Conceptual Framework for Extended Life Cycle Assessment of Soy and Beef Chains

Farahnaz Pashaei Kamali, Miranda Meuwissen, and Alfons Oude Lansink
Business Economics Group, Wageningen University, The Netherlands
farahnaz.pashaeikamali@wur.nl **;** *miranda.meuwissen@wur.nl* **;** *Alfons.oudelansink@wur.nl*

Abstract

In the context of increasing concern about sustainable production of feed and food, this concept has initiated a debate on appropriate framework, tools and methods to evaluate food and feed along the chains. This paper presents literature review for evaluation of triple bottom line impacts of soy and beef chains in particular, and food chains in general. We reviewed literature on the sustainability of soy and beef chains and concluded that synchronous quantitative assessment of triple bottom line impacts along the soy and beef chains is currently lacking. We proposed to define a framework to bridge the gap between concepts of sustainability and carry out economic, environmental and social evaluation of food business cases especially for soy and beef chains. The framework includes defining relevant triple bottom line indicators, stakeholder preferences and defining quantitative methods for assessment of these impacts simultaneously. However, this paper is still under development and defining framework has been partly done. Moreover, stakeholders' preferences have not been finished yet.

Keywords: *soy chains, beef chains, LCA*

1 Introduction

The significant increase in global consumption of food due to population growth causes severe economic, social and environmental problems in the world (Tilman et al., 2002). In this context, sustainability emerged as essential agenda for whole nations. "Sustainable development has been defined as meeting the needs of the present without compromising the ability of future generations to meet their needs" (Baldwin, 2009). Currently this is regarded as a key concept for all societies and organizations to consider when dealing with the quality of life. Moreover, food sectors face the need to increase production while at the same time sustaining it (FAO, 2011). This makes sustainable food production a key issue on the agenda of scientists, policymakers, producers and other relevant stakeholders.

The concept of sustainability simultaneously considers social, ecological and economic issues of products and services. In order for decision makers to select among various 'sustainable products' triple bottom line (people, planet and profit) assessment concurrently is needed. In this way, it would be possible to select (and design) food production chains with e.g. less environmental degradation, economic instability and social insecurity. Furthermore, such integrated assessments would ideally cover the whole life cycle of a product to ensure inclusion of all relevant impacts including issues of waste, land use change and processing. Such 'life cycle thinking' has become gradually more important in the international community (UNEP/SETAC, 2009). Life cycle methods consider the entire life of products and services, provide a comprehensive view of impacts and are widely used and generally accepted for assessing impacts (Vries and de Boer, 2010).

Triple bottom line analyses covering whole life cycles of products along feed and food chains are however still rare today and are mostly qualitative. For instance, Heller et al. (2003) defined life cycle based sustainability indicators for assessing the U.S. food system, but the actual assessment was missing. Similar long-lists of sustainability indicators along food supply chains were put together by Yakovleva (2007) and Berkum, et al. (2008) without applying a real quantitative assessment. Likewise, Duchin (2005) accomplished a study on sustainable consumption of food focussing on environmental and economic input-output models based on life cycle thinking. However, he addressed the issue at the macro level which does not allow for conclusions at the detailed product level. Most of the works on food production to date have focused on the various environmental and economic impacts separately. Detailed analyses at the product level do exist, but they mostly focused on ecological sustainability (Boer, 2003, Thomassen et al., 2008, Lehuger et al., 2009).

Sustainability by itself in food supply chains covers broad range of activities, which is different from one supply chain to other. Therefore, specifying the assessment objective for particular supply chains can be the path to create the state of the art track in those specific food supply chains. Then it can be generalized and applied as a developed method for other food supply chains. In this regard, we focused on Latin America (LA) – Europe (EU), soy and beef chains. Latin America is one of the main producers and exporters of beef and soy where Europe is an important importer of these food sources (SALSA, 2010). Current production rates and circumstances in Latin America however cause various problems for the involved farmers, local communities and the environment, such as air and water pollution and a number of ecological diseases (Hillstorm and Collier, 2004). Moreover, for the production of the desired yields, surplus investments in production capacity and infrastructure are needed. There is a common interest between Latin America and Europe to sustain production and export of soy and beef (SALSA, 2010); however, this objective is not possible without defining systematic and organized way for evaluation of impacts. Therefore, it is the aim of this paper to design a state of the art framework for extended life cycle assessment (ELCA) concerning economic, environmental and social impacts of soy and beef chains. The preliminary basis for this framework is the diverse ideas and research outcomes of other scientists. This framework and the applied tools following it are intended to suggest a structured way of thinking about how to assess sustainability of soy and beef in particular and food chains in general. It also provides clear links from the literature in this field to the research goals and questions. Moreover, this framework will support decision makers in soy and beef supply chains who aim at minimising external effects of activities in whole product chains. Our focus is therefore on the types of impacts which are preferred by business and non-business stakeholders in soy and beef sectors. Furthermore, the extended LCA is hence developed to facilitate soy and beef supply chains to conduct business in a socially responsible, environmentally friendly and economically stable manner. For this purpose this paper addresses the following questions: first of all, what sustainability criteria must such an assessment methodology consider and measure in soy and beef chain? And how these criteria should be addressed and measured in available studies?

2 Methodology

To address the first aforementioned question, identification of key indicators is done. An indicator is defined as an impact which is quantitatively measurable or qualitatively analyzable. Up to this point, there have been few comprehensive lists of integrated sustainability impacts (economic, environment and social) (Heller and Keoleian, 2003, Yakovleva, 2007). This research is built upon previous work which surveyed a large component of the comprehensive impact assessment fields for classification and analysing in greater detail. The method is developed and subsequently expanded to include those economic, environmental, and social impacts which could be covered in a more comprehensive sustainability impact assessment.

The list of impacts will be prioritised and verified in a stakeholder workshop and also by questionnaire lists from farmers, experts, policy makers, citizens and consumers of soy and beef chains. The outcome of the literature review, workshop and survey will be the starting point for building up the list of indicators that should be included in any sustainability assessment of food supply chains.

To address question two, we reviewed twenty one LCA studies from scientific journals related to soy and beef chains (see Table 1 & Table 2). In Table 1 and Table 2, four main categories are selected for evaluation. These categories include: case study of proposed food supply chains (addressing the geographical area of the proposed products and services), system boundary of the intended study (referring to the parts of supply chain which are covered), the type of chain (to show the product(s) and service(s) that are evaluated, such as main products, post products, or by-products) and finally impact category (which will display the list of impacts that authors have assessed). Furthermore, six studies are reviewed for triple bottom line impacts (see Table 3 Table 4). The aim of this review is to investigate which studies have considered triple bottom line impacts.

3 Result and discussion

3.1 Literature review

There are many LCA studies dealing with different aspects of various soy and beef chains. Different researchers have approached by various methodological and framework adaptation either in one of the chain stages or through the whole chain. These are mostly models of different products and by-products by consideration of local and global impacts based on LCA approach.

Our proposed literature review is presented by defining the indicators and is followed by clarifying the gap of available studies regarding the simultaneous assessment of these indicators. Based on the obtained results, possible methods for evaluation of indicators (impacts) are defined. Relevant triple bottom line indicators will be identified through literature in the field of sustainability assessment, life cycle assessment, environmental impact assessment, economic feasibility analysis and value added chain analysis and also different databases (such as LCA and LCC impact assessment methods, FAO). In detail, the list of environmental impacts has been selected from literature and also from LCA impact methods such as Eco- Indicator 99, EPS, EDIP/UMIP 96 and RecCiPe 2008 (Baumann and

Tillman, 2004, Goedkoop et al., 2009). In addition, some of the social impacts (for instance human health) have possibility to be evaluated by LCA methods (Goedkoop et al., 2009).For those kind of impacts we also used LCA literature for defining indicators. The other social impacts have been selected generally from literature and reports (Labuschagnea and Brentb, 2005). Regarding economic impacts we chiefly used literature and also LCC guide books such as SETAC[1] publications (Swarr et al., 2011, Hunkeler et al., 2008).

Based on available literature in food and feed and other resources like FAO guidelines, Global Report Initiative, LCA reports and many other resources we have selected the list of impacts for each category. In terms of environmental perspective, global warming potential (GWP), ozone depletion (OD), land use change (LUC), cumulative energy demand (CED), eutrophication and acidification of water and soil (EP& AC) are the most common impacts. From this set of impacts a number of them have a global scope, while others have a regional one. It means that a particular environmental mechanism can have very important impacts in one region, but not in another (Goedkoop et al., 2009). According to economic impacts, the broad range of impacts is available. For instance Farm Income (FI), Future Direct Costs (FDC), Property Value (PV), Economic Prosperity Resilience(EPR), Burden of National Debt (BND) and Market Impacts (MI) have been defined (Hunkeler et al., 2008). These categories also address impacts in national and international level. Social impacts got less attention by life cycle analysts, cover pack of impacts with the core idea based on human wellbeing in all kinds. All relevant impacts to this category linked to human and activities causing impacts to Human's life. Employee Education (EE), Equality (EQ), Labour Rights (LR) and Human Health (HH) are most common social impacts (FAO, 2012, Hunkeler et al., 2008, Goedkoop et al., 2009, 3M-company, 2011, UNEP/SETAC, 2009).

In available studies the assessment of different soy and meat products have been done by using qualitative and quantitative models based on LCA approach. Such differences between LCA studies are often located in the goal and scope definition phase. We evaluated eleven studies for soy and ten studies for beef. This section presents an overview of previous studies on the application of life cycle assessment on sustainability pillars. The tables provide an overview of the basic assumptions within these studies; however, we do not aim to explain possible result variations. The main objective is to evaluate scenarios and scope of these studies to define the gap.

Environmental impacts assessment is one of the core objectives of life cycle assessment, so almost most of the studies rely on environmental LCA. United soy bean board (2010) accomplished a project focused on soy based lubricants. The main objective of this project was to update the cradle-to-gate data for LCA analysis. This study can be categorised under environmental impacts, since as a result of this study environmental inventory data on soybean processing, refining and production of key soy derived feedstocks have been added to previous databases. Thus, the main aim was inventory analysis of chain but not assessment of impacts (United Soy Bean Board, 2010). Likewise,   Li et al. (2006) assessed a number of impacts of soy oil production; however, the focus was only on processing phase with considering GWP and CED from environmental impacts. It means the overall chain impacts have not been evaluated [2](Li et al., 2006). Some researchers, Pradhan, et al. (2009), Majer, et al. (2009), and Adler, et al. (2007) carried out single issue assessment focused only

[1] SETAC: Society of Environmental Toxicology and Chemistry, http://www.setac.org/
[2] The evaluation of only specific part of chain is so called cut off criteria in LCA

on one impact category[3]. This method is implemented due to specific reasons, for instance request of organizations or companies to compare two similar products and services with just small differences.

In available literature, only one study (Hua et al., 2008) aimed to evaluate retail price of final product. This effort can be regarded as economic objective which aimed to compare similar products to show if it is economically preferable or not. Besides, Kytzia et al. (2004) carried out a life cycle based analysis which considered economy of natural resources of beef production. In general from economists' view the impacts which are decreasing profitability and stability of chain are categorised as economic impacts. Apparently, regarding these kinds of impacts based on LCA the available studies are rare. In literature, only one study (Pradhan et al., 2009) has targeted to address social life cycle assessment. The study considered employment education, equality, labour rights and human health and offer new approach for social life cycle assessment by methodological and potential application to product. Recently social LCA got specific attention, Dreyer et al.(2006) defied framework for social LCA and Labuschagnea et al. (2005) tried to develop social indicatores for project and technology life cycle management; however, real assesassment of social indicatores is still infant.

According to review of available LCA studies of soy and beef, number of studies which have taken into account economic, environmental and social aspects simultaneously is limited. Therefore, we tried to expand or change our research focus form LCA based assessment to sustainable soy and beef production. According to Table 3, five studies were reviewed for soy sustainability. The indicators that these studies have taken into account are not the same and each one considered different categories. As shown in Table 3, Berkum et al. (2008) carried out qualitative analysis for soy biodiesel in Brazil; the main focus of the study is social, economic and environment risk assessment. Hill et al. evaluated economic competitiveness, net social benefit and net energy balance of soy biodiesel production (Hill et al., 2006). Impacts of increasing economic profitability of products on different environmental and social indicators are considered as hot spots in most of articles. In this regard, Nepstad et al. (2003) targeted to show impacts of increasing economic profitability of soy bean production on deforestation and local society. This study is basically a qualitative approach (Daniel C. Nepstad et al., 2003). In addition, Jaccoud et al. (2003) have proposed in their paper to define the list of indicators for evaluation of Brazilian soy qualitatively (D'Alembert Jaccoud et al., 2003). A similar study has been accomplished by De Almeida et al. (2007); however, by defining the other indicators qualitatively for soy biodiesel (Edmar Fagundes De Almeida et al., 2007). Regarding the meat (beef) chain, only one study has evaluated triple bottom line impacts along the chain qualitatively (Dy´rmundsson, 2006). He has tried to address economics and farm income, resource utilization, landscape conservation, marketing of local value-added products maintenance of the rural population along the sheep chain in north Europe.

In brief, the review of available literature shows that many attempts have been made to develop the assessment of impacts in food supply chains by LCA approach. However, these studies basically focus on environmental impacts rather than others, therefore apparently

[3] This method of evaluation impacts is so called single issue assessment

available literature provides only a partial intuition of the problem and a simultaneous assessment of triple bottom line parameters along feed and food chains based on LCA is still missing. Also, the number of studies regarding soy and beef sustainability with consideration of triple bottom line impacts without LCA approach not only is few but also is limited to qualitative approaches. Based on literature review on existing studies regarding soy and beef and also taking into account their theoretical frameworks underlying different approaches and assessment methods, the conceptual framework is developed. This framework considers triple bottom line indicators simultaneously. For this purpose, food supply chains indicators are listed in three economic, environment and social categories. These three main categories include more detailed indicators or impacts. Literature review results help identifying the gap in each category. Defining possible methodology for assessing the impacts completes the conceptual framework (Figure 1).

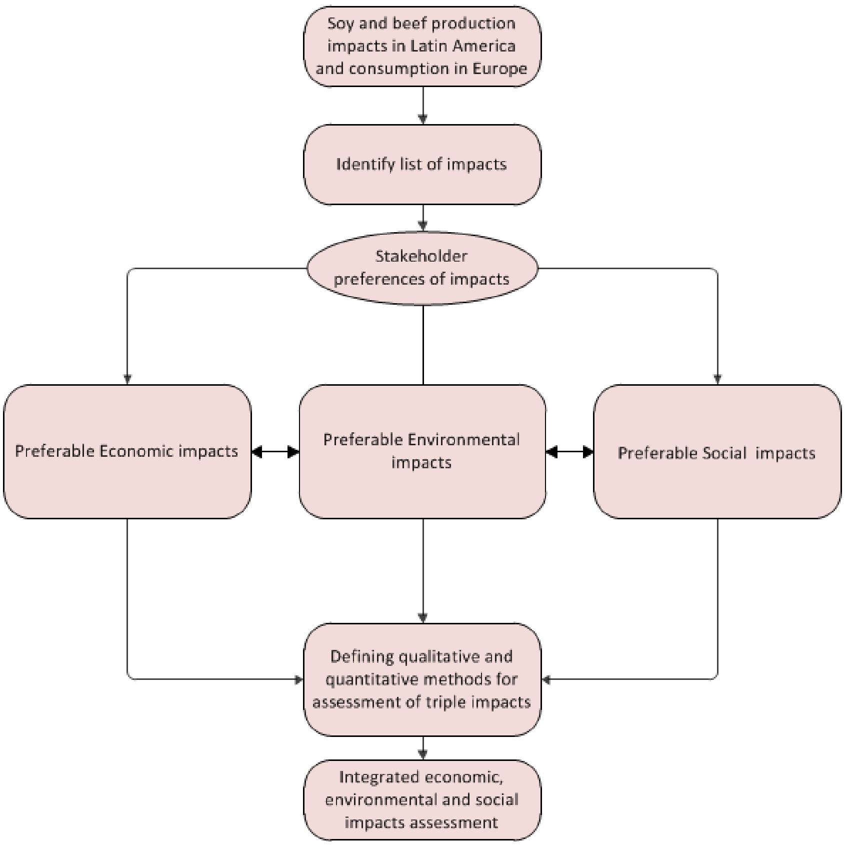

Figure 1. Conceptual Framework for Extended LCA

Table 1.
An overview of available soy life cycles and related impacts

Study soy	Case study	System boundary	Chain	Impact category (Soy)					Explanation
				Environmental impacts					
				GWP	OD	LUC	CED	LEI	
(USB, 2010**)**	USA	Cradle to gate	Soy based lubricants	×	×	-	×	×	Data Inventory
(Pradhan et al., 2009**)**	USA	Plantation-production	Soy biodiesel	-	-	-	×	-	
(Majer et al., 2009**)**	-	Full chain	Soy biodiesel	-	-	×	-	-	
(Adam J. Liska, 2009**)**	USA- Brazil	Full chain	Soy biodiesel	×	-	-	-	-	
(Hua et al., 2008**)**	USA	Full chain	Soy biodiesel	×	-	-	×	-	
(Dalgaard et al., 2008**)**	Argentina	Full chain	Soy meal	×	×	-	-	×	
(Hua et al., 2008**)**	China	Source to wheel	Soy biodiesel	×	-	-	×	-	Evaluation of retail cost
(Adler et al., 2007**)**	USA	Plantation	Soy biodiesel	×	-	-	-	-	
(Li et al., 2006**)**	-	Oil extraction phase	Soy bean oil	×	×	-	-	×	
(YONG LI, 2006**)**	-	Oil processing	Soy bean oil	×			×		Evaluation of processing method
(Berit Mattsson, 2000**)**	Brazil	Plantation	Soy bean	-	-	×	-	-	

GWP: Global warming potential, OD: ozone depletion, LUC: Land Use Change, CED: Cumulative Energy Demand, LEI: Local Environmental Impacts (soil, Water acidification and eutrophication)

Table 2
An overview of available meat life cycles and related impacts

Study Beef	Case study	System boundary	Chain	Impact category(beef)					Explanation
				Environmental impacts					
				GWP	OD	LUC	CED	LEI	
(Karen A. Beauchemin, 2010)	Canada	Farm (including feedlot)	Beef meat	×	-	-	-	-	
(Christel Cederberg, 2009)	Brazil – Sweden	Cradle- harbour (gate)	Beef & Milk	×	-	×	×	-	Brazil-Sweden chain
(McAlpine et al., 2009)	Australia, Colombia, Brazil	LCA(NA)	LCA(NA)	-	-	×	-	-	
(Upananda Paragahawewa, 2009)	New Zealand	Farm to gate	Cheese	-	-	-	-	-	Defined framework for S-LCA
(Núñez and Fermoso, 2005)	-	Cradle to gate	Meat	×	×	-	×	×	
(Kytzia et al., 2004)	Switzerland	Cradle to gate	Meat and Milk	-	-	-	-	-	Economy of natural resources
(Cederberg and Stadig, 2003)	Sweden	Cradle to farm gate	Milk & Beef	×	-	×	×	×	-
(Eide, 2002)	Norway	Cradle to gate	Industrial Milk	×	×	-	×	×	-
(Niels Jungbluth, 2000)	-	Cradle to gate	Meat	×	×	-	×	×	-
(Cederberg and Mattsson, 2000)	Sweden	Cradle-production phase	Organic Milk	×	×	×	×	×	

GWP: Global warming potential, OD: ozone depletion, LUC: Land Use Change, CED: Cumulative Energy Demand, LEI: Local Environmental Impacts (soil, Water acidification and eutrophication)

Table 3.
An overview of available soy three P impacts

Study soy	Case study	Product	Triple impacts (Environmental Economic, Social)	Explanation
(Siemen Van Berkum and Bindraban, 2008)	Brazil	Soy biodiesel	Environmental, economic and social risk assessment	
(Hill et al., 2006)	USA	Soy biodiesel	• Economic competitiveness, • Net social benefit • Net energy balance	
(Daniel C. Nepstad et al., 2003)	Brazil	Soy bean	• Deforestation • Farming systems • Local farmer	Impacts of increasing economic profitability of soy bean on deforestation and local society (theoretical approach)
(D'Alembert Jaccoud et al., 2003)	Brazil	Soy	• Zoning and land-use planning • Tax related policies • Best management environmental practices in agriculture • Legal Reserves and Protected Areas • Water management • Employment • Rural settlement and socio-development • Research and development	
(Edmar Fagundes De Almeida et al., 2007)	Brazil	Soy Biodiesel	• Deforestation • GHG emission • Land availability • Job quality • Low labour intensity • Health • cost price of feedstock	Defining the relevant factors qualitatively

Table 4.
An overview of available soy three P impacts

Study meat	Case study	Product	Triple impacts (Environmental Economic, Social)	Explanation
(Dy´rmundsson, 2006)	North Europe	Sheep	• Economics and farm income • Resource utilization • Landscape conservation, • Marketing of local value-added products • Maintenance of the rural population	Theoretical evaluation

3.2 *Method for impact assessment*

There are different methods capable to incorporate assessment of economic, environmental and social impacts. Some of the most well-known are life cycle assessment; life cycle costing, cost benefit analysis and activity based costing. However, there is no specific standard method that is applicable in all situations. The methodology and its application depend on goals and scopes of the study. In our literature review we have not investigated the applied methods in detail, since first of all almost most of these studies are based on LCA methodology and then the scope of our future work is different. However, we try to define measurement methods, possible for using assessment of integrated impact.

3.2.1 Defining the method for Economic impact assessment

Conventional Life cycle costing is based on a purely economic evaluation with consideration of various stages of life cycle (Hunkeler et al., 2008). This method helps to understand cost drivers of a product system to identify not only the deficiency of the system but also the improvement options. In this method costs are covered by real money flow as well as directly by one or more of the actors in the product life cycle. Actors are internal costs that generally are covered by the main producers or users (Swarr et al., 2011, Hunkeler et al., 2008). Since life cycle costing is an approach for estimation of economic impact assessment (similar to life cycle assessment), defining of indicators is crucial for measurement of this dimension of sustainability. By this method we will assess life cycle costing of different chains in standalone or comparable approach[4]. Furthermore, this methodology allows to identifying win-win situation and trade of in products life cycle alongside social and environmental life cycle (Swarr et al., 2011). For carrying out a life cycle costing a consistent accounting framework must be developed including reference time and currency. In this regard, two approaches for carrying out LCC are recommended By SETAC group: total cost of ownership (TCO) and activity based costing (ABC). TCO evaluates the total costs of using item; however, ABC covers the overall cost in addition to other general costs (including service costs)(Hunkeler et al., 2008).

3.2.2 Defining the method for environmental impact assessment

For assessing the environmental impacts we will use ReCeipe 2008 method (Goedkoop et al., 2009). This method is a life cycle method which deals with the impacts in two levels: midpoint and endpoint. Midpoint level impacts assessment is a traditional method determining impact category indicators at an intermediate point of the impact pathways (Goedkoop et al., 2009, Jolliet et al., 2004). In midpoint level, emissions of hazardous substances and extractions of natural resources are converted into the impact category. Assessment of environmental parameter “greenhouse gas emission”, as an example, can be measured by CO2 equivalents per kilogram of product over a period of 20 years (Goedkoop, et al., 2009). Consequently by this method the effect of a number of impact categories can be weighed for importance.

[4] Standalone LCA, assess’ product and services alone, comparable LCA, compares two or more products.

3.2.3 Defining the method for social impact assessment

Regarding social impacts we consider to use damage-oriented (endpoint) methods. These methods aim to interpret impacts results in the form of damage indicators at the level of social concern (Bare and Gloria, 2008, Jolliet et al., 2004). For instance, for evaluating human health damage the concept of disability adjusted life years (DALY) will be used. This method is categorised under endpoint impact categories. However, these endpoint methods just cover partly social impacts. For evaluation of comprehensive list of social impacts we need to apply some qualitative methods. Although some studies have tried to develop social life cycle assessment and its relevant methods (Dreyer et al., 2006), the number of studies addressing this issue are few and is infant.

4 Conclusion

This study presents a framework for extended LCA of soy and beef supply chains, with a focus on integrated impact assessment. The framework covers the entire sustainability life cycle of food supply chains especially soy and beef chains with emphasis on impact categories preferred by business and non-business stakeholders.

To design extended LCA and develop it rather than environmental LCA, two new categories, economic and social LCA, are proposed with different sub-categories. The extended LCA framework consists of two main parts: preferable impact categories are defined by stakeholders and defined lack of previous studies (regarding sustainability assessment of food supply chain) by literature review. The literature review shows that many attempts are made to assess the impacts of soy and beef chains. However, simultaneous assessment of triple bottom line impacts along the whole chain received less attention. Based on this gap and considering the possible methods for evaluation of impacts, the conceptual framework for extended life cycle assessment is developed (under development).

This extended LCA is supposed to be a valuable decision support tool. However, the framework will be developed thoroughly after getting the results of stakeholder surveys and interviews.

References

3M-Company (2011). 3M Company - 2011 Sustainability Report.

Adam, J., Liska, H. S. Y., Virgil, R., Bremer, Terry J., Klopfenstein, Daniel T., Walters, Galen E. Erikson, and Kenneth, G. Cassman (2009). Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol. *Industrial Ecology,* **13:** 58-74.

Adler, P. R., Del Grosso, S. J., and Parton, W. J. (2007). Life-cycle assessment of net greenhouse-gas flux for bioenergy cropping systems. *Ecological Applications,* **17:** 675-691.

Baldwin, C. J. (2009). *Sustainability in the Food Industry,* Iowa Wiley-Blackwell

Bare, J. C., Gloria, T. P. (2008). Environmental impact assessment taxonomy providing comprehensive coverage of midpoints, endpoints, damages, and areas of protection. *Journal of Cleaner Production,* **16:** 1021-1035.

Baumann, H., Tillman, A.-M. (2004). *The Hich Hiker's Guide to LCA,* Lund, Studentliterature AB,Lund, Sweden.

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

Boer, I. J. M. D. (2003). Environmental impact assessment of conventional and organic milk production. *Livestock Production Science,* **80:** 69-77.

Cederberg, C., Mattsson, B. (2000). Life cycle assessment of milk production — a comparison of conventional and organic farming. *Cleaner Production,* **8:** 49–60.

Cederberg, C., Stadig, M. (2003). System Expansion and Allocation in Life Cycle Assessment of Milk and Beef Production. *Jurnal of Life Cycle Assessment,* **8:** 350-356.

Christel Cederberg, C. C., Flysjö, A.(2009). Life cycle inventory of greenhouse gas emissions and use of land and energy in Brazilian beef production.

D'alembert Jaccoud, Stephan, P., Lemos De Sá , R., and Richardson, S. (2003). Sustainability Assessment of Export-Led Growthin Soy Production In Brazil.

Dalgaard, R., Schmidt, J., Halberg, N., Christensen, P., Thrane, M., and Pengue, W. (2008). LCA of Soybean Meal. *Jurnal of Life cycle assessment,* **13:** 240-254.

Nepstad, Daniel C., Stickler, Claudia M., and Almedia, O. T. (2003). Globalization of the Amazon Soy and Beef Industries: Opportunities for Conservation. *Conservation Biology,* **20**: 1595–1603.

Dreyer, L. C., Hauschild, M. Z., and Schierbeck, J. (2006). A framework for social life cycle impact assessment. *Jornal of Life cycle assessment,* **11:** 88-97.

Duchin, F. (2005). Sustainable Consumption of Food: A Framework for Analyzing Scenarios about Changes in Diets. *Industrial Ecology,* **9:** 99-114.

Dy´Rmundsson, O. L. R. (2006). Sustainability of sheep and goat production in North European countries—From the Arctic to the Alps. *Small Ruminant Research,* **62**: 151–157.

Fagundes De Almeida, E., Bomtempo, J.V., and Silva, C. M. D. S. E. (2007). The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis. Rio De Janeiro.

Eide, M. H.(2002). Life Cycle Assessment (LCA) of Industrial Milk Production. *Life cycle aseessment,* **7:** 115-126.

FAO (2011). Sustainability Assessment of Food and Agriculture systems (SAFA). Natural Resources Management and Environment Department

FAO (2012). Sustainability Assessment of Food and Agriculture Systems (SAFA). Natural Resources Management and Environment Department Food and Agriculture Organization of the United Nations

Goedkoop, M., Heijungs, R., Huijbregts, M., Schryver, A. D., Struijs, J., and Zelm, R. V.(2009). ReCiPe 2008. PRé Consultants, Amersfoort, Nwthwerands, CML, University of Leiden, Netherlands, RUN, Radboud University Nijmegen Netherlands, RIVM, Bilthoven, Netherlands.

Heller, M. C., Keoleian, G. A. (2003). Assessing the sustainability of the US food system: a life cycle perspective. *Agricultural System,* **76:** 1007-1041.

Hill, J., Nelson, E., Tilman, D., Polasky, S., and Tiffany, D. (2006b). Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *PNAS,* **30:** 11206–11210.

Hillstorm, K., Collier, L. (2004). *Latin America and the Caribbean: a continental overview of environmental issues,* California.

Hua, Z., Tan, P., Yan, X., and Lou, D. (2008). Life cycle energy, environment and economic assessment of soybean-based biodiesel as an alternative automotive fuel in China. *Jurnal of Energy,* **33**.

Hunkeler, D., Lichtenvort, K., and Rebitzer, G. (2008). *Environmental Life Cycle Costing,* Pensacola, Florida, SETAC(Society of Environmental Toxicology and Chemistry).

Jolliet, O., Muller-Wenk, R., Bare, J., Brent, A., Goedkoop, M., Heijungs, R., Itsubo, N., Pena, C., Pennington, D., Potting, J., Rebitzer, G., Stewart, M., Udo De Haes, H., and Weidema, B.(2004). The LCIA midpoint-damage framework of the UNEP/SETAC Life Cycle Initiative. *International Journal of Life Cycle Assessment,* **9:** 394-404.

Beauchemin, K. A., Shannan, H. H. J., Little, M., Mcallister, T. A., and Mcginn, S. M. (2010). Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. *Agricultural Systems,* **103:** 371-379.

Kytzia, S., Faist, M., and Baccini, P. (2004). Economically extended—MFA: a material flow approach for a better understanding of food production chain. *Cleaner Production,* **12:** 877–889.

Labuschagnea, C., Brentb, A. C. (2005). Sustainable Project Life Cycle Management: the need to integrate life cycles in the manufacturing sector. *International Journal of Project Management,* **23:** 159-168.

Lehuger, S., Gabrielle, B., and Gagna, N. (2009). Environmental impact of the substitution of imported soybean meal with locally-produced rapeseed meal in dairy cow feed. *Cleaner Production,* **17:** 616- 624.

Li, Y., Griffing, E., Higgings, M., and Overcash, M. (2006). Life Cycle Assessment of Soybean Oil Production. *Journal of Food Proces Engineering,* **29:** 429-445.

Majer, S., Mueller-Langer, F., Zeller, V., and Kaltschmitt, M. (2009). Implications of biodiesel production and utilisation on global climate - A literature review. *European Journal of Lipid Science and Technology,* **111:** 747-762.

Mcalpine, C. A., Etter, A., Fearnside, P. M., Seabrook, L., and Laurance, W. F. (2009). increasing world consumption of beef as a driver of regional and global change: A call for policy action based on evidence from Queensland(Australia), Colombia and Brazil. *Elsevier,* **19:** 21-23.

Jungbluth, N.,Scholz, O.T., and Roland W. (2000). Food Purchases: Impacts from the Consumers' Point of View Investigated with a Modular LCA. *Life cycle aseessment,* **134:** 134-142.

Núñez, Y., Fermoso, J. (2005). Comparative life cycle assessment of beef, pork and ostrich meat: a critical point of view. *Agricultural Resources Governance and Ecology,* **4:** 140-151.

Pradhan, A., Shrestha, D., Mcaloon, A., Yee, W., Haas, M., A. Duffield, J., and Shapouri, H. (2009). Energy Life-Cycle Assessment of Soybean Biodiesel.

SALSA(2010). Knowledge-based sustainable value-added food chains: innovative tools for monitoring ethical, environmental and socio-economical impacts and implementing Eu-Latin America shared strategies. Project Group.

Van Berkum, S., Bindraban, P. S.(2008). Toward sustainable Soy. LEI Wageningen UR.

Swarr, T. E., Hunkeler, D., Klöpffer, W., Pesonen, H.-L., Ciroth, A., Brent, A. C., and Pagan, R. (201)1. *Environmental Life Cycle Costing, Acode of practice*, SETAC.

Thomassen, M. A., Dalgaard, R., Heijungs, R., and Boer, I. (2008). Attributional and consequential LCA of milk production. *Life Cycle Assessment,* **13:** 339-349.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., and Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature,* **418**: 671-677.

UNEP/SETAC 2009. Guidelines for Social Life Cycle of Products. UNEP/SETA.

Upananda Paragahawewa, P. B., and Small, B. (2009). Social Life Cycle Analysis (S-LCA): Some Methodological Issues and Potential Application to Cheese Production in New Zealand. AgResearch.

USB (2010). Soybean Production Costs An Analysis of the United States, Brazil, and Argentina. United Soybean Board.

Vries, M. D., De Boer, I. J. M. (2010). Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livestock science,* **128**: 1-11.

Yakovleva, N. (2007). Measuring the Sustainability of the Food Supply Chain: A Case Study of the UK. *Environmental Policy & Planning,* **9**:75-100.

Yong Li, E. G., Higgins, M., and Overcash, M. (2006). Life Cycle Assessment Of Soybean Oil Production. *Food process engineering,* **29:** 429-445.