wal-Mart and other companies on LCA and supply-chain management, Wal-Mart and other companies are trying to improve the productivity of its supply chain by working directly with producers, manufacturers and distributors to increase the efficiency of the environmental and water footprints of its products. Wal-Mart is setting the international standard and catalyzing the international market place with what Wal-Mart calls its Productivity Loop or supply chain management expectation of its suppliers.[16]

The primary motive behind Wal-Mart's leadership in this growing field of environmental footprinting is not entirely clear. They may be motivated by a new corporate commitment to demonstrate industry leadership in sustainability and thereby encouraging its suppliers to follow their lead. Working internally and with other suppliers, Wal-Mart has found cost savings and innovation opportunities by investigating energy use, waste streams and other impacts on natural resources and the community. Wal-Mart sees tremendous potential for driving down costs, reducing environmental impacts of its products, and enhancing quality while helping its suppliers be sustainable. Another reason is that Wal-Mart is responding to an increasing level of consumer and media consciousness of sustainability issues that include climate change, toxic substances, ethical sourcing and excessive consumption (Five Winds International, 2010). Consumers, many who are adopting LOHAS (lifestyles of health and sustainability) living, are demanding more 'green' products and defining a new market segment (worth an estimated

[16] Personal conversations with Catherine Greener (Boulder, Colorado) June 14, 2010.

$209 billion per year) that Wal-Mart is responding too. Moreover, consumers are realizing that they can affect these sustainability issues through their purchasing power and product choices.

Another reason Wal-Mart is taking a lead in the retail sector may be that have been listening to sustainability advisors like Anita M. Burke, Amory Lovins and Hunter Lovins about the risks to the sustainability of their supply chains with risks such as the energy of cheap energy, climate change impacts, growing consumer expectations for organics, and other factors. Wal-Mart may already be seeing some of these pressures showing up on in their financial performance statistics. They may thus be motivated out of self-interest to maintain both market share and ensure that their supply chain is not threatened. Burke believes Wal-Mart is being strategic by testing the readiness of their suppliers and the market for environmental performance monitoring. Wal-Mart's initial suite of sustainability assessment indicators are a combination of quantitative and qualitative measures. These indicators will likely become more quantitative as the environmental reporting and monitoring by its suppliers and their respective producers matures.

According to Burke[17], Wal-Mart's expectations for environmental and social sustainability reporting can be expected to expand into new areas of environmental and social performance indicators:

Environmental Indicators:

- Tonnes of waste
- Acres of forests
- Days of human life (likely workplace injuries)
- Barrels of oil
- Passenger vehicles; how many vehicles off the road (this is likely related to different potential units to describe energy savings)
- Tonnes of CO_2e emissions reduced
- How many trucks they took off the road annually
- How much energy it took to power homes: cost saving
- Gallons of water
- Number of life-years recovered
- Heads of cattle

[17] Personal communication with sustainability consultant Anita M. Burke (Founder and President, The Catalyst Institute: www.catalystinstitute.com) on June 11, 2010.

Social Indicators category:

- Living wage
- Forced labour
- Child labour
- Access to community services

Precisely how these emerging indicators will be measured and consistently used by suppliers to Wal-Mart remains uncertain. However, it is clear that expectations for even more comprehensive environmental and social monitoring and reporting appears to be growing.

One potentially important opportunity we identified in our review of Wal-Mart's emerging sustainability standards is their potential commitment to reducing the carbon footprint of their products by sourcing from local suppliers. Should Wal-Mart move in the direction of giving preferential treatment to suppliers located in closer proximity to their retail outlets, this may have a positive effect on Alberta farmers and food producers with respect to Alberta Wal-Mart stores. There may be a growing concern about the rising cost of transportation due to long food-miles (from farm to retail outlet) for many of the larger retailers like Wal-Mart. In conversation with one local food expert in Vancouver, it was noted that Cisco has publicly said that transportation is getting difficult due to rising costs (fuel) so much so that they may have to pull out of deliveries to any markets north of Vancouver with small population centres.

How these supply chain standards will affect suppliers and producers, for example in Alberta and Canada, remains to be seen. At this stage, Wal-Mart has not yet begun reporting the sustainability performance scores of its suppliers; though this is likely to change. According to Five Winds International, consultants in corporate sustainability and LCA studies, Wal-Mart's advisors want these scores published at the product level so consumers can assess the information. It is important to note that it is the retailers, not the producers, who are designing these sustainability rating schemes based on their own strategic needs. For many smaller producers meeting Wal-Mart's sustainability reporting requirements may become increasingly challenging, both from a time and cost perspective. According to our interview with one expert in organic agriculture, some smaller farms and food producers have found it onerous and expensive to meet Wal-Mart's standards. Moreover, Wal-Mart has been unwilling to pay its suppliers for fulfilling the additional costs with its focus on low priced goods.[18] Ultimately the question of who pays for these higher standards will have to be resolved to ensure the financial sustainability of producers while meeting the demands of the retailer, and the health, dietary and safety demands of consumers.

[18] This was the experience of at least one mid-sized organic dairy supplier to Wal-Mart in the US, based on one of our expert interviews.

Another challenge of Wal-Mart's approach, as noted by one sustainability expert we interviewed, is that Wal-Mart's standards tend to be very high-level and are not well-defined. What measurement protocols should be used by suppliers, on a consistent basis across all aspects of the supply chain, are not yet clear. Instead, the LCA and sustainability measurement consulting *market* is defining the measurement tools for suppliers, one analysis project at a time. Moreover, LCA methods are inconsistently applied by a variety of consultants. In a sense, every consultant is establishing a new measurement benchmark or standard with each subsequent LCA analysis, based on solely on local cost not adequacy and quality of the measurement methodology. Nor has Wal-Mart provided sufficient measurement protocols to its suppliers on how to measure environmental impacts; the result is that the consulting market may be defining these measurement protocols and metrics solely based on the appetite and willingness of to pay for LCAs, GHG emission analysis, and environmental impact assessments. Notwithstanding these limitations of measurement, few other retailers have the potential to influence the behaviours of producers and suppliers towards the sustainability criterion articulated by the GRI guidelines and as advocated by some sustainability consultants.

5.1.2 Loblaws

Loblaws, Canada's largest food retailer, has made some progress in terms of establishing sustainability standards for its food products, though it lags behind Wal-Mart's commitments. The one exception is Loblaw's recent announcement (2009) of a sustainable seafood policy that will result in sourcing all seafood sold in its retail locations from sustainable sources by the end of 2013. Their new procurement policy is a commitment that covers all canned, frozen, fresh, wild and farmed seafood products, in all categories.

The Loblaw Sustainable Seafood Policy Initiative represents Loblaw's commitment to conservation of marine resources and a healthy ocean environment. The Sustainable Seafood Policy has been developed with the input of independent scientific advice and guidance of marine and fisheries experts. In practice, this means, for example, that all wild-caught seafood sold by Loblaws "will be certified to MSC (Marine Stewardship Council) or other independent equivalent standards."[19] For farmed seafood, Loblaw supports the development of credible aquaculture certification by encouraging our vendors and stakeholders to participate in the World Wildlife Fund's (WWF) "Aquaculture Dialogues". In addition, suppliers will be required, once standards are completed, to become certified to those or similar standards. Loblaws has

[19] Source: http://www.loblaw.com/en/pdf_en/lcl_seafood_policy_initiative.pdf accessed August 31, 2010.

committed to work with their advisors and key stakeholders to maintain and expand the Marine Stewardship Council (MSC) certification of wild-caught fish.

Loblaws is also committed to supporting local Canadian farmers and economies, by partnering with over 400 growers. In 2009, it's *Grown Close to Home* program, supported the sale of local growers harvest at the peak of the harvest season; approximately 40% of produce found in Loblaw stores in July and August was sourced from Canadian growers. Over the past two years, the *Grown Close to Home* program has increased produce sales by more than 16% during the local harvest period. They have also been increasing their direct-from-farm deliveries. They also showcased Canadian growers in commercials and flyers and improved in-store displays and point-of-sale materials to raise awareness and encourage more customers to buy locally.[20]

Loblaws is also committed to decreasing its carbon footprint through energy efficiency improvements and by working with suppliers to encourage them to do the same. To determine their carbon footprint, Loblaws uses a grocery industry-developed calculator that is compliant with the World Resources Institute (WRI) Greenhouse Gas Protocol.

Loblaws does not appear to have the same kinds of supply chain management standards as Wal-Mart has established with its suppliers. Therefore, it is not clear what kind of expectations might emerge for Canadian suppliers of meat, poultry, dairy, and produce with respect for sustainability reporting and environmental footprinting.

5.1.3 McDonalds Environmental Scorecard

McDonald's, like Wal-Mart, is another example of a large food retailer who has established supply chain standards and sustainability expectations for its suppliers. McDonald's used the GRI guidelines for its CSR reporting to prioritize key issues in their 2009 CSR report.[21] Sustainable Supply Chain management is one of their six priorities for achieving sustainable success. McDonald's had committed to the completion of it's Environmental Scorecard (ES) by the end of 2009 and a complete roll-out to all of its suppliers of beef, poultry, pork, potatoes and buns in McDonald's top nine markets by 2010. McDonald's ES measures water, energy, waste and air emissions metrics and promotes continuous improvement. In

[20] *Loblaw 2009 Corporate Social Responsibility Report.*

[21] McDonald's Corporation. 2009 Worldwide Corporate Social Responsibility Online Report. Available at http://www.aboutmcdonalds.com/mcd/csr/report/overview.-RightParaContentTout-43872-ReportsLinkList-44436-File1.tmp/McDonald's%202009%20Global%20CR%20Report%20Overview.pdf accessed August 7, 2010.

addition, an initial estimate of McDonald's supply chain carbon footprint is underway and will be completed in early 2010.

The performance of McDonald's suppliers is regularly evaluated using McDonald's Supplier Performance Index. Review of adherence to the McDonald's supply chain sustainable management programs and others related to sustainable supply are included in McDonald's Supplier Performance Index. Suppliers are expected to share and apply McDonald's own vision of sustainable supply to their own respective suppliers (McDonald's indirect suppliers). Suppliers are also asked to understand industry-wide sustainability challenges and opportunities related to the ingredients they use to make our products.

While McDonald's has had its own corporate environmental scorecard and does evaluate its suppliers performance, its public CSR report lacks quantitative rigor in terms of the environmental performance of its suppliers. Instead, McDonald's CSR report has focused on a qualitative approach, through short stories of supplier environmental performance innovations. Ideally, there needs to be a combination of quantitative statistics complimenting the stories of environmental performance, both for the overall corporation and for its supply chain management system.

5.1.4 Marks and Spencer (UK)

Marks and Spencer, the major British retailer, launched a major initiative, known as "Plan A", in 2007 with the objective of dramatically increasing the environmental sustainability of the business within 5 years and expected to cost £200 million.[22] The commitments span five themes: climate change, waste, sustainable raw materials, 'fair partnership' and health with the aim that, by 2012, it will:

- Become carbon neutral
- Send no waste to landfill
- Extend sustainable sourcing
- Help improve the lives of people in their supply chain
- Help customers and employees live a healthier life-style

Five Winds International, a Canadian consulting firm specializing in sustainability assessment, rated Marks and Spencer (M&S) ahead of Wal-Mart, Loblaws and TESCO in terms of overall sustainability

[22] Description of Marks and Spencer's *Plan A* can be found at http://plana.marksandspencer.com/about accessed August 31, 2010.

performance in its report *RETAIL: A Sustainability Benchmark* (2010).[23] Of particular note was M&S "Plan A" which includes a commitment to seek more local UK suppliers for its food products.

According the M&S *Our Plan A Commitments 2010-2015*, the company has been working with its business partners to develop best practices through work in pilot eco-factories and farms. They have taken these best practices and turned them into a set of factory and farm sustainability standards that they plan to use to drive performance across thousands of farms and factories in their supply chain. These standards will include:

- All of M&S's food suppliers will be covered by a balanced performance scorecard that includes social and environmental issues as well as lean manufacturing, with 25% of them achieving the very highest (Gold) performance standard by 2015.
- All 10,000 farmers who supply us with fresh meat, dairy, produce and flowers will be part of our Sustainable Agriculture Programme by 2012. By 2015 they will also have engaged in the Programme the many thousands of farmers that supply M&S with agricultural ingredients used to produce food.

According to one food industry expert we interviewed, Marks & Spencer has taken major steps in labeling its food items according to food miles. "Marks and Spenser will tell you what country a product is from and how many kilometers it has traveled. Every package label tells you how many kilometers; on meats, produce and cheeses." This is part of Marks & Spencer's commitment to reducing its carbon footprint. The labeling of food according to travel miles, carbon footprint, and country of origin, is part of a growing trend in Europe. In North America, food-miles and production-origin labeling has not yet become a standard practice amongst food retailers though this may change as European standards and experience grows. The key advantage Europe has is shorter transportation distances and smaller scale agricultural operations.

5.1.5 Nature's Path Foods

Nature's Path Foods, based in Richmond, B.C., are a good example of an organic food producer and processor that buys certified organic grains and produce from farmers and produces and sells their organic products in both Canada and the US through retailers like Wal-Mart. Nature's Path Foods has experienced the challenges of complying with Wal-Marts Sustainability Assessment Standards.

[23] According to Kevin Brady of Five Winds International this study was conducted solely by Five Winds International as an expression of interest in the subject.

According to Dag Flack, Organic Program Manager, Nature's Path Foods has had little problem satisfying Wal-Mart's standards as they have historically had internal sustainability policies. Their supply-chain relationship with certified organic producers (e.g. grain farmers) ensures that the highest standards for environmental performance of Natures' Path Foods products (e.g. cereals) are met. Meeting Wal-Mart's standards has meant making Nature's Path Foods existing environmental impact measures fit into the Wal-Mart standards or reporting framework. While an additional effort, it has not been difficult or onerous.

What is unique about Nature's Path Foods is that their organic product line, by virtue of using organically certified grains and other organic inputs, meets and likely exceeds the Wal-Mart standards as well as complying with the GRI guidelines. As Flack noted, their products effectively eliminate 100% of pesticide, artificial fertilizers, Genetically Modified Organisms (GMO) input, and water input (i.e. all certified organic crops are produced without irrigation and rely only on rainwater). This would suggest that organic products might represent the optimum environmental performance (i.e. a kind-of LEED platinum benchmark for food production), at least as it pertains to the domains of pesticide use, water and GMO inputs.

Nature's Path Foods is also unique in that they consider the long-term impacts of their production and supply-chain relationship with organic farmers by considering the implications to soil and ecosystem health over time. According to Flack, there is some evidence that the long-term use (e.g. over 50 years or more) of artificial fertilizers and pesticides may eventually deplete the soil organic matter and render many soils 'dead' in terms of natural productivity. This suggests the importance of taking a long-term view in environmental impact analysis and LCA studies, along with the importance of considering the impacts of land use practices on ecosystem and soil health.

Flack views Wal-Mart's adoption of sustainability standards as a positive trend and a positive affirmation of the practices of Nature's Path Food. With Wal-Mart's environmental expectations possibly expanding beyond their current standards, as we have noted, a trend towards more sustainable agri-food production may be underway. Nature's Path Foods views increasing sales of its products at Wal-Mart leading to more acres of land converted to certified organic production. An interesting question arises: as Wal-Mart receives more environmental performance data from its suppliers through its sustainability assessment questionnaire might they consider the organic standards of Nature's Path Foods as the basis for establishing Wal-Mart's own 'gold standard' for environmental performance for its other suppliers?

5.2 Local Food Plus (Ontario)

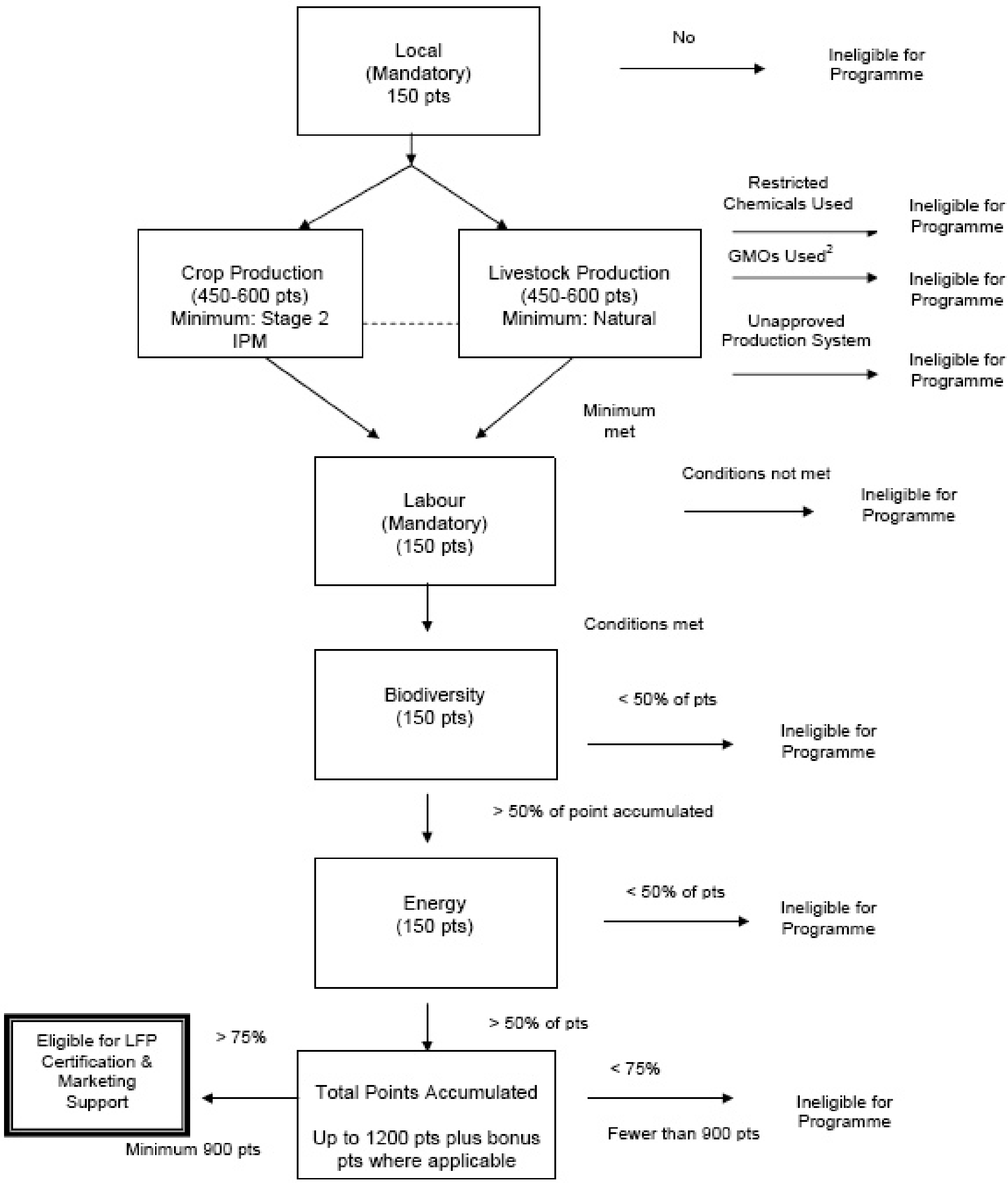
Local Foods Plus (LFP) is a non-profit organization that helps to support demand for local food producers in Ontario by certifying production that meets its local production and sustainability criterion. This is a good example of an industry association versus the retail sector (e.g. Wal-Mart) driving the standards for environmental footprinting and sustainability reporting.

The primary Sustainable Food Production Criterion include:

- Employ sustainable production systems that reduce or eliminate synthetic pesticides and fertilizers; avoid the use of hormones, antibiotics, and genetic engineering; and conserve soil and water.
- Provide safe and fair working conditions for on-farm labour.
- Provide healthy and humane care for livestock.
- Protect and enhance wildlife habitat and biodiversity on working farm landscapes.
- Reduce on-farm energy consumption and greenhouse gas emissions.

The sustainability criterion system, which uses a series of questions that suppliers must answer, results in an overall sustainability score, out of a maximum 1200 points (see Figure 6). A detailed list of the sustainability criterion is provided in Appendix 4.

Figure 6: Local Food Plus Production Criterion System



Since launching in September 2006, LFP has become the leading certification standard for local sustainable food production in North America. Local Food Plus bridges the urban-rural divide by bringing farmers, processors, distributors, consumers, retailers, restaurants, and institutions of all sizes in shaping a more sustainable food system. LFP's comprehensive and rigorous certification system addresses production, labour, native habitat preservation, animal welfare, and on-farm energy use, and leverages these standards to open new higher-value markets for farmers and processors. They are the only organization in Canada working on the ground to develop supply chains and other infrastructure that make it possible to scale up for food system change by linking small and medium-sized producers with purchasers of all sizes.

LFP provides a year-round supply of regional products, ranging from dairy and meat to greenhouse vegetables and fruit. They are constantly seeking and forming new partnerships with retailers, restaurants, institutions, and distributors who are committed to supporting regional farmers who meet LFP standards for environmental and social sustainability.

LFP builds new local supply chain relationships. As local markets expand, many farmers, processors, and food companies can access these supply chains to avoid supply relationships that may divert products out of the province or region. With LFP currently operating only in Ontario, no other region of the country can yet use a regional or provincial LFP certification mark. However, as the LFP programme expands, processors with multiple plants will be able to source product from local producers in the region of sale rather than from out of province suppliers, further supporting the development of local supply chains. LFP partners with restaurants and retailers interested in buying LFP certified local sustainable food. LFP also works with distributors to create the supply chain linkages necessary to ensure that LFP certified local sustainable food is accessible to buyers.

While currently limited to Ontario, two Alberta farmers[24] were recently been certified under the LFP program; LFP has plans to extend their certification program to other provinces.

Certification:
The certification process involves LFP working with producers to gather the information that inspectors will need to assess their production practices. Experienced independent inspectors are contracted by LFP with additional training to inspect to LFP standards. These inspectors visit the farm or processing facility and conduct the inspection. The inspection report is then sent to an external reviewer who will make the final decision regarding certification. The farm or processing operation is recertified annually, with an on-site inspection every three years. Regular spotchecks are also conducted.

[24] Including Sunworks Farms (www.sunworksfarm.com) a certified organic producer of beef, bison, lamb, pork, turkey, chicken, and eggs).

The cost of certification has been partially subsidized through the generous support of Ontario foundations such as the Toronto Community Foundation. These subsidies are expected to sunset as the LFP program reaches financial maturity through greater market expansion.

Standards:

LFP's farm standards are a central part of the LFP program. These were developed with input from a wide range of stakeholders, to be meaningful, rigorous and credible, yet accessible to many farmers. LFP is building a "big tent," where farmers who are committed to sustainable production and continuous improvement are welcome. LFP's standards are designed to provide guidance to farmers on practice and system requirements to be certified as an LFP operation. Organically certification is considered equivalent to the LFP certification such organic farmers are grandfathered in the LFP system.

LFP certification involves compliance with a set of both mandatory and points-based standards. Local production is a mandatory requirement for LFP certification. Farmers must accumulate 75% of the available points from their production practices in order for their operation to meet LFP standards. Standards have been written through an extensive, collaborative process that involves a range of experts, including LFP staff, extension agents, scientists, and the farmers who are likely to use the standards. Standards are for a specific crop or animal production system where none may have previously existed in a region.

For example, in the first phase of standards writing, LFP identified Stage 2 IPM (Integrated Pest Management) / ICM (Integrated Crop Management) / IFP (Integrated Fruit Production) standards that have been developed elsewhere in the world (e.g. U.S., Europe, Australia/New Zealand). These standards were then modified for application to Canadian regions to take into account differences in climates, soils, pest complexes, approved chemicals, and market conditions. The next phase involves reviewing the list of pesticides approved for that particular crop and classifying them as 'green-listed' (usable according to approved agronomic practices and approved pesticide labels), 'yellow-listed' (can be used on a restricted basis), or 'red-listed' (cannot be used at all). These listings are based on the crop profiles of Agriculture and Agrifood Canada (AAFC) and the label database of the Pest Management Regulatory Agency (PMRA), and are then assessed against pesticide toxicity indicators. LFP protocols make use of the Environmental Impact Quotient (EIQ) scale developed by Kovacs et al. at Cornell University (http://www.nysipm.cornell.edu/publications/eiq/) to help determine the appropriateness of the pesticides registered for use on a particular crop to an ecological IPM protocol. This scale is based on the impacts of pesticides on terrestrial and aquatic organisms (including impacts on beneficial and non-target organisms), and humans. The green-amber-red categorization scheme is designed to respond to environmental issues and the needs of growers for multiple tactics for pest control. In addition, LFP does not permit in its programme plants or livestock destined directly for human consumption that are derived from genetically modified constructs (i.e. GMOs). These are examples of some of the screens LFP uses for certification.

Reporting:

LFP certification requires farmers and processors to maintain accurate records and reporting systems for the inspection process. However, to reduce paperwork, LFP certification builds on existing certification systems and whenever possible accepts inspection processes and reports for existing performance standards, such as organic certification or environmental farm plans. Where appropriate, LFP conducts inspections concurrently with other certification bodies.

In our opinion based on our literature review, the LFP monitoring and reporting protocols for environmental and social sustainable agriculture represent the most rigorous and comprehensive we have reviewed for assessing sustainable agriculture with respect to consideration for biodiversity, ecosystem health and soil sustainability. However, the LFP is not as comprehensive its measurement protocols as the GRI environmental and social indicators guidelines. In our opinion, the LFP standards might represent the ‘LEED Certified Platinum’-equivalent standard for agriculture in Canada if they were to also consider the inclusion of energy, water and waste measurement parameters from the GRI guidelines.

5.3 Bloomberg Corporate Sustainability Indicators Database

Bloomberg L.P. — a privately held financial software, news, and data company that makes up one third of the $16 billion global financial data market providing financial software tools such as analytics and equity trading platform, data services and news to financial companies and organizations around the world through the Bloomberg Terminal —has developed the most comprehensive data base on sustainability indicators using a list of 100 possible indicators for 3,000 companies. The data is not publicly available but provided through Bloomberg's terminals.[25] Environmental and social performance data exists for 2600 companies, including some data on energy use and intensity, GHG emissions, water use and intensity, waste (including solid and toxic waste), and other environmental variables. This demonstrates that environmental performance monitoring and reporting is growing across many sectors and thus the potential for comparability of environmental and social performance between corporations and across sectors.

5.4 Additional Reflections and Considerations

The following are reflections on the previous assessment of emerging supply chain sustainable management systems.

- The demand for social and environmental sustainability performance rating systems are likely going to grow in the 21st century, led by retailers like Wal-Mart. This will mean that real sustainable product innovation by producers and suppliers of agricultural food products will need to demonstrate a deep understanding of the environmental and social attributes of their products, the materials (including energy) that go into them, the possible human and ecological health impacts of their operations, and a deeper knowledge of the product development processes used to create them.

- Given that the environmental dimension of the supply chain is not visible in the product, consumers require additional information, like traceability codes or quality labels on final products, to make informed decisions. The integrity of the system must be high given low verification opportunity for the consumer. The success of the system is based on consumer trust in the integrity of the information being provided (Wognum et al., In press).

[25] The Bloomberg sustainability indicator data set was provided by Toby Heaps, editor and chief of Corporate Knights Magazine who used the environmental and social indicator data, available through Bloomberg terminals, to compare and rank Canada's top 50 'sustainable' corporations for 2010 (available at http://www.corporateknights.ca/special-reports/63-best-50-corporate-citizens.html accessed August 10, 2010). In addition to the Bloomberg data, *ASSET4*, a Thomson Reuters business, provided the following data to Corporate Knights for publicly traded companies: a) Total CO2e emissions in tonnes, b) Total indirect and direct energy use in gigajoules, c) Total water use in cubic metres, and d) Total waste produced in tonnes.

- Tracking and tracing systems are compulsory for food supply chains in the EU (General Food Law – 178/2002/EC). Extending the concept to sustainability standards is not unrealistic given that systems are already in place (Peter, 2010, In press).

- Offsite emissions from a company's supply chain or from products sold by the company are currently not mandatory in the Greenhouse Gas Protocol. Peters' (2010) notes that while offsite greenhouse gas emissions are the most difficult for a company to estimate they are often the most important in terms of total amount.

- Factors contributing most to impacts are not necessarily intuitive. For example, an LCA commissioned by Pepsi Co. to quantify the environmental impacts of an orange juice product found that the biggest single source of CO_2 emissions was natural gas use associated with making nitrogen fertilizer (Martin, 2009).

- An EU sustainable food chain roundtable launched May 6, 2009 is seeking to develop a methodology for assessing the environmental footprint of individual foods and drinks by 2011. In July 2010, the group released 10 principles for voluntary assessment (European Food Sustainable Consumption and Production Round Table, 2010).[26]

Principles for the voluntary environmental assessment of food and drink products

- Identify and analyse the environmental aspects at all life-cycle stages
- Assess the significant potential environmental impacts along the life-cycle
- Apply recognised scientific methodologies
- Periodically review and update the environmental assessment

Principles for the voluntary communication of environmental information

- Provide information in an easily understandable and comparable way so as to support informed choice
- Ensure clarity regarding the scope and meaning of environmental information

[26] Available at http://www.food-scp.eu/files/Guiding_Principles.pdf accessed August 31, 2010.

Principles for both voluntary environmental assessment and communication

- Ensure transparency of information and underlying methodologies and assumptions
- Ensure that all food chain actors can apply the assessment methodology and communication tools without disproportionate burden
- Support innovation
- Safeguard international trade

6. Alberta Data Sources for Environmental Footprinting and Life Cycle Assessment[27]

Our literature review also considered potential Alberta agriculture and food processing industry data sources to populate an environmental footprinting framework, agricultural LCAs, and GRI environmental and social indicator guidelines. This is a cursory assessment of known publically available data sources revealing some data gaps that would need to be filled with farm-level monitoring and reporting, modeling, or the use of coefficients that could convert production statistics to GHG emission equivalents, pesticide impacts related to eutrophication and acidification, as examples.

6.1 Farm data

Alberta farmers have the ability to record and provide large amounts of data necessary to conduct LCA of production processes. Much of that data is in the private rather than public domain. Examples of data within the domain of farm record keeping are:

Pre production:

- Seed origin and supplier, germination %, seed certification (pedigree seed), seed treatments
- Livestock pedigree, birth records (age verification), health and treatment records

Production:

- Planting date, rate
- Soil sampling and testing (Benchmarks, land use benchmarks/time)
- Fertilizer formulations and application method/rate; same for pesticides
- Field scouting records (emerging weeds, disease)
- Crop damage (hail, frost, wind)
- Harvest dates, ambient conditions

[27] Taken from analysis prepared by Tom Goddard (Alberta Agriculture and Rural Development).

- Global positioning system (GPS) data may be collected at cultivation, seeding, spraying, harvesting, and scouting operations. GPS contains date/time and location and may be combined with application/harvest rate, field label, etc. Derivative data may include field size, speed, start/stop/duration times
- Weather, some farms have weather stations on farm sites
- Equipment type, fuel consumption (per hr, per acre)
- Livestock feed sources, amounts, estimated or measured analysis of feeds, days on feed, finished weights, carcass scoring
- Livestock pasture management, stocking rates, pasture conditions

Quality:

- Yields, quality (percent thins, protein, oil content, grade, etc)

6.2 Public data

There are several sources of public data that may complement farm-acquired data. These data sources may be used directly, used as reference data (e.g. how farm weather compared to other area stations) or used for derivative data (e.g. annual percent departure from longer term averages). Alberta is fortunate in having likely the best soils and climate data in Canada.

Soils:

The soil inventory for the agricultural area is available with an online viewer where one can observe soil map polygons superimposed upon colour ortho air photo coverage. There are approximately 20,000 polygons in the agricultural zone. The polygon tool can calculate areas of fields (e.g. grassed area available for grazing within a quarter section). There is also a plain language interpretation of what the soils are within a polygon. Behind the view is a series of flat dbase files that contain details of the soil information, only a small portion that is shown on the viewer. The soil map unit file contains 10 variables explaining the map unit and associated slopes. The soil name file contains 20 variable relating to the classification and characteristics of named soils in Alberta. The soil layer file contains 32 variables describing the characteristics of soil profiles (e.g. depths of horizons, pH, salinity, organic matter, etc). A soils professional can interpret the data appropriately and provide approximations of soil properties on a sub field level. Alberta Soils Information Centre (connects to viewer, data, and associated documents): http://www.agric.gov.ab.ca/asic

The National Ecological Framework for Canada is a public domain spatial database and polygons that contain biophysical data in a hierarchical framework. It is used as a basis for segmenting and processing other data sources. The ecostratification is consistent and comparable across Canada. http://sis.agr.gc.ca/cansis/publications/ecostrat/intro.html

Climate:

All of the historic daily weather records for Alberta have been obtained, interpolated to a 10 km grid and stored on a computer server. Users can connect to the server and select from a range of standard products of long term precipitation, temperatures, drought indices, etc (use the "climate mapper").[28] Users may also create any map they wish for any period and portion of the province (use the "weather mapper"). For example, using the Alberta Climate Information System (ACIS), one can map the most recent 10 days of precipitation or the cumulative growing degree-days for the current growing season.

6.3 Licensed data

Alberta Agriculture and Rural Development have a large collection of spatial databases that are licensed for government or ministry use only. However, the results of the use of the database may be freely distributed.

Agriculture Census data (every five years):

Statistics Canada agriculture census data is available electronically for the last several decades. Since the 1991 census the data has also been summarized on a watershed basis as well as ecodistricts (about 100 in agricultural area) or soil landscapes of Canada polygons (about 900 in agricultural area). The census data is rich in production and economic data, including data on:

Alberta basemap data:

There are nearly 100 layers of basemap data for Alberta (e.g. roads, rivers, railways, lakes, etc).

Individual datasets:

Several surveys or one time processing of data are available. Examples include the Alberta weed survey, which surveys weed problems as well as details about cultural practises; the soil test dataset, which contains descriptive statistics by ecodistrict for soil test, levels from the 1960s to the 1990s. Research datasets, including agronomic trials, variety testing trials and research trials.

[28] Alberta Climate Information Service: http://www.agric.gov.ab.ca/acis

6.4 Alberta Carbon Market

Alberta created North America's first compliance market for carbon offsets with legislation in 2007. Companies with large emissions must reduce their annual emissions by a prescribed amount (-12%) or offset their emissions by paying into a tech fund or purchasing offset credits generated in Alberta. The offset credits must be from government approved protocols. Protocols are developed according to ISO 14064 (part 2) and third party verification is done according to ISO 14064 (part 3). Protocols do not quantify all upstream and downstream sources of CO_2e emissions but rather only the components that are different due to the practise change. Data used in quantification of projects is private. Project results will be public information. The results of the 2007 accounting period should be available by mid 2008. Protocols and other information are available from http://www.carbonoffsetsolutions.ca

6.5 Quantification issues

Explicit variables may not be available for every facet of a production system and accepted standards or estimates may need to be used. Examples are the fuel consumption rates of transport trucks used to haul grain or livestock. Standard consumption rates (and greenhouse gas coefficients) may be acceptable substitutes for measured data. With the availability of basic production data, derivative data can be calculated such as N_2O emissions per tonne of grain or kilogram of meat. Likewise transportation distances may need to be normalized or assumed not to vary and not be included in the calculations. Decisions on what to include in calculations, if standard coefficients or values are to be used, and how far upstream and downstream to track inputs and outputs, may all need to be decided upon by a review team of scientists (as per ISO frameworks).

Some farm management data may not always be recorded, may vary somewhat and may not be commonly known by farmers. Examples are time of day that crop spraying is done, typical waiting times to load/unload. In these cases a consensus of farmer opinion (qualitative information) may be an acceptable alternative for real data.

7. Recommendations and Options

This section of the report provides a list of recommendations and options for Alberta Agriculture and Rural Development to take into account when developing an environmental footprint model for agriculture and food processing in Alberta. The Alberta Government could play a key role, in partnership with farmers and the agri-food industry, in helping to coordinate a provincial environmental monitoring and reporting system for assessing the long-term sustainability of agriculture and food production.

Project direction recommendation 1:

Develop and support an Alberta environmental and social impact data monitoring, impact assessment and reporting system, as well as measurement guidelines or protocols for Alberta's key agricultural products and processes to meet emerging food retail and food processing environmental accountability demands.

Rationale:

The availability of relevant environmental and social impact indicator data from existing Alberta agricultural census and data sources must be assessed to determine the strengths and weaknesses (i.e. gaps) of Alberta's agriculture and food processing industry in meeting emerging demands for environmental performance. Pressures from retailers like Wal-Mart on food processors and their respective suppliers to meet their own environmental performance criterion or 'score cards' are already growing putting pressure on North American food processors that in turn is putting pressure on farmers and food producers to meet these standards. Alberta's agricultural sector (particularly grain, beef and dairy) would be wise to assess its capacity to meet these new monitoring and reporting expectations.

For example, in order to fulfill the basic environmental impact analysis for beef, pork, poultry, lamb, dairy, crops and vegetables will require energy use, GHG emissions, land use, eutrophication and acidification impacts (requiring data on pesticide, herbicide, fertilizer and manure use, in terms of not only area of land but also volume of application) statistics. Some of the agricultural LCA studies into GHG emissions related to beef and pork production represent a good starting point but are largely inadequate to meet, for example, Wal-Mart's current environmental scorecard criterion. A commitment to conducting more comprehensive LCA studies, that should also include assessment of land use impacts on soil fertility and biodiversity, for Alberta's agricultural industries will be critical to strategically position Alberta producers in an ever-changing global food industry. It is clear that at least in the medium-term, retailers like Wal-Mart will be setting the agenda for what environmental and social indicators get measured.

Based on our analysis, we feel Alberta's agriculture and food processing sector is not currently prepared to comply with the GRI sustainability reporting guidelines, nor the Food Processing Industry Supplement guidelines. However, a commitment to begin the development of an Alberta agricultural environmental impact monitoring and assessment system using the core GRI environmental and social indicators would be an important step. Using the GRI guidelines for establishing an environmental reporting and monitoring system would also satisfy the reporting expectations of retailers like Wal-Mart, and more. Consideration should be given to the environmental impact indicators proposed by Lillywhite (2008) for the development of environmental footprint profiles for various agricultural products, using indicators like energy use, land use, eutrophication and acidification, and water use. The list of impact categories can be expanded over time as inventory and measurement capacity improves. The overall goal would be to provide for a broad provincial overview of the environmental and social sustainability of Alberta agriculture at the provincial, soil-district, eco-zone or watershed level and at the product level (e.g. beef, pork, poultry, dairy, grains).

Project direction recommendation 2:
Develop a data inventory to support certification and participation in supply chain sustainability programs.

Rationale:
Supply chain standards and other sustainability certification requirements are changing the food market place and increasing reporting demands on suppliers. The reporting demands placed on suppliers will also ultimately be passed down to producers or farms. Alberta producers and food processors should be prepared to meet these growing demands for environmental monitoring and reporting placed upon them by retailers like Wal-Mart. The data inventory needs to be comprehensive recognizing several key factors: supply chain standards are under development; there are multiple sustainable marketing models, which have different input needs; and an ever-changing market place.

The data inventory for the province could be modeled on the Global Reporting Initiative environmental indicators and measurement protocols (e.g. the GRI water protocols). Data sources and data bases included in the inventory should be made accessible for free to support producers wishing to comply with certification programs. The database could be supported by characterization value for each eco-zone.

Project direction recommendation 3:

Research community-based data collection options including implementing an electronic environmental reporting structure and tracking key data as part of an annual Alberta farm survey.

Rationale:

Data availability will be a critical limiting factor in supporting any environmental footprint model. The Department of Agriculture and Development should explore the potential of tracking key data as part of the annual Alberta farm survey. Another option is to develop a user-friendly environmental reporting system to assist producers in complying with emerging environmental impact reporting expectations and sustainability certification initiatives, such as those of Wal-Mart. Producers would implement information assisting them in collecting the necessary data to participate in certification programs. In addition, the structure would organize information in a useable format to inform general farm planning. Tasks to consider in research include: success of existing electronic environmental reporting structures; needs assessment of producers; evaluation of potential uptake, and costs analysis. Aggregate data from the environmental reporting system could be used to estimate an Alberta environmental footprint based on locally provided data.

Project direction recommendation 4:

Assess the Alberta's agriculture biocapacity and soil fertility based on eco-zone specific yield factors.

Rationale:

Having detailed provincial agriculture biocapacity data, using available data on soil fertility or land quality (e.g. soil organic carbon), would be useful to understand the supply of agriculture potential in the province and to explore the implications and magnitude of agriculture resources being exported outside the province. Understanding the relationship between environmental impacts (from data from LCA studies) to available biocapacity and soil health will become increasingly important to ensuring the long-term sustainability of Alberta's agricultural sector. As noted, current agricultural LCAs and environmental scorecards like Wal-Mart's (and to some extent the GRI environmental indicators) fail to account for the qualitative impacts on land-use on soil fertility and long-term productivity. Consideration for the impacts of agricultural practices on soil in addition to measuring other environmental impacts may be an important role the Alberta Agriculture and Rural Development could play in assessing the overall sustainability of Alberta agriculture.

Also, Alberta agricultural biocapacity data would allow an environmental footprint model to distinguish between land used to produce food for export markets and land used to serve local or domestic markets. Exporting production means that local natural capital is being used to serve consumption elsewhere. The development of eco-zone yield factors necessary to estimate provincial agriculture biocapacity would also be valuable for estimating the EF of a specific operation or product and to support estimating the EF as a land use impact indicator in LCA studies. Crop land biocapacity should be estimated using direct crop yield data. Pasture land biocapacity can be estimated by developing a scale based on the Land Suitability Rating System.

Project direction recommendation 5:
Develop and support a made-in-Alberta environmental and social impact indicator performance reporting system and protocols for agriculture.

Rationale:
There may be an opportunity for Alberta's agricultural sector to take a lead in Canada in establishing its own standards and certification process using environmental and social impact criterion, measurement protocols, and reporting standards that are relevant to Alberta. This might be accomplished through a collaborative effort between government and Alberta's agriculture and food processing industries. The Local Food Plus certification standards and process and organic food certification protocols provide some insights into what is possible when key environmental impact indicators (e.g. pesticides, greenhouse gas emissions, eutrophication and acidification, and water use) are used for certification purposes. The program could be structured in such a way that adopters are recognized for their achievement and receive marketing support from the province. The rigour of the standard should be such that complying with the standard would meet or exceed current supply chain certification requirements, such as Wal-Mart's, reaching for higher 'gold-standards' like GRI guidelines, the LEAF Marquee standard, the LFP standards, organic certification and others. We believe the LEAF Marque standard offers a starting point to develop a gold standard for Alberta. The standard should be based on recognized international standards for compatibility with other requirements and certification programs in other countries. Producer and industry stakeholders must play an active role in the development of an environmental footprint gold standard.

Project direction recommendation 6:

Explore the possibility of expanding the agricultural protocols established as part of Alberta's offset trading program to quantify environmental benefits beyond CO_2 savings. Other possible impact categories to include are: eutrophication and acidification potential, land impact, and water use.

Rationale:

The protocols developed to support Alberta's offset trading system comply with ISO-14064 process. The protocols currently measure the CO_2 reductions achieved by implementing the protocol. The agricultural protocols can be expanded to quantify other environmental benefits beyond CO_2 savings.

Project direction recommendation 7:

Explore the possibility of offering incentives to encourage farmer participation in an environmental reporting framework.

Rationale:

Environmental management frameworks can be costly and time intensive to implement and maintain. Producers often do not fully understand the potential costs and benefits of implementing a program. The current uptake of voluntary environmental frameworks is low (Vincent and Bouma, 2008). Incentives to explore include: offering technical support, waiving certification costs, offering recognition (awards, marketing support), and supporting branding programs.

Environmental footprint and sustainability indicator and reporting system development considerations:

Consideration 1: Strong system in place

- A proposed sustainability system needs to be based on scientific protocols and relevant local data and be useful to the agricultural community. The emphasis of early work should focus on 1) developing a system supporting regional characterization factors and, 2) developing a model that has support from the agriculture community.

Consideration 2: What data does the department have at its disposal/ or can have?

- A robust model needs to be populated with good data. Any model should be cognizant of data availability, data costs, and reliability of data sources. Data considerations include:

- What data do farmers already collect and report on?
- What is feasible to ask farmers to collect?
- What does the Agriculture Retailer collect?
- What does the government collect?

Consideration 3: Emphasize transparency and openness

- Assumptions behind the model should be transparent and data sources open. Users should have the option to change/modify the assumptions to reflect situation or provide feedback to adjust models for future updates.

General modeling considerations:

1. All models are based on assumptions and a specific world view.

2. Results will be influenced by the conversion factors selected, coefficients used, and data sources.

3. Models often rely on average values, proxy values, or macro level data. As a consequence, results lose relevance when applied at the local level undermining the capacity of the model to inform micro-level decision making.

4. Coming up with standardized indicators that can be audited and verified is difficult.

5. Completing modeling exercises can be costly, resource intensive, and time intensive.

6. Due to data lags, most models are based on data that is several years old.

7. Year-over-year comparisons are often challenging because data are being compiled inconsistently.

8. It is difficult to make comparisons between studies given differences in definitions and study scope.

9. Any approach will be limited: "It is probable that no single method, analysis or label can convey the environmental burden associated with a single product, in a easy to understand way, which would satisfy everyone" (Lillywhite, 2008).

References

Andersson, K., Ohlsson, T., 1999. Life cycle assessment of bread produced on different scales. International Journal of LCA 4 (1), 25-40.

Andersson, K., Ohlsson, T., & Olsson, P., 1998. Screening life cycle assessment (LCA) of tomato ketchup: A case study. Journal of Cleaner Production 6 (3-4), 277-288.

Anielski, M., Wilson, J., 2006. City of Leduc Genuine Wealth Assessment. Prepared for the City of Leduc.

Anielski, M., Johannessen, H., 2010. Edmonton 2008 Genuine Progress Indicator Report. Prepared for the City of Edmonton.

Arsenault, N., Tyedmers, P., & Fredeen, A., 2009. Comparing the environmental impacts of pasture-based and confinement-based dairy systems in Nova Scotia (Canada) using life cycle assessment. International Journal of Agricultural Sustainability, 7 (1), 19-41.

Aughagen, A., 1994. Wissenschaftliche Grundlagen zure Berechnung einer Ausgleichsausgabe. Berlin, D: Auhagen & Pertners GmbH. Im Auftrag der Senatsverwaltung fur Stadtentwicklumg und Umweltschutz Abt.III.

Ayres, R.U., 2000. Commentary on the utility of the ecological footprint concept. Ecological Economics 32, 357-358.

Baig, M., Gamache, P., 2009. The Economic, Agronomic and Environmental Impact of No-Till on the Canadian Prairies. Prepared for Alberta Reduced Tillage Linkages. August 2009, version 1.

Basset-Mens, C., & van der Werf, H., 2005. Scenario-based environmental assessment of farming systems: The case of pig production in France. *Agriculture, Ecosystems & Environment 105 (1-2), 127-144.*

Bauer, C., 2006. GIS data and land use in life cycle impact assessment - experiences on global scales. In, International Expert Workshop Initiative on Land-use impacts, Guildford, UK.

Baumann, H. & Tillman, A., 2004. The Hitch Hiker's Guide to LCA. Lund, Sweden: Studentlitteratur.

Beauchemin, K., Janzen, H., Little, S., McAllister, T., & McGinn, S, 2010. Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. Agricultural Systems 103, 371-379.

Berlin, J., 2002. Environmental life cycle assessment (LCA) of Swedish semi-hard cheese. International Dairy Journal 12 (11), 939-953.

Brentrup, F., Küsters, J., Kuhlmann, H., & Lammel, J., 2001. Application of the life cycle assessment methodology to agricultural production: An example of sugar beet production with different forms of nitrogen fertilisers. European Journal of Agronomy 14, 221-233.

Brentrup, F., Kusters, J., Lammel, J., & Kuhlmann, H., 2002. Life cycle assessment of land use based on the Hemeroby concept. International Journal of Life Cycle Assessment 7, 339-348.

Brentrup, F., Kusters, J., Kuhlmann, H., & Lammel, J., 2004. Environmental impact assessment of agricultural production systems using the life cycle assessment methodology: I. Theoretical concept of a LCA method tailored to crop production. European Journal of Agronomy 20, 247-264.

Brown, H., De Jong, M., Levy, D., 2009. Building institutions based on information disclosure: lessons from GRI's sustainability reporting. Journal of Cleaner Production 17 (6), 571–580.

Brown, H., De Jong, M., Lessidrenska, T., 2007. The Rise of the Global Reporting Initiative (GRI) as a Case of Institutional Entrepreneurship. Harvard University, John F. Kennedy School of Government. Working Paper 36, May 2007.

BSI, 2008. PAS 2050: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. British Standards Institution. Available at http://shop.bsigroup.com/en/Browse-by-Sector/Energy--Utilities/PAS-2050/. Accessed June, 2010.

Carlsson-Kanyama, A., 1998. Climate change and dietary choices – How can emissions of greenhouse gases from food consumption be reduced? Food Policy 23 (3-4), 277-293.

Casey, J., Holden, N., 2006. Quantification of GHG emissions from sucker-beef production in Ireland. Agricultural Systems 90, 79-98.

Cederberg, C., Mattsson, B., 2000. Life cycle assessment of milk production – A comparison of conventional and organic farming. Journal of Cleaner Production 8 (1), 49-60.

Chambers, N., Simmons, C., and Wackernagel. M., 2000. Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability. Earthscan Publishers.

Chapagain, A.K., Hoekstra, A.Y., and H.H.G. Savenije., H.H., 2006. Water saving through international trade of agricultural products, Hydrology and Earth System Sciences 10 (3), 455-468.

Chapagain, A.K., Orr, S., 2009. An improved water footprint methodology linking global consumption to local water resources: A case of Spanish tomatoes. Journal of Environmental Management 90, 1219-1228.

City of Calgary, 2008. Ecological Footprint Baseline Report, 2008. Prepared by the department of Environmental and Safety Management with support of the Global Footprint Network.

City of Calgary., Global Footprint Network, 2009. Ecological Footprint online calculator. Accessible at: www.footprintnetwork.org/en/index.php/GFN/page/calgary_footprint_calculator.

de Vries, M., de Boer, I.J.M., 2010. Comparing environmental impacts for livestock products: A review of life cycle assessments. Livestock Science 28 (1), 1-11.

Doublet, Geneviève, Jungbluth, N. 2009. Environmental Production Information and LCA An Example of the Swiss Ecological Time Unit. Pamphlet prepared by ESU-services Ltd., Kanzleistrasse 4, CH–8610 Uster, Switzerland.

Eide, M., 2002. Life cycle assessment (LCA) of industrial milk production. International Journal of LCA 7 (2), 115-126.

Fair Labor Association., 2007. Monitoring Guidance & Compliance Benchmarks. Version 1.2. Available at www.fairlabor.org. Accessed July 2010.

Finnveden, G., 1996. Resources. In: Udo de Haes, H. (Ed.), Towards a methodology for life cycle impact assessment, SETAC-Europe, Belgium.

Five Winds International. 2010. RETAIL: A Sustainability Benchmark. Prepared by Kevin Brady, Josh Hendry, and Shaheen Kanchwala.

Five Winds International. 2010. RETAIL: A Pivot Point for Sustainability. Prepared by Kevin Brady, Five Winds International.

Frey, S., Barrett, J., 2006. The Footprint of Scotland's diet: the environmental burden of what we eat. A report for Scotland's Global Footprint Project. Stockholm Environment Institute. September 2006.

Gerbens-Leenes, P.W., Moll, H.C., Schoot Uiterkamp, A.J.M., 2003. Design and development of a measuring method for environmental sustainability in food production systems. Ecological Economics 46, 231-248.

Global Reporting Initiative. 2010. Sustainability Reporting Guidelines & Food Processing Sector Supplement. RG Version 3.0. Available at http://www.globalreporting.org/ReportingFramework/SectorSupplements/FoodProcessing/ Accessed August 8, 2010.

Global Reporting Initiative. 2008. Sustainability Reporting in the Food Processing Sector: A Survey Conducted by the Global Reporting Initiative. Available at http://www.globalreporting.org/NR/rdonlyres/13865428-9EAC-4EB0-A8E3-A31AA2F5C38C/3471/FOODReportFinal.pdf accessed August 30, 2010.

Global Reporting Initiative. 2003. Water Protocol. February 2003.

Global Reporting Initiative. 2002. Energy Protocol. December 2002.

Global Footprint Network., 2009. Ecological Footprint Standards 2009. Oakland: Global Footprint Network. Available at http://www.footprintstandards.org. Accessed June 2010.

Guthrie, J., Farneti, F., 2008. GRI sustainability reporting by Australian public sector organizations. Public Money and Management December, 361–368.

Guinée, J.B., Van Oers, L., De Koning, A., & Tamis, W., 2006. Life cycle approaches for Conservation Agriculture. Part I: A definition study for data analysis. Part II: Report of the Special Symposium on Life Cycle Approaches for Conservation Agriculture on 8 May 2006 at the SETAC-Europe 16th Annual Meeting at The Hague. In, Department of Industrial Ecology & Department of Environmental Biology, pp. 156.

Haas, G., Wetterich, F., & Köpke, U, 2001. Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment. Agriculture, Ecosystems and Environment

83, 43-53.

Haas, G., Wetterich, F., & Geier, U., 2000. Life cycle assessment framework in agriculture on the farm level. International Journal of LCA 5 (6), 345-348.

Hauschild, M., Dreyer, L., & Jørgensen, A., 2008. Assessing social impacts in a life cycle perspective – Lessons learned. CIRP Annals – Manufacturing Technology *57* (1), 21-24.

Heijungs, R., Guinée, J., Huppes, G., Lankrijer, R., Ansems, A., Eggels, P., 1992. Environmental life cycle assessment of products; guide and backgrounds. In, The Netherlands: CML, Rijko Universiteit Leiden.

Hertwich, E., J., H., Pease, W., 2000. A theoretical foundation for life-cycle assessment: Recognizing the role and values in environmental decision making. J Ind Ecol 4, 13-28.

Hoekstra, A.Y., 2007. Human appropriation of natural capital: comparing ecological footprint and water footprint analysis. UNESCO Institute for Water Education. July 2007.

Hoekstra, A.Y., Chapagain, A.K., 2007. Water footprints of nations: water use by people as a function of their consumption pattern. Water Resources Management 21 (1), 35-48.

Holmberg, J., Lundqvsit, U., Robert, K-H, and Wackernagel, M., 1999. The Ecological Footprint from a systems perspective of sustainability. International Journal of Sustainable Development and World Ecology 6, 17-33.

Hospido, A., Moreira, M., & Feijoo, G., 2003. Simplified life cycle assessment of Galician milk production. International Dairy Journal 13, 783-796.

International Organization for Standardization., 2006a. ISO 14040: Environmental management – Life cycle assessment – Principles and framework.

International Organization for Standardization., 2006b. ISO 14044: Environmental management – Life cycle assessment – Requirements and guidelines.

Jeanneret, P., Baumgartner, D., R., K., Gaillard, G., Huguenin-Elie, O., Nemecek, T., Weibel, P., 2006. Integration of Biodiversity As Impact Category For LCA In Agriculture. In, 16th SETAC Conference, 7-11 May, 2006, The Hague.

Jørgensen, A., Le Bocq, A., Nazarkina, L., & Hauschild, M., 2008. Methodologies for social life cycle assessment. International Journal of LCA 13(2), 96-103.

Katajajuuri, J., Virtanen, Y., Voutilainen, P., & Tuhkanen, H., 2003. Life cycle assessment results and related improvement potentials for oat and potato products as well as for cheese. Life Cycle Assessment in the Agri-food Sector, Processing from the 4th International Conference, p. 222-225. Bygholm, Denmark.

Keystone Alliance., 2009. Field to Market: The Keystone Alliance for Sustainable Agriculture Environmental Resource Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States. January 2009. Available online: http://keystone.org/spp/env-sustain_ag.html. Accessed June 2010.

Kissinger, M., Gottlieb, D., 2010. Place oriented ecological footprint analysis – the case of Israel's grain supply. Ecological Economics 69, 1639-1645.

Kissinger, M., Rees, W., 2009. Footprints on the prairies: Degradation and sustainability of Canadian agricultural land in a globalizing world. Ecological Economics 68, 2309-2315.

Koehler, A., 2008. Water use in LCA: Managing the planet's freshwater resources. International Journal of LCA 13(6), 451-455.

Krajnc, D., Glavic, P., 2005. A model for integrated assessment of sustainable development. Resource, Conservation and Recycling 43, 189-208.

Lindeijer, E., 2000. Review of land use impact methodologies. Journal of Cleaner Production 8, 273-281.

Lillywhite, R., 2008. The environmental footprint: A method to determine the environmental impact of agricultural production. University of Warwick. Institutional repository: http://go.warwick.ac.uk/wrap. Accessed August, 2010.

Lindeijer, E., Müller-Wenk, R., & Steen, B., 2002. Impact assessment of resources and land use. SETAC, Pensacola, USA.

Lynch, B., 2010. An examination of environmental reporting by Australian state government departments Accounting Forum 34, 32-45.

Meisterling, K., Samaras, C., & Schweizer, V., 2009. Decisions to reduce greenhouse gases from agriculture and product transport: LCA case study of organic and conventional wheat. Journal of Cleaner Production 17, 222-230.

Martin, A., 2009. How green is my orange? New York Times. January 29, 2009.

Mattsson, B., Cederberg, C., Blix, L., 2000. Agricultural land use in life cycle assessment (LCA): case studies of three vegetable oil crops. Journal of Cleaner Production 8, 283–292.

Milà i Canals, L., 2006. LC Initiative land-use impact assessment framework Land-use impacts in LCA: a framework from the UNEP/SETAC Life Cycle Initiative. In, International Expert Workshop Initiative on Land-Use Impacts, Guildford, UK.

Milà i Canals, L., Burnip, G., & Cowell, S., 2006. Evaluation of the environmental impacts of apple production using life cycle assessment (LCA): Case study in New Zealand. *Agriculture, Ecosystems & Environment, 114*(2-4), 226-238.

Milà i Canals, L., Clift, R., Basson, L., Hansen, Y., & Brandão, M., 2006. Expert Workshop on Land Use Impacts in Life Cycle Assessment (LCA) 12-13 June 2006 Guildford, Surrey (UK). International Journal of Life Cycle Assessment 11, 363-368.

Mila i Canals, L., Romanyà, J., & Cowell, S., 2006. Method for assessing impacts on life support functions (LSF) related to the use of 'fertile land' in Life Cycle Assessment (LCA). Journal of Cleaner Production, 1-15.

Moffat, I., 2000. Ecological footprints and sustainable development. Ecological Economics 32, 359-362.

Moneva, J. M., Archel, P., Correa, C., 2006. GRI and the camouflaging of corporate unsustainability. Accounting Forum 30 (2), 121–137.

Moran, D., Wackernegal, M., Kitzes, J., Heurmann, B., Phan, D., Goldfinger, S., 2009. Trading spaces: calculating embodied ecological footprint in international trade using a product land use matrix (PLUM). Ecological Economics 68, 1938-1951.

Müller-Wenk, R., 1998. Land use: the main threat to species, how to include land use in LCA. In, Institute for Economy and Ecology, St. Gallen University, Switzerland.

Müller-Wenk, R., 2006. How to determine the impacts of land use. In, The International Expert Workshop Initiative on Land-Use Impacts, Guildford, UK.

Owens, J., 2002. Water resource in life-cycle assessment: Consideration in choosing category indicators. Journal of Industrial Ecology 5(2), 37-54.

Pelletier, N., 2008. Environmental performance in the US broiler poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions. Agricultural Systems 98, 67-73.

Pelletier, N., Arsenault, N., & Tyedmers, P., 2008. Scenario modeling potential eco-efficiency gains from a transition to organic agriculture: Life cycle perspectives on Canadian canola, corn, soy, and wheat production. Environmental Management 42, 989-1001.

Pelletier, N., Lammers, P., Stender, D., & Pirog, R., In Press. Life cycle assessment of high- and low-profitability commodity and niche swine production systems in the upper Midwestern United States.

Pelletier, N., Pirog, R., & Rasmussen, R., 2010. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. Agricultural Systems 103, 380-389.

Peters, G.P., 2010. Carbon footprints and embodied carbon at multiple scales. Current Opinion in Environmental Sustainability. Doi:10.1016/j.cosust.2010.05.004

Poritosh R., Daisuke N., Takahiro, O., Qingyi, X., Hiroshi, O., Nobutaka, N., Shiina, T., 2009. A review of life cycle assessment (LCA) on some food products. Journal of Food Engineering 90 (1), 1-10.

Romanyà, J., Serrasolses, I., Vallejo, R., 2006. Defining a framework to measure soil quality. In, The International Expert Workshop Initiative on Land-Use Impacts, Guildford, UK.

Ryedgren, B., 2006. Quantitative BiodiversityImpact Assessment in Vattenfall Nordic Generation. The Biotope Method. In, The International Expert Workshop Initiative on Land-use impacts, Guildford, UK.

Schenck, R.C., 2006. Testing LCA indicators for biodiversity. In, The International Expert Workshop Initiative on Land-Use Impacts, Guildford, UK.

Skouloudis, A., Konstantinos, E., Kourmousis, F., 2010. Assessing non-financial reports according to the Global Reporting Initiative guidelines: evidence from Greece. Journal of Cleaner Production 18, 426-438.

SNC-Lavalin Agro, 2009. A life cycle analysis of carbon dioxide equivalents (CO_2e) of Alberta barley, wheat, peas and canola meal used in pork production, slaughter and further processing. Report prepared for Alberta Agriculture and & Rural Development.

Sparling,B., Brethour, C., Thangaraj, R., and Schmidt, C., 2008. Capturing Environmental Marketing Opportunities in Alberta. Project 3: Assessment of Environmental Management Systems in Other Jurisdictions. Prepared for Alberta. Agriculture and Rural Development by George Morris Centre. March 28th, 2008.

Stadig, M., 1997. Life cycle assessment of apple production – Case studies for Sweden, New Zealand and France. SIK Report 630 1997. Gothenburg, Sweden: SIK.

Stechbart, M., Wilson, J., 2010. Province of Ontario Ecological Footprint and Biocapacity Analysis. Produced for State of Ontario's Biodiversity 2010 Report. Published by Global Footprint Network. April 2010.

Stoeglehner, G., Narodoslawsky, M., 2008. Implementing ecological footprinting in decision-making processes. Land Use Policy 25, 421-431.

Swiss Confederation, Federal Office for the Environment. 2009. The Ecological Scarcity Method Eco-Factors 2006: A Method for impact assessment in LCA. Federal Office for the Environment FOEN, Bern, Switzerland, 2009.

Treweek, J., Bubb, P., 2006. Biodiversity Indicators for Impact Assessment. In, International Expert Workshop Initiative on Land-Use Impacts, Guildford, UK.

Turner, K., Lenzen, M., Wiedmann, T., and Barrett, J., 2007. Examining the global environmental impact of regional consumption activities — part 1: a technical note on combining input–output and ecological footprint analysis. Ecological Economics 62, 37-44.

Udo de Haes, H., Jolliet, O., Finnveden, G., Hauschild, M., Krewitt, W., Muller-Wenk, R., 1999. Best available practice regarding impact categories and category indicators in life cycle impact assessment, part 1. International Journal of Life Cycle Assessment 4, 66-74.

Udo de Haes, H.A., Finnveden, G., Goedkoop, M., Hauschild, M., Hertwich, E.G., Hofstetter, P., Jolliet, O., Klopffer, W., Krewitt, W., Lindeijer, E., Muller-Wenk, R., Olsen, S.I., Pennington, D.W., Potting, J., Steen, B. (eds.), 2002. Life Cycle Impact Assessment: Striving towards best practice. SETAC Press, Pensacola, FL.

Udo de Haes, H.A., 2006. How to approach land use in LCIA or, how to avoid the Cinderella effect? Comments on 'Key Elements in a Framework for Land Use Impact Assessment Within LCA'. Letter to the Editor. International Journal of Life Cycle Assessment 11, 219-221.

UNEP/SETAC, L.C.I., 2006. Minutes of the International Expert Workshop Initiative on Land-use impacts. In, Guildford, UK.

Vincent, B., Bouma, J., 2008a. Capturing Environmental Marketing Opportunities in Alberta. Project 1: Canadian Consumer Support for Environmental Attributes of Agricultural Products. Prepared for Alberta Agriculture and Rural Development by Toma & Bouma Management Consultants. March 28th, 2008.

Vincent, B., Bouma, J., 2008b. Capturing Environmental Marketing Opportunities in Alberta. Project 2: International and Multinational Corporation Market Assessment. Prepared for Alberta. Agriculture and Rural Development by Toma & Bouma Management Consultants. March 28th, 2008.

Vitousek, P., Ehrlich, P., Ehrlich, A., Matson, P., 1986. Human appropriation of the products of photosynthesis. Bioscience 36, 368-373.

Wackernagel, M., Rees, W., 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Gabriola Island, BC.

Wackernagel, M., Monfreda, C., Moran, D., Wermer, P., Goldfinger, S., Deumling, D., and Murray, M., 2005. National Footprint and Biocapacity Accounts 2005: The underlying calculation method. Global Footprint Network. Online: www.globalfootprintnetwork.org.

Weidema, B., Lindeijer, E., 2001. Physical impacts of land use in product life cycle assessment. Final report of the EURENVIRON-LCAGAPS sub-project on land use. In, Department of Manufacturing Engineering and Management, Technical University of Denmark, Lyngby.

Wiedmann, T., 2009. A first empirical comparison of energy Footprints embodied in trade – MRIO versus Plum. Ecological Economics 68, 1975-1990.

Wiedmann, T., and Barrett, J., 2005. The use of input-output analysis in REAP to allocate ecological footprints and material flows to final consumption categories. Ecological Budget UK. February, 2005.

Wilson, J., 2001. Ecological Footprint of Alberta. Alberta Genuine Progress Indicator. Pembina Institute.

Wilson, J., 2006. Ecological Footprint of Alberta. Alberta Genuine Progress Indicator Report Update 2006. Pembina Institute.

Wilson, J., Anielski, M., 2004. Ecological Footprint of 18 Canadian Municipalities. Federation of Canadian Municipalities. Ottawa, ON.

Wilson, J., Anielski, M., 2008. Alberta Ecological Footprint Draft Report. Measuring the Sustainability of Alberta's Progress. Report I – Ecological Footprint Accounts. Prepared for Alberta Environment. Internal document only.

Wilson, J., Grant, J., 2009. Calculating ecological footprints at the municipal level: what is a reasonable approach for Canada? Local Environment 14 (10), 963-979.

Wilson, J., Anielski, M., 2010. School Ecological Footprint calculator beta version. Prepared for Calgary Board of Education and University of Calgary.

Wognum, P.M., Bremmers, H., Trienekens, J., Van der vorst, J., and Bloemhof, J., In press. Systems for sustainability and transparency of food supply chains – current status and challenges. Advanced Engineering Informatics. Doi:10.1016/j.ael.2010.06.001.

Appendix 1: Sector Expert Interviews

A number of experts in the field of environmental performance reporting, LCA analysis, agri-food producers, local food industry contacts, and retail sector experts, were interviewed to gather anecdotal information to supplement the formal literature review of this project.
The list of those experts interviewed include:

Herb Barbolet

An Associate with the Centre for Sustainable Community Development at Simon Fraser University since 2003. Herb has been active in community development for more than 30 years - Working in community planning, energy conservation, citizen participation, cooperative housing, and food and agriculture. He now works in food policy research, projects and programmes: linking food to community economic development, health and safety, environment, social justice, and international development - from the very local to the global. He is one of the leading food activists in North America. Herb has a B.A. in Urbanism, a Master's in Community Development, and doctoral studies in Community Development and later in Community Planning and Political Economy. Herb co-authored food assessments for The Provincial Health Service Authority and a food assessment guides for the Vancouver Coastal Health, Fraser Health and the United Way.

Kevin Brady

Director, Five Winds International

Kevin Brady is a founding partner and a director of Five Winds International. In his twenty-year career, he has advised numerous companies, governments and industry associations on the development of sustainability strategies and implementation frameworks. Kevin leads Five Winds' Strategic Sustainability Services which specializes in helping clients develop a clear understanding of what sustainability means to their organization and of how to improve their environmental and social performance in ways that create value. Kevin is a guest lecturer on product life cycle strategies at the Sustainable Enterprise Academy and is well known for his leadership in the development of the ISO standards process on climate change and the ISO 14040 series of standards on life cycle assessment. Kevin recently completed a benchmark study of retail sustainability benchmark report that rated and compared the sustainability performances of Marks and Spencer, Wal-Mart, Loblaws, TESCO, Home Depot, and Whole Foods.

Mark Brownlie

CEO, Sustainability Matters

Mark is the Chief Executive of Responsibility Matters, a Calgary-based consulting firm assisting companies and non-profits with sustainability communications and strategies. He is an expert in corporate sustainability measurement and reporting and is a former communications director with Global Reporting Initiative (Boston, MA).

Anita M. Burke

Founder, Catalyst Institute (www.catalystinstitute.com)

Sustainability consultant and founder of the Catalyst Institute. Anita Spent 18 years with Shell International as advisor to the Shell International Committee of Managing Directors on the operationalisation of sustainable development and the energy portfolio implications of a carbon constrained future. During that time she worked in all aspects of the upstream and downstream portions of the oil business, she has delivered profitable technologies and organizational processes that have delivered on the sustainable development and climate change strategic vision. She has helped to co-create visionary strategies for the future and practical, tactical actions to deliver on our need to go beyond organic and disentangle us from the hydrocarbon energy system.

Paul Cabaj

President, Taktika Sustainability Strategies

An Edmonton-based expert in local food systems, supply chain management, and cooperative businesss enterprise.

Dag Falck

Organic Program Manager, Nature's Path Foods Inc.

Dag was educated as an agronomist in Norway and spent 15 years as an organic inspector in Western Canada and the US. before joining us in 2003. He is a pioneer and leader in the organic movement, and serves on several boards and councils at the forefront of the organic community. He has been an organic inspector for 15 years. At Nature's Path, Dag oversees all aspects of our organic supplies, policies and consumer interaction. He builds strong organic networks and connections between farmers, manufacturing and consumers; he helps to ensure that enough cropland is converted to Certified Organic; and he provides organic farmers with access to resources and techniques that ensure the highest quality of organic crops. Dag represents Nature's Path as the chair of the Permitted Substances List working group that amends and updates the organic standard through the Canadian General Standards Board, I'm chair of the Organic Agriculture Centre of Canada, and Secretary of the Non GMO Project Board, and dozens of other government and industry committees.

Catherine Greener

Co-founder, Cleargreen Advisors

Catherine Greener is co-founder of Cleargreen Advisors. Prior to founding Cleargreen Advisors, Catherine was Saatchi & Saatchi's vice president of sustainability consulting and participated in the Steering Committee for the Walmart Sustainability Index. Catherine has more than 20 years of experience in the implementation of sustainability, lean manufacturing and industrial quality management systems. She has led sustainability and resource efficiency projects for clients ranging from entrepreneurial startups to the industrial facilities of multinational corporations and Fortune 500 companies. She has experience in the food and beverage processing, automotive, chemical, semiconductor, facility automation (robotics), and construction industries. Catherine holds a Bachelor of Science degree in Industrial Engineering from Northwestern University. Her MBA is from University of Michigan.

Toby Heaps

Editor and Co-Founder, Corporate Knights magazine.

Toby Heaps is the president, editor and co-founder of Corporate Knights, an independent Canadian-based media company focused on prompting and reinforcing sustainable development in Canada. Launched in 2002, Corporate Knights magazine is the world’s largest circulation magazine dedicated to the subject of responsible business. It is distributed quarterly as an insert to 100,000 subscribers of The Globe and Mail. Toby has a Bachelor of Arts degree from McGill University in Economics, with a minor in International Development. From 1997-98, he spent one year in the Belgrade Field Program (LLB in Management Studies) with the London School of Economics and Political Science.

Tanmayo Krupanszky

Canadian Organic Standards (Toronto)

Tanmayo, who serves as a communication advisor to the Canadian Organic Growers, is a professional coach, facilitator and speaker. Trained and certified in the co-active coaching model with the Coaches Training Institute, Tanmayo supports leaders and teams who want to refocus their priorities, know what motivates them and learn how to make lasting changes. Her clients include executives, senior management and strategic leadership teams.

Don Mills

Director of Standards and Certification, Local Food Plus (Toronto)

Don grew up on a dairy farm in Southwestern Ontario and continues to farm with his family. His agriculture experience includes raising beef and pork, dairy farming, and specialty harvesting. Don serves on the Provincial Council and National Executive Council of the National Farmers Union and was a member of the Ontario Minister of Agriculture's Strategic Advisory Committee.

Jessie Radies

Owner, Blue-Pear Restaurant

Founder, Live Local (Edmonton)

Jessie Radies began her career in the restaurant business as a Kentucky Fried Chicken Employee. Jessie and her husband Darcy Radies opened Blue Pear, a boutique restaurant that offers a beautiful five course meal. Committed to the importance of supporting local businesses, Jessie has helped strengthen Edmonton's Independent business scene by founding Original Fare and more recently Keep Edmonton Original, and Live Local -- helps citizens, independent businesses and communities ensure ongoing opportunities for independent entrepreneurs, prevent the displacement of locally-owned businesses, and promote citizen engagement in the development of the community.

Nuna da Silva

PE Americas/PE International (Boston, MA)

Nuna is the Managing Director for PE Americas, part of PE International ('experts in sustainability), and is responsible for the development of new projects in life cycle assessment consulting services and software solutions. He is an industry expert in LCA and has been involved in numerous assessments related to agriculture and food.

Appendix 2: Concordance of GRI Environmental and Social Sustainability Indicators with Life-Cycle Analysis Indicators/Measurement Units.

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
ENVIRONMENTAL PERFORMANCE INDICATORS				
Environmental Materials				
Materials used by weight or volume	EN1 (core)	X		
Percentage of materials used that are recycled input materials	EN2 (core)	X		
Energy				
Direct energy consumption by primary energy source	EN3 (core)	X	Energy Use (EU): Use of renewable and non-renewable energy resources	On-farm energy use, on-farm mechanization (MJ)
Indirect energy consumption by primary source	EN4 (core)	X		
Energy saved due to conservation and efficiency improvements	EN5 (additional)	X		
Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives	EN6 (additional)	X		
Initiatives to reduce indirect energy consumption and reductions achieved	EN7 (additional)	X		

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Water				
Water (water footprint/use, water quality index (surface))				
Total water withdrawal by source	EN8 (core)	X	Impacts on water availability and quality	Irrigation (m2)
Water sources significantly affected by withdrawal of water	EN9 (additional)	X		
Percentage and total volume of water recycled and reused	EN10 (additional)	X		
Biodiversity and Landuse				
(e.g. landscape diversity, e.g. wetlands, wildlife corridors)				
Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	EN11 (core)	X "land or waters…"		
Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	EN12 (core)	X "land or waters…"		
Habitats protected or restored.	EN13 (additional)	X		
Strategies, current actions, and future plans for managing impacts on biodiversity.	EN14 (additional)	X		
Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.	EN15 (additional)	X		
Biotic Resource Use (NPP)			Appropriation of the products of biological productivity	NPP: Net Primary Productivity related to crop production
Land Use			Direct or indirect occupation of land	Field area for crop production (m2)
Emissions, Effluent and Waste				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Total direct and indirect greenhouse gas emissions by weight	EN 16 (core)	X	Global Warming Potential (GWP): Increased radiative forcing in the atmosphere (W/m^2)	CO_2 and other GHG emissions: enteric methane, emissions from manure, fertilizer production, field emissions of N_2O
Other relevant indirect greenhouse gas emissions by weight	EN 17 (core)	X		
Initiatives to reduce greenhouse gas emissions and reductions achieved	EN 18 (additional)	X		
Emissions of ozone-depleting substances by weight	EN 19 (core)	X	Photochemical Ozone Creation:Production of photochemical/ summer smog	Field emissions of N_2O, fertilizer use, energy use, on-farm mechanization (C_2H_4)
		X	Ozone Depleting Potential(ODP): Reduction of stratospheric ozone	CFC-11 related to On-farm mechanization, transportation
NOx, SOx, and other significant air emissions by type and weight	EN 20 (core)	X		
Total water discharge by quality and destination	EN 21 (core)	X		
Total weight of waste by type and disposal method	EN 22 (core	X		
Total number and volume of significant spills	EN 23 (additional)	X		
Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, and VIII, and percentage of transported waste shipped internationally	EN 24 (additional)	X		
Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.	EN 25 (additional)	X		
Human toxicity related to pesticide use			Human exposure to substances detrimental to human health	Pesticide use (1,4-DB); kg/ha; EIQ
Aquatic eco-toxicity related to pesticide use			Exposure of the environment to ecologically toxic substances	Pesticide use (1,4-DB); kg/ha; EIQ
Eutrophication potential (EP)			Contributions to nutrient loading in water bodies	Fertilizer runoff, emissions from manure (kg PO_4)

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Acidification potential (AP)			Deposition of acid precipitation	Ammonia emissions from fields (SO_2, kg/ha)
Products and Services				
Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	EN26 (core)	X		
Percentage of products sold and their packaging materials that are reclaimed by category.	EN27 (core)	X		
Compliance				
Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.	EN28 (Core)	X		
Transport				
Significant environmental impacts of transporting products and other goods and materials used for the organization's operations, and transporting members of the workforce.	EN29 (additional)	X		
Environmental Protection Expenditures				
Total environmental protection expenditures and investments by type.	EN30 (additional)	X		
SOCIAL PERFORMANCE				
Social Performance: Labor Practices & Decent Work				
Employment				
Total workforce by employment type, employment contract, and region.	LA1 (Core)	X		
Total number and rate of employee turnover by age group, gender, and region.	LA2 (Core)	X		
Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.	LA3 (additional)	X		
Labor/Management Relations				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Percentage of employees covered by collective bargaining agreements.	LA4 (Core)	X		
Minimum notice period(s) regarding significant operational changes, including whether it is specified in collective agreements.	LA5 (Core)	X		
Percentage of working time lost due to industrial disputes, strikes and/or lock-outs, by country.		FP3 (Core)		
Occupational Health and Safety				
Percentage of total workforce represented in formal joint management-worker health and safety committees that help monitor and advise on occupational health and safety programs. (Additional)	LA6 (Core)	X		
Rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities by region.	LA7 (Core)	X		
Education, training, counseling, prevention, and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases.	LA8 (Core)	X		
Health and safety topics covered in formal agreements with trade unions.	LA9 (additional)	X		
Training and Education				
Average hours of training per year per employee by employee category.	LA10	X		
Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	LA11 (additional)	X		
Percentage of employees receiving regular performance and career development reviews.	LA12 (additional)	X		
Diversity and Equal Opportunity				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, and other indicators of diversity.	LA13 (Core)	X		
Ratio of basic salary of men to women by employee category.	LA14 (Core)	X		
Social Performance: Human Rights				
Investment and Procurement Practices				
Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	HR1 (Core)	X		
Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.	HR2 (Core)	X		
Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained.	HR3 (additional)	X		
Non-Discrimination				
Total number of incidents of discrimination and actions taken.	HR4 (Core)	X		
Freedom of Association and Collective Bargaining				
Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights.	HR5 (Core)	X		
Child Labor				
Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor.	HR6 (Core)	X		
Forced and Compulsory Labor				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced or compulsory labor.	HR7 (Core)	X		
Security Practices				
Percentage of security personnel trained in the organization's policies or procedures concerning aspects of human rights that are relevant to operations.	HR8 (additional)	X		
Indigenous Rights				
Total number of incidents of violations involving rights of indigenous people and actions taken.	HR9 (additional)	X		
Social Performance: Society				
Community				
Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities, including entering, operating, and exiting.	SO1 (Core)	X		
Healthy and Affordable Food				
Nature, scope and effectiveness of any programs and practices (in-kind contributions, volunteer initiatives, knowledge transfer, partnerships and product development) that promote healthy lifestyles; the prevention of chronic disease; access to healthy, nutritious and affordable food; and improved welfare for communities in need.		FP4		
Corruption				
Percentage and total number of business units analyzed for risks related to corruption.	SO2 (Core)	X		

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Percentage of employees trained in organization's anti-corruption policies and procedures.	SO3 (Core)	X		
Actions taken in response to incidents of corruption.	SO4 (Core)	X		
Public Policy				
Public policy positions and participation in public policy development and lobbying.	SO5 (Core)	X (Commentary added to invite reporting on lobbying activities, and their context, related to the subsidized production of key product ingredients.)		
Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	SO6 (additional)	X		
Anti-Competitive Behavior				
Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes.	SO7 (additional)	X (Commentary added to invite reporting on lobbying activities, and their context, related to the subsidized production of key product ingredients.)		
Compliance				
Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations.	SO8 (Core)	X		
Social Performance: Product Responsibility				
Customer Health and Safety				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	PR1 (Core)	X (Commentary added to include the assessment of significant environmental and social impacts across the life-cycle stages of products and services. Compilation added to report on procedures, steps and results).		
Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	PR2 (additional)			
Percentage of production volume manufactured in sites certified by an independent third party according to internationally recognized food safety management system standards.		FP5 (Core)		
Percentage of total sales volume of consumer products, by product category, that are lowered in saturated fat, trans fats, sodium and added sugars.		FP6 (Core)		
Percentage of total sales volume of consumer products, by product category sold, that contain increased fiber, vitamins, minerals, phytochemicals or functional food additives.		FP7 (Core)		
Products and Service Labeling				
Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements.	PR3 (Core)	X		
Policies and practices on communication to consumers about ingredients and nutritional information beyond		FP8 (Core)		

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
legal requirements.				
Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labeling, by type of outcomes.	PR4 (additional)	X		
Practices related to customer satisfaction, including results of surveys measuring customer satisfaction.	PR5 (additional)	X		
Marketing Communications				
Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship.	PR6 (Core)	X (Commentary added to describe the influence of food marketing on dietary habits; to specify types of marketing communications; to invite reporting on policies and guidelines relating to marketing to vulnerable groups; references added.		
Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship by type of outcomes.	PR7 (additional)	X		
Customer Privacy				
Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	PR8 (additional)	X		
Compliance				

Indicator Name	GRI (Global Reporting Initiative) Standards	GRI Food Processing Sector standards	Indicators considered in ag-relevant LCA studies	LCA Measurement Unit
Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services.	PR9 (core)	X		
Animal Welfare				
Breeding and Genetics:				
Percentage and total of animals raised and/or processed, by species and breed type.		FP9 (Core)		
Animal Husbandry				
Policies and practices, by species and breed type, related to physical alterations and the use of anaesthetic.		FP10 (Core)		
Percentage and total of animals raised and/or processed, by species and breed type, per housing type.		FP11 (Core)		
Policies and practices on antibiotic, antiinflammatory, hormone, and/or growth promotion treatments, by species and breed type.		FP12 (Core)		
Transportation, Handlng and Slaughter				
Total number of incidents of non-compliance with laws and regulations, and adherence with voluntary standards related to transportation, handling, and slaughter practices for live terrestrial and aquatic animals.		FP13 (Core)		

Appendix 3: GRI Environmental and Social Sustainability Indicators, Industry Standards, Bloomberg Sustainability Ratings, and Sample of Corporate Reporting.

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
ENVIRONMENTAL PERFORMANCE INDICATORS								
Environmental Materials								
Materials used by weight or volume	EN1 (core)						X	
Percentage of materials used that are recycled input materials	EN2 (core)					X	X	
Energy								
Direct energy consumption by primary energy source	EN3 (core)	X	X	X	X		X	
Indirect energy consumption by primary source	EN4 (core)						X	
Energy saved due to conservation and efficiency improvements	EN5 (additional)					X		
Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these	EN6 (additional)					X	X	

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
initiatives								
Initiatives to reduce indirect energy consumption and reductions achieved	EN7 (additional)					X		
Water								
Water (water footprint/use, water quality index (surface))								
Total water withdrawal by source	EN8 (core)					X	X	X
Water sources significantly affected by withdrawal of water	EN9 (additional)					X		
Percentage and total volume of water recycled and reused	EN10 (additional)					X		
Biodiversity and Landuse *(e.g. landscape diversity, e.g. wetlands, wildlife corridors)*						X		
Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	EN11 (core)							
Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside	EN12 (core)					X		

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
protected areas.								
Habitats protected or restored.	EN13 (additional)					X		
Strategies, current actions, and future plans for managing impacts on biodiversity.	EN14 (additional)					X		
Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.	EN15 (additional)					X		
Biotic Resource Use (NPP)						X		
Land Use								
Emissions, Effluent and Waste								
Total direct and indirect greenhouse gas emissions by weight	EN 16 (core)							
Other relevant indirect greenhouse gas emissions by weight	EN 17 (core)							
Initiatives to reduce greenhouse gas emissions and reductions achieved	EN 18 (additional)	X	X	X	X	X	X	X
Emissions of ozone-depleting substances by weight	EN 19 (core)						X	

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
NOx, SOx, and other significant air emissions by type and weight	EN 20 (core)						X	
Total water discharge by quality and destination	EN 21 (core)	X			X			
Total weight of waste by type and disposal method	EN 22 (core						X	
Total number and volume of significant spills	EN 23 (additional)						X	
Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, and VIII, and percentage of transported waste shipped internationally	EN 24 (additional)						X	X
Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.	EN 25 (additional)						X	
Human toxicity related to pesticide use							X	
Aquatic eco-toxicity related to pesticide use								
Eutrophication potential (EP)								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Acidification potential (AP)								
Products and Services								
Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	EN26 (core)		X	X	X			
Percentage of products sold and their packaging materials that are reclaimed by category.	EN27 (core)	X			X			
Compliance								
Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.	EN28 (Core)						X	
Transport								
Significant environmental impacts of transporting products and other goods and materials used for the organization's operations, and transporting members of the workforce.	EN29 (additional)							
Environmental Protection Expenditures								
Total environmental protection expenditures and investments by type.	EN30 (additional)						X	

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
SOCIAL PERFORMANCE								
Social Performance: Labor Practices & Decent Work								
Employment								
Total workforce by employment type, employment contract, and region.	LA1 (Core)							
Total number and rate of employee turnover by age group, gender, and region.	LA2 (Core)							
Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.	LA3 (additional)							
Labor/Management Relations								
Percentage of employees covered by collective bargaining agreements.	LA4 (Core)							
Minimum notice period(s) regarding significant operational changes, including whether it is specified in collective agreements.	LA5 (Core)							
Percentage of working time lost due to industrial disputes, strikes and/or lock-outs, by country.								
Occupational Health and Safety							X	

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Percentage of total workforce represented in formal joint management-worker health and safety committees that help monitor and advise on occupational health and safety programs. (Additional)	LA6 (Core)							
Rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities by region.	LA7 (Core)							
Education, training, counseling, prevention, and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases.	LA8 (Core)							
Health and safety topics covered in formal agreements with trade unions.	LA9 (additional)							
Training and Education								
Average hours of training per year per employee by employee category.	LA10							
Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	LA11 (additional)					X		

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Percentage of employees receiving regular performance and career development reviews.	LA12 (additional)							
Diversity and Equal Opportunity								
Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, and other indicators of diversity.	LA13 (Core)							
Ratio of basic salary of men to women by employee category.	LA14 (Core)							
						X		
Social Performance: Human Rights								
Investment and Procurement Practices								
Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	HR1 (Core)							
Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.	HR2 (Core)							

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained.	HR3 (additional)						X	
Non-Discrimination								
Total number of incidents of discrimination and actions taken.	HR4 (Core)							
Freedom of Association and Collective Bargaining								
Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights.	HR5 (Core)							
Child Labor								
Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor.	HR6 (Core)							
Forced and Compulsory Labor								
Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced	HR7 (Core)							

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
or compulsory labor.								
Security Practices								
Percentage of security personnel trained in the organization's policies or procedures concerning aspects of human rights that are relevant to operations.	HR8 (additional)							
Indigenous Rights								
Total number of incidents of violations involving rights of indigenous people and actions taken.	HR9 (additional)							
Social Performance: Society								
Community								
Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities, including entering, operating, and exiting.	SO1 (Core)							
Healthy and Affordable Food								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Nature, scope and effectiveness of any programs and practices (in-kind contributions, volunteer initiatives, knowledge transfer, partnerships and product development) that promote healthy lifestyles; the prevention of chronic disease; access to healthy, nutritious and affordable food; and improved welfare for communities in need.								
Corruption								
Percentage and total number of business units analyzed for risks related to corruption.	SO2 (Core)							
Percentage of employees trained in organization's anti-corruption policies and procedures.	SO3 (Core)							
Actions taken in response to incidents of corruption.	SO4 (Core)							
Public Policy								
Public policy positions and participation in public policy development and lobbying.	SO5 (Core)							

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	SO6 (additional)							
Anti-Competitive Behavior								
Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes.	SO7 (additional)							
Compliance								
Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations.	SO8 (Core)							
Social Performance: Product Responsibility								
Customer Health and Safety								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	PR1 (Core)							
Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	PR2 (additional)							
Percentage of production volume manufactured in sites certified by an independent third party according to internationally recognized food safety management system standards.								
Percentage of total sales volume of consumer products, by product category, that are lowered in saturated fat, trans fats, sodium and added sugars.								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Percentage of total sales volume of consumer products, by product category sold, that contain increased fiber, vitamins, minerals, phytochemicals or functional food additives.								
Products and Service Labeling								
Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements.	PR3 (Core)							
Policies and practices on communication to consumers about ingredients and nutritional information beyond legal requirements.								
Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labeling, by type of outcomes.	PR4 (additional)							
Practices related to customer satisfaction, including results of surveys measuring customer satisfaction.	PR5 (additional)							
Marketing Communications								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship.	PR6 (Core)							
Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship by type of outcomes.	PR7 (additional)							
Customer Privacy								
Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	PR8 (additional)							
Compliance								
Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services.	PR9 (core)							
Animal Welfare								

Indicator Name	GRI (Global Reporting Initiative) Standards	LCA studies conducted by Commodities Class (Beef, Pork, Poultry, Dairy, Grains, Vegetables)				Industry Standards		Retail Industry Expectations for Standards/Measurement (e.g. Wal-Mart standards)
		Grains and Legumes (wheat, canola, corn, soy, legumes)	Beef	Pork	Dairy	Local Food Plus (Ontario)	Bloomberg Environmental Key Performance Indicators	Wal-Mart (supplier reporting requirements)
Breeding and Genetics:								
Percentage and total of animals raised and/or processed, by species and breed type.								
Animal Husbandry								
Policies and practices, by species and breed type, related to physical alterations and the use of anaesthetic.								
Percentage and total of animals raised and/or processed, by species and breed type, per housing type.								
Policies and practices on antibiotic, antiinflammatory, hormone, and/or growth promotion treatments, by species and breed type.								
Transportation, Handlng and Slaughter								
Total number of incidents of non-compliance with laws and regulations, and adherence with voluntary standards related to transportation, handling, and slaughter practices for live terrestrial and aquatic animals.								

Appendix 4: Local Food Plus Sustainability Food Production Criterion for Producers

Labour Standards 150 points

This element of the standards is designed to ensure that labour laws are respected. It does not impose conditions beyond those legally required (e.g., the standard does not require a unionized labour force, but does require that the conditions for organizing be respected, as the law requires). The standard is of two parts, depending on the number of employees. This standard is mandatory (150 points allotted to each farm that complies with the elements listed below). Failure to comply excludes operations from the programme. Under this standard, a worker is someone regularly employed and that includes: Permanent full-time staff, Permanent part-time staff, Contract staff, and Seasonal workers. Those who are regularly employed for a period that exceeds three months are counted in determining the number of workers, including managers and supervisors who work at the workplace. Farms with 6 workers or more are subject to OPTION A. For farms with 5 or fewer employees, a simplified LFP standard is in effect, OPTION B.

OPTION A – For farms with 6 workers or more

Elements

401. Overarching conditions

401.1 Operators should comply with all ILO conventions relating to labour welfare and the UN Charter of Rights for Children12.

401.2 All employment conditions comply with all local and national regulations for:

- wages
- workers age
- working hours
- working conditions
- occupational health and safety
- job security
- unions
- pensions
- other legal and health requirements

401.3 If the operation has a seasonal worker programme, the workers must have a contract consistent with existing recognized programmes. An operation with violations in the past 12 months is not eligible for the LFP programme.

402. Plans and responsible persons

402.1 A risk assessment for safe and healthy working conditions has been carried out and used to develop an action plan to fix problems and create worker awareness.

402.2 An owner/manager is clearly identified as responsible for worker health, safety and welfare issues.

402.3 A worker health and safety representative has been identified. In cases where there are more than 20 workers, a joint health and safety committee has been established.

403. Training

403.1 A person (e.g. foreman, crew boss) is trained in First Aid and emergency procedures.

403.2 All relevant workers are trained/certified in operating farm machinery.

403.3 All workers that mix and apply pesticides trained and certified to provincial legislation standards.

403.4 Training records are kept for all workers.

403.5 Certification training under the Occupational Health and Safety Act will be required if you have 50 or more workers regularly employed on a dairy, beef, hog, poultry, mushroom or greenhouse operation.

404. Safety

404.1 All employees working with dangerous and/or complex machinery are provided with approved safety wear and equipment.

404.2 Proper protection equipment is always worn by spray applicator(s) during pesticide mixing and spraying.

404.3 Emergency and first aid procedures are posted in accessible areas, in languages reflecting the work force.

404.4 Approved First Aid kits are available in work areas, with workers trained on their use.

404.5 Hazards are clearly identified with warning signs.

404.6 Accident and emergency instructions clearly understood by all workers.

404.7 Clean toilet and washing facilities are available for all workers.

404.8 Workers applying pesticides receive annual health checks

OPTION B – For farms with 5 workers or fewer

401.2 All employment conditions comply with all applicable local and national regulations for:

wages

- workers age
- working hours
- working conditions
- occupational health and safety
- job security
- unions
- pensions
- other legal and health requirements

Biodiveristy	150 points
Up to 150 base points are available for enhancing biodiversity, with potential bonus points of 50. Mandatory elements must be met. Farmers must surpass 50% of the basepoints applicable to their operation. Some elements may not be applicable to your operation and these are not included in the base points calculation. Biodiversity elements must be closely associated with the part of the farm being certified for LFP production	
501. Planning	Mandatory, no points allotted
501.1 The most recent Environmental Farm Plan (EFP) version or equivalent is completed, or planned for completion within the upcoming year (farmer has registered for workshop and / or has timetable to submit plan for review). Upon completion, needed nutrition management and biodiversity improvements are scheduled for implementation and applications to cost-shared BMP programmes are planned, if appropriate funding provisions identified.	10 Base points, if applicable to the farm
501.2 Species at risk identified and plan in place to protect them	10 Base points, if applicable to the farm
501.3 For farms with woodlots, timber extraction must follow a plan to minimize negative impacts on biodiversity.	10 Base points, if applicable to the farm
501.4 Farmer involved in regional activities to enhance habitat (watershed councils, corridor planning and maintenance, etc.).	15 Bonus points
502. Natural areas protection	
502.1 Clearing of primary ecosystems is prohibited and farmer must not have engaged in such clearing in the 3 years prior to application to LFP certification.	Mandatory, no points allotted
502.2 Farmers should maintain a significant portion of farm for biodiversity and nature conservation. (See Appendix 500A for options on how to calculate the amount of the farm protected for biodiversity purposes.)	10 Base points

502.3 Primary forests, well developed secondary forests and sites of environmental significance are conserved (as identified in EFP). Inappropriate recreational activity and rubbish dumping in forests is prohibited. Trees should only be replanted (of types appropriate to natural regeneration) to supplement natural regeneration. Animals must not graze forest understory.	15 Base points
502.4 Invasive exotic species must not be introduced to natural ecosystems. Those already there should be removed with biological, cultural or physical means, with pesticides only used if such measures fail, or create secondary complications.	10 Base points
503. Water protection	
503.1 Livestock do not have direct access to streams and natural water sources.	10 Base points
503.2 Abandoned wells filled and plugged.	5 Base points
503.3 Grassed buffers and runoff control structures around surface water Minimum 6-10 meter buffers, with additional area to comply with provincial regulations regarding slopes, pesticides, fertilizers, manure spreading and setbacks.	15 Base points
503.4 Drains stabilized and maintained to prevent erosion.	5 Base points
503.5 Spraying of non-crop vegetation and waterways is prohibited (see exotics exception) unless spot spraying to control alternate pest hosts.	Mandatory, no points allotted
503.6 Riparian areas vegetated for water quality protection. There is a good canopy cover (>50%) of mixed multi-aged, native species to provide shade. Newly established plantings have a ground cover including a mix of grasses and shrubs with a second-story of cover and habitat, especially along stretches of streams or rivers needing stabilization.	15 Base points
504. Creating food and habitat for wildlife	
504.1 Plants that attract beneficial insects are established.	5 Base points
504.2 Bird perches are established on field edges to encourage predatory birds.	5 Base points
504.3 Windbreaks are established around fields.	5 Base points
504.4 Owl or bat boxes are established for predator populations populations.	5 Base points
504.5 Native vegetation is established along unused areas, fencerows, buildings, etc	10 Base points
504.6 Fallow fields are left with plant cover to provide food, water, and/or cover; this includes cover crops, or crop residue left on soil surface. Fallow is permitted in specific circumstances (e.g., nematode control for orchard replant).	10 Base points
504.7 Irrigation never disrupts habitats sufficiently to cause changes in species activity (e.g., water supplied to farm ponds to maintain habitat).	5 Base points
504.8 Wildlife habitat corridors maintained between natural areas or established where lacking. A corridor must be more than a roadway.	10 Bonus points
504.9 Leaves standing deadwood for raptors and woodpeckers.	5 Bonus points
504.10 Grass is unmowed and grain harvest delayed during migration or reproduction periods.	10 Bonus points

504.11 Vehicle traffic and activities around natural areas are limited during migration and reproductive times and/or when wildlife is present. 10 Bonus points

505. Closing nutrient cycles

505.1 Since biodiversity is dependent on optimal energy, nutrient and water flows, farms minimize their export of nutrients, beyond that inherent to crop and animal product sales (e.g., manure and straw export would be minimized). Mandatory, no points allotted

Appendix 500A – Options for protecting biodiversity

Choose OPTION A or OPTION B

OPTION A

The measure used compares the farm acres in “all other lands” (from 2001 Census) with the average for the census district, a proxy for land that could be habitat. Farm must exceed by at least 1 % point the census district average.

OPTION B

The farm must set aside at least 7% of their agricultural area to enhance biodiversity. Examples of countable areas: non-fertilized, species rich permanent meadows and pastures, fallow land (minimal period: 15 months), standard native fruit trees and isolated trees in suitable places (120 square yards per tree), hedges, copses and embankment copses, ditches, ponds and pools, marsh land, waste ground, piles and stacks of stones, drystone walls, non-made up natural paths.

For operations with multiple farms providing LFP products, each farm must meet this minimum requirement.

Energy Standard

Summary

This standard evaluates the extent to which farmers have plans in place to reduce energy inefficiency and packaging, and their implementation. It builds on elements of the Environmental Farm Plan process. Farmers receive up to 50 points for having a plan. If elements of the plan are being implemented, an additional 50 points can be acquired. Finally, if the farmer is going beyond the provisions of the Environmental Farm Plan, a further 50 points can be assigned. Total points available: 15

601. Part I – Developing a plan

Farmer has signed up for an EFP workshop. --- 15 points

OR

Farmer has submitted plan for peer review. --- 25 points

OR

Farmer's plan has been accepted. --- 50 points

OR

Farmer has an equivalent plan with comparable detail to an EFP. --- 50 points

Total points for this section: 50

602. Part II – The EFP provisions are being implemented

Farmer has implemented his/her farm plan (or equivalent) and has done some of the following (10 points per item, up to 50 points) (taken from EFP worksheets #6, 7, 13, 14):

- reuse and/or recycle plastic film coverings
- reuse and/or recycle packaging containers
- recycling petroleum product packaging, where programmes available
- reuse and recycling building materials as much as possible
- recycle oil, fuel and anti-freeze, where possible
- reuse machinery parts and take unusable parts to scrap dealer
- have refrigerants removed by certified personnel
- reuse or recycle tires
- eliminate water leaks in house and on farm
- install water conservation fixtures in house and farm buildings
- do not dispose of solvents and cleaning agents in the household or farm plumbing
- install high-efficiency lighting in house and farm buildings
- properly insulate and seal house and farm buildings

603. Part III – Going beyond current EFP requirements

Farmer is going beyond current EFP requirements and has done some of the following (10 points per item, up to 50 points):

- Capturing heat from crop, animal and industrial processes
- Energy efficient motors, appliances and equipment
- Greywater reuse programme
- 3R Programme for house and farm office
- Energy efficient and low waste packaging (if required) from farm to processor
- Energy efficient transport to processor or end user

604. Part IV - Bonus points

Bonus points are available for the following activities:

- Bonus: Renewable fuels are purchased for use in equipment and vehicles or farmer belongs to a windmill coop (10 pts)
- Bonus: On-farm energy generation for on-farm use or sale, including windmill, biofuel (not from sources that compete with the food chain), methane generation and small scale hydro (up to 20 points)

Appendix 5: Bloomberg Sustainability Rating Data Base, 2010 for Selected Food Processing and Retail Companies.

Bloomberg Sustainability Ratings Indicators	Units	Agrium	Loblaw Companies	Wal-Mart Stores Inc.	TESCO PLC	Whole Foods Market Inc.	Tyson Foods Inc.
ENERGY_CONSUMPTION	MWh	29289450	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WATER_CONSUMPTION	cubic meters	68000	Not disclosed	Not disclosed	1200	Not disclosed	104103.6
FUEL_USED		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
TOTAL_WASTE	tonnes	18.761	Not disclosed	Not disclosed	487	Not disclosed	159.064
TOTAL_CO2_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WASTE_RECYCLED		Not disclosed	Not disclosed	Not disclosed	400	Not disclosed	25.405
CO2_INTENSITY		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ISO_14001_SITES		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
DIRECT_CO2_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
NOX_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
INVESTMENTS_IN_SUSTAINABILITY		Not disclosed	Not disclosed	500	60	Not disclosed	1.9
TOTAL_GHG_EMISSIONS	tonnes	3426	Not disclosed	20214.73	4851	Not disclosed	Not disclosed
DISCHARGE_TO_WATER	tons/tonnes?	4.17449	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
RAW_MAT_USED		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
HAZARDOUS_WASTE	tonnes	4.798	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ELECTRICITY_USED		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PAPER_CONSUMPTION		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_SCOPE_1		Not disclosed	Not disclosed	5801.302	1813	Not disclosed	Not disclosed
TRAVEL_EMISSIONS		Not disclosed	Not disclosed	1298.324	Not disclosed	Not disclosed	Not disclosed
GHG_SCOPE_2		Not disclosed	Not disclosed	14413.43	3038	Not disclosed	Not disclosed
PARTICULATE_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENVIRON_FINES_AMT		1.119928	Not disclosed	Not disclosed	Not disclosed	Not disclosed	0.039478
SO2_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
INDIRECT_CO2_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
VOC_EMISSIONS		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
RENEW_ENERGY_USE		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENVIRONMENTAL_ACCTG_COST		Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
NUM_ENVIRON_FINES	number	51	Not disclosed	Not disclosed	Not disclosed	Not disclosed	4
CO2_INTENSITY_PER_SALES		Not disclosed	Not disclosed	Not disclosed	46.27	Not disclosed	Not disclosed

GHG_SCOPE_3	Not disclosed	Not disclosed	Not disclosed	49	Not disclosed	Not disclosed
WASTE_WATER	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
SULPHUR_OXIDE_EMISSIONS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
NUMBER_SPILLS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	57
ENVIRONMENTAL_AWARDS_RECEIVED	Not disclosed	2	Not disclosed		Not disclosed	
PAPER_RECYCLED	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
%_SITES_CERTIFIED	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
METHANE_EMISSIONS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ODS_EMISSIONS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PCT_RECYCLED_MATERIALS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GAS_FLARING	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
NUMBER_OF_SITES	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PCT_WATER_RECYCLED	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CARBON_MONOXIDE_EMISSIONS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PERCENT_OF_DISCLOSURE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WATER_PER_UNIT_OF_PROD	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
AMOUNT_OF_SPILLS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PHONES_RECYCLED	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
NUCLEAR_%_ENERGY	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
SOLAR_%_ENERGY	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENERGY_EFFIC_POLICY	Y	Y	Y	Y	Not disclosed	Y
ENVIRON_QUAL_MGT	N	N	N	N	Not disclosed	Y
WASTE_REDUCTION	N	Y	Y	Y	Not disclosed	Y
EMISSION_REDUCTION	Y	Y	Y	Y	Not disclosed	Y
GREEN_BUILDING	N	Y	Y	Y	Not disclosed	N
VERIFICATION_TYPE	N	N	N	N	Not disclosed	N
SUSTAIN_PACKAGING	N	Y	Y	Y	Not disclosed	Y
ENVIRON_SUPPLY_MGT	Y	Y	N	Y	Not disclosed	Y
CLIMATE_CHG_POLICY	N	N	Y	Y	Not disclosed	Y
CLIMATE_CHG_PRODS	N	Y	N	Y	Not disclosed	N
BIODIVERSITY_POLICY	N	Not disclosed	Y	Not disclosed	Not disclosed	N
NUMBER_EMPLOYEES_CSR	6618	140000	Not disclosed	468508	Not disclosed	104000
AWARDS_RECEIVED	Not disclosed	Not disclosed	35	2	Not disclosed	7
PCT_EMPLOYEES_UNIONIZED	7.4	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
COMMUNITY_SPENDING	1.33	Not disclosed	423	57	Not disclosed	Not disclosed
PCT_WOMEN_EMPLOYEES	Not disclosed	Not disclosed	59.78	Not disclosed	Not disclosed	Not disclosed
PCT_WOMEN_MGT	16	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
EMPLOYEE_TURNOVER_PCT	6.6	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed

WORK_ACCIDENTS_EMPLOYEES	Not disclosed	Not disclosed	Not disclosed	1489	Not disclosed	Not disclosed
FATALITIES_TOTAL	1	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
FATALITIES_EMPLOYEES	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
LOST_TIME_INCIDENT_RATE	1.01	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
LOST_TIME_ACCIDENTS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
FATALITIES_CONTRACTORS	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
EMPLOYEE_TRAINING_COST	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
EMPLOYEE_AVERAGE_AGE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PCT_MINORITY_EMPLOYEES	Not disclosed	Not disclosed	35.04	Not disclosed	Not disclosed	Not disclosed
PCT_DISABLED_IN_WORKFORCE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
PCT_MINORITY_MGT	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
SRI_ASSETS_UNDER_MANAGEMENT	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
FAIR_REMUNERATION_POLICY	N	N	N	N	Not disclosed	N
HEALTH_SAFETY_POLICY	Not disclosed	Y	Y	Y	Not disclosed	Y
EQUAL_OPPORTUNITY_POLICY	Y	N	Y	Y	Not disclosed	Y
TRAINING_POLICY	Y	Y	N	Y	Not disclosed	Y
HUMAN_RIGHTS_POLICY	Y	Y	N	Y	Not disclosed	N
UN_GLOBAL_COMPACT_SIGNATORY	N	Not disclosed	N	Not disclosed	Not disclosed	N
EMPLOYEE_CSR_TRAINING	Y	Not disclosed	N	Not disclosed	Not disclosed	N
ENERGY_INTENSITY_PER_SALES	5557770	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENERGY_INTENSITY_PER_EBITDA	34621090	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WATER_INTENSITY_PER_SALES	12903.23	Not disclosed	Not disclosed	28.14193	Not disclosed	4046.157
WATER_INTENSITY_PER_EBITDA	80378.25	Not disclosed	Not disclosed	349.4467	Not disclosed	92208.66
CO2_INTENSITY_PER_EBITDA	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WATER_INTENSITY_PER_ENERGY	0.002321655	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENERGY_INTENSITY_PER_EMPLOYEE	4425725	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
WATER_INTENSITY_PER_EMPLOYEE	10275.01	Not disclosed	Not disclosed	2.90514	Not disclosed	1000.996
CO2_INTENSITY	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CO2_INTENSITY_PER_EMPLOYEE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_INTENSITY_PER_SALES	650.0949	Not disclosed	57.98	89.29261	Not disclosed	Not disclosed
WATER_DISCHARGE_PCT	0.006138956	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_INTENSITY_PER_EBITDA	4049.646	Not disclosed	778.8075	1166.386	Not disclosed	Not disclosed
GHG_INTENSITY_PER_EMPLOYEE	517.6791	Not disclosed	Not disclosed	10.35415	Not disclosed	Not disclosed
COMMUNITY_SPEND_%_PRETAX_PROFIT	0.2033639	1.929587	Not disclosed	Not disclosed		
GHG_INTENSITY_PER_ENERGY	0.000116971	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
POL_DONATIONS_%_PRETAX_PROFIT	0.005178703	Not disclosed	Not disclosed	0	Not disclosed	Not disclosed
PAPER_CONSUMPTION_PER_EMPLOYEE	Not disclosed	Not disclosed	Not disclosed	Not disclosed		
TRAVEL_CO2_PER_EMPLOYEE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed

CO2_INTENSITY_PER_SALES	Not disclosed	Not disclosed	Not disclosed	46.27	Not disclosed	Not disclosed
TRAVEL_GHG_PER_EMPLOYEE	Not disclosed	Not disclosed	Not disclosed	0.1045873	Not disclosed	Not disclosed
TRAINING_SPEND_PER_EMPLOYEE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENERGY_INTENSITY_PER_BOE	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CO2_INTENSITY_PER_KWH_SOLD	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CO2_INTENSITY_PER_RPM	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
SRI_ASSETS_%_TOTAL_AUM	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_INTENSITY_PER_ELEC_SOLD	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_INTENSITY_PER_SQ_FT	Not disclosed	Not disclosed	Not disclosed	0.05484392	Not disclosed	Not disclosed
WATER_INTENSITY_PER_SQ_FT	Not disclosed	Not disclosed	Not disclosed	0.01759815	Not disclosed	Not disclosed
GHG_INTENSITY_PER_RPM	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ENERGY_INTENSITY_PER_SQ_FT	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CO2_INTENSITY_PER_GWH_SOLD	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
FUEL_CONSUMPTION_PER_RPM	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
CO2_INTENSITY_PER_SQ_FT	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
GHG_INTENSITY_PER_GWH_SOLD	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
BOARD_SIZE	12	13	14	18	10	10
INDEPENDENT_DIRECTORS	11	7	9	9	9	6
PCT_INDEPENDENT_DIRECTORS	91.67	54	64.29	50	90	60
BOARD_MEETINGS_PER_YR	10	Not disclosed	6	9	18	7
BOARD_MEETING_ATTENDANCE_PCT	100	Not disclosed	75	94.53	75	75
BOARD_DURATION	Not disclosed	Not disclosed	Not disclosed	Not disclosed	12	Not disclosed
%_WOMEN_ON_BOARD	27	Not disclosed	13.333	16.66	20	20
BOARD_AVERAGE_AGE	60.75	Not disclosed	53.47	55	56.2	59.1
AUDIT_COMMITTEE_MEETINGS	8	Not disclosed	15	5	11	9
POLITICAL_DONATIONS	0.03386872	Not disclosed	Not disclosed	0	Not disclosed	Not disclosed
BOARD_AGE_LIMIT	70	Not disclosed	Not disclosed	Not disclosed	Not disclosed	Not disclosed
ETHICS_POLICY	Y	Y	Y	Y	Not disclosed	Y
GRI_COMPLIANCE	Y	Y	N	N	Not disclosed	Y
CEO_DUALITY	N	Not disclosed	N	N	Y	N

Source: Bloomberg Data, 2010.