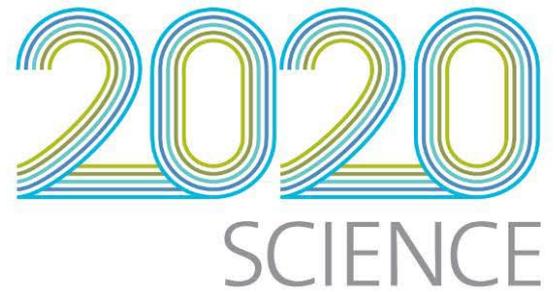# Social Life Cycle Analysis (S-LCA): Some Methodological Issues and Potential Application to Cheese Production in New Zealand

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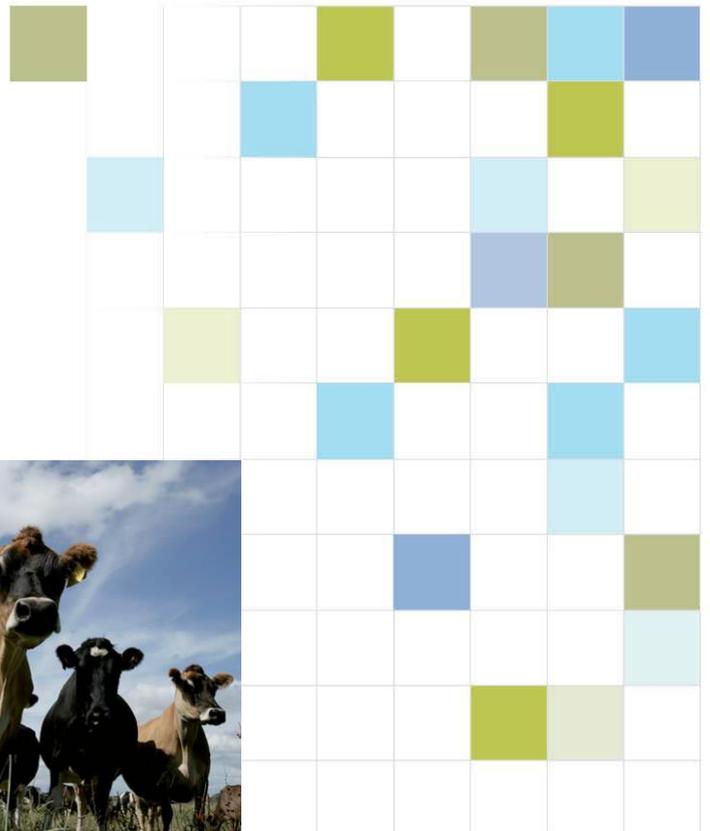
Social Life Cycle Analysis (S-LCA): Some Methodological Issues and Potential Application to Cheese Production in New Zealand

June 2009

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1. Executive summary

This was an internally funded AgResearch AR&C project. The purpose of the project was to develop AgResearch capability in Social Life Cycle Assessment (S-LCA) through a case study of New Zealand cheese production. However, S-LCA is a very new field with few studies conducted and few papers discussing potential methodologies. Indeed, when the project began, there was no established and agreed upon methodology or framework published, nor were there any authoritative guidelines on how to conduct S-LCA. As a consequence, the focus of the project has been on the analysis of the relatively sparse and inconsistent existing literature and the development of a framework suitable for conducting a S-LCA case study of New Zealand cheese production. This report presents the framework that was developed and discusses its application to the case study. To our knowledge, there have been no other studies on S-LCA of any food production process.

The aim of S-LCA is twofold; first, to bring life cycle thinking to the analyses of the social impacts of the production, consumption and disposal of products, processes and services, and second, to further develop life cycle thinking so that it may be a more useful tool in the pursuit of the goal of sustainable development and consumption. Traditionally, Life Cycle Assessment (LCA) was primarily concerned with environmental impacts (referred to in this document as E-LCA). However, sustainability thinking is usually considered to also include at least two other dimensions; the economic and the social. Within life cycle thinking, Life Cycle Costing (LCC) has been developed to consider economic impacts and S-LCA is currently under development to include the social dimension.

In order to understand the concepts and process of S-LCA, it is important to consider E-LCA. The LCA community was keen to develop S-LCA so that it is harmonised with E-LCA with the intention that E-LCA, LCC and S-LCA might be integrated in such a way as to provide a powerful tool for decision making with respect to sustainable development and consumption. Therefore, this report first focuses on explicating aspects of E-LCA that are particularly relevant to S-LCA. It then moves to discussing how these aspects are reflected in S-LCA theory and practice. Despite the currently immature development of S-LCA, we believe that the technique has significant future potential as a tool to aid the sustainable development imperative.

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2.   Introduction

Environmental Life Cycle Assessment (E-LCA) is a technique developed to assess the environmental impacts associated with a product, process, or service over its entire life cycle, from 'cradle to grave'. Two principal environmental impacts are accounted for: resource appropriation and environmental emissions. E-LCA allows a cumulative estimation of the environmental impacts from the extraction of raw materials required to make a good or service, through the production chain, the distribution chain, the use phase, and finally through to the disposal stage when the materials are reused, recycled or returned to the earth in landfills or incinerated (Scientific Applications International Corporation, 1996).

The life cycle thinking approach provides the basis for a full evaluation of environmental impacts of any given activity (production of good or service) and facilitates process improvement through highlighting environmental 'hotspots' and unexpected externalities requiring attention. Alternatively, E-LCA may be used to compare the resource use and environmental emissions produced by similar competing goods and services – thus allowing the selection of the good or service from the most environmentally benign and eco-efficient source. E-LCA can be used to help reduce the environmental impacts of the production of goods and services. Therefore, it is an important tool for use in the progress towards the goal of environmental sustainability. Historically, Life Cycle Assessment (LCA) and life cycle thinking grew out of the engineering discipline and has primarily focussed on the environmental impacts of products and services. More recently, the LCA community has begun to consider how life cycle thinking and LCA might contribute to the imperative of sustainable development.

It is clear that sustainable product and service development and consumption are important components of sustainable development in general. Sustainable development was defined by the World Commission on Environment and Development (WCED) as "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own" (WCED, 1987). However, it is well recognised in the sustainability literature that environmental sustainability is only one of a number of dimensions of sustainable development.

Although the concept of sustainability still seems to be evolving, with a range of variations of sustainability frameworks proposed by various authors and authorities, there are at least two other dimensions usually considered as essential; the economic

and the social dimensions (some frameworks also propose additional dimensions, for example cultural, institutional or political). The LCA community takes the three pillars approach to sustainable development of social, environment and economy, which they sometimes refer to as the 3P's – People, Planet, Prosperity (UNEP, 2009).

If life cycle thinking is to play a more comprehensive role in the sustainability imperative, then it must also address the issues of economic and social sustainability. A comprehensive LCA tool for sustainable product development and consumption must be able to assess the impacts or contribution of a product, its production process, its use and disposal across all dimensions of sustainability simultaneously (Bassett-Mens, Small, Paragahawewa, Langevin, Blackett, 2008). In other words, it must have environmental, social and economic components integrated into the overall assessment. To date, there are few tools which posses these qualities, however, Life Cycle Assessment (LCA) has considerable potential to evolve and fill this gap. Indeed, members of the LCA community are currently investigating the potential of LCA to achieve this goal.

For this purpose, two relatively new tools or process, Life Cycle Costing (LCC) and Environmental Life cycle Costing (E-LCC), are currently being developed and used by the LCA community for assessing the economic impacts of products and services over their entire life cycle. However, the application of LCA techniques to account for the social impacts of product development and consumption over the entire life cycle is a new area. At the commencement of this project, a small number of published papers discussed different approaches to S-LCA, but there were no official guidelines, nor any agreement upon a framework or method for conducting S-LCA of products and services. Indeed, there were very few published attempts at S-LCA at all, and none, that we were able to find, in the area of agriculture or food production.

The main objective of this report is to discuss the evolution of S-LCA with a view to constructing effective methods to include the social aspects of agricultural production activities from a life cycle perspective. In particular, our original purpose was to elaborate on a methodology to assess social aspects of cheese production in New Zealand. However, upon starting the project, it was apparent that due to the lack of an existing framework for conducting S-LCA, our primary need was, first, to develop a S-LCA framework. That is the initial focus of this report.

Coincidently, just as this project came to completion, the United Nations Environmental Programme (UNEP), the Society for Environmental Toxicology and

Chemistry (SETAC) and the Life Cycle Initiative (UNEP, 2009) published the first official set of "Guidelines for Social Life Cycle Assessment of Products" (hereafter referred to as 'the Guidelines'). Fortunately, there is a considerable similarity in approach between the framework that we have developed and that proposed in the Guidelines. Clearly, the Guidelines will become the standard framework to which S-LCA researchers will seek to harmonise and standardise the S-LCA process. However, the Guidelines admit that S-LCA is a subject fraught with difficulty and that much work remains to be done to develop a rigorous and standardised S-LCA methodology.

In order to understand S-LCA it is necessary to consider how E-LCA (originally just referred to as LCA) developed.

2.1   The History of LCA

The earliest LCA work appeared in the late 1960's and early 1970's in two main forms. First, as Resource and Environmental Profile Analysis (REPA), this process was a quantification of resource use and environmental releases for any given product. In Europe this process was known as Ecobalance. Second, as energy efficiency research; this research was driven by the world oil shock/energy crisis of the 1970's. Both of these methodologies were fuelled by growing social and business concerns over the availability of future resources and raw materials (Scientific Applications International Corporation, 1996). Publications such as "The Limits to Growth" commissioned by the Club of Rome (Meadows, Meadows, Randers and Behrens, 1972) and Rachel Carson's "Silent Spring" (Carson, 1962) were beginning to bring many new issues around resource availability and use and environmental pollution in to the public arena. Azapagic and Perdan describe this as a reactive phase for sustainable development, where the focus was on quick fix or end of pipe solutions generally driven by regulation.

To begin with, the initial focus of LCA's predecessors was energy efficiency with some secondary consideration of waste products and the consumption of raw material. Motivation was primarily concerned with reducing the cost of production and achieving efficiency gains rather than addressing environmental impacts or externalities. Early examples include Coca Cola's (1969) internal review of resource consumption and environmental releases associated with various types of beverage containers (Jensen et al., 1998). As part of this study, raw material and fuel inputs required for different type of containers where quantified along with the 'environmental loadings' from each

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different manufacturing process (Scientific Applications International Corporation, 1996).

Both the REPA and energy efficiency approaches developed specific methodologies and protocols for application which evolved under the influence of various agencies, industries and academics. Development continued in both the US and Europe, although somewhat slower, once the oil crisis abated. However, a renewed interest in LCA appeared as concerns about household and hazardous waste management grew in the late 1980's (Scientific Applications International Corporation, 1996). The field broadened and evolved during the 1980's in what appears to be a diffuse manner with several key schools of thought developing in Europe and the US.

The need for a rigorous methodology to standardise the practice of LCA was evident early on, in that, if LCA's were conducted using different methodologies then it was difficult or impossible to compare one LCA with another or, for different researchers conducting an LCA on the same product to reliably reproduce similar results.

The 1990's were, for LCA methodologies, a time of method standardisation as the field became defined by a series of negotiated guidelines and universal standards (Guinee, Gorrée, Heijungs, Huppes, Kleijn,and Koning, 2002). Pressure to standardise LCA methods, according to Scientific Applications International Corporation (1996), originated due to concerns from numerous quarters that LCA was being used to market "green' products with no sound methodological basis. Key players in the evolution of LCA standards were, and still are, The Society for Environmental Toxicology and Chemistry (SETAC), the International Organisation for Standardisation (ISO) and the United Nations Environment Programme (UNEP).

SETAC became involved with LCA in 1989 principally from a scientific perspective. They represent the research side of LCA and hold several annual meetings/conferences around LCA research and application. Guinee et al., (2002) suggest there is a division in interest between the European and North American SETAC braches with the former focusing more on the development and harmonisation of LCA methodology and the later analysing the limitations of LCA.   SETAC published "A Technical Framework for LCA" in 1991 as a first attempt at creating a standardised approach to LCA. This work was advanced in "the Nordic Guidelines on Life Cycle Assessment" published in 1995 (Guinee et al., 2002). This organisation still plays a significant role in LCA debate and process evolution and has formed a partnership with UNEP called the "Life Cycle Initiative".

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ISO became involved in 1994 to produce the first complete series of standards for LCA (14040 series). This first standard brought together the different schools of thought on LCA and forced them to agree on terminology and the wording of the standards. The final result, published in 1997, was a standard set of methods and shared definitions and concepts to apply to any given situation. This publication has effectively superseded all other previous standards and guidelines for LCA practitioners.   Issues covered by the guidelines include technical, organisational (i.e., design and review processes) and stakeholder involvement aspects of an LCA (Guinee et al., 2002). ISO continues to play a role in LCA through updating standards as required.

UNEP is another major player in LCA. They have been involved in numerous LCA publications and work extensively with SETAC. UNEP has a particular interest in the application of LCA techniques in developing economies (Guinee et al., 2002). Overall, the development of LCA has been strongly supported by an increasing environmental awareness in OECD countries coupled with strengthening environmental legislation and quality standards. Moreover, the increasing interest and concern of consumers regarding the impacts and origins of their food, other goods and services on the environment has also provided an impetus for the development of LCA tools.

2.2   The birth of S-LCA

In the late 1990's 'life cycle thinking' gained increasing traction in the international community being mentioned in the World Summit on Sustainable Development declaration in 2002 (UNEP, 2009).   UNEP describes life cycle thinking as being "…about going beyond the traditional focus on production sites and manufacturing processes so that the environmental, social, and economic impact of a product over its entire life cycle, including the consumption and end use phase, is taken into account" (http://www.unep.fr/scp/lifecycle). UNEP (2009, p.29) identified the following life cycle thinking benefits "Life cycle approaches avoid shifting problems between life cycle stages or between geographic areas. The shifting of one type of problem to another can be avoided as well."

Elucidating the relationship between life cycle thinking and the consumer, UNEP (2009, p.8), in the Guidelines, states "Buyers are now drived (sic) to be conscious of the effects their choices have on our environment and on the local economies. Do we buy from the farm stand or the supermarket? Which choice will result in a less polluted, more sustainable globe? Perhaps even more daunting is the fact that some of our choices will have social and socio-economic effects as well, not only on workers

but also on entire communities where production takes place. The social and socio-economic consequences are the primary concern of a social and socio-economic life cycle assessment (S-LCA)."

As well as enhancing consumers' ability to choose between products or services on the basis of their social impacts, S-LCA can also facilitate the social responsibility of companies by "providing information about the potential social impacts on people caused by the activities in the life cycle of their product" (Dreyer, Hauschild and Schierbeck, 2006, p.81). This company oriented approach to S-LCA is different from E-LCA and its consequences will be considered later in this paper.

Since the turn of the century, several authors have argued the need for, feasibility of, or attempted to carry out, a product S-LCA (e.g. Labuschagne and Brent, 2006; Dreyer et al. 2006; Grieβhammer et al., 2006; Hunkeler, 2006; Klopffer, 2003). However, S-LCA is in its infancy compared to E-LCA. This is reflected in the literature debates around how to undertake the early stages in the conceptual LCA model. Nonetheless, it is generally considered that S-LCA has a great deal of potential to add a further dimension to E-LCA, making the approach more holistic and a step closer to a tool to assist in moving towards sustainable production and consumption.

This report explores the current debates in S-LCA, summarising and evaluating them with the aim of developing a conceptual framework appropriate to a S-LCA of Cheese production in New Zealand.

3.   The Social LCA process

The idea of including social aspects in LCA was picked up in 2006 by the UNEP-SETAC Life Cycle Initiative Cross cutting taskforce 3. This task force agreed to follow an approach similar to that proposed by ISO 14040 for environmental life cycle analysis (E-LCA) (Grieβhammer et al., 2006). As a result, Social LCA methodology, like E-LCA, consists of four steps;

1.   Goal definition,
2.   Scope definition,
3.   Inventory analysis,
4.   Impact assessment.

Although Social LCA researchers generally agree with maintaining the four steps to retain familiarity and comparability of approach with E-LCA, numerous other aspects

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of the methodologies are the subject of ongoing debate in the literature and a number of differences between E-LCA and S-LCA have been identified. One important difference concerns the nature of impacts. Environmental impacts tend to be negative (the term 'impact category' is sometimes used interchangeably in E-LCA with 'damage category'), whereas in the social realm impacts may be either negative or positive as compared with a specific human value, or normative standard sanctioned or mandated by society.

3.1 Area of Protection (AoP

In E-LCA the primary intent is to sustain or protect existing environmental qualities in line with society's values regarding the environment. Thus, in E-LCA the environmental qualities that are valued by society and which require sustaining or protecting are denoted as Areas of Protection (AoP). Four AoP's have been defined in E-LCA. These are: human health (as impacted by environmental factors – clearly an anthropocentric interpretation of environment - this AoP was included in the E-LCA process before the development of S-LCA), the natural environment, natural resources, and the man made environment (Udo de Haes et al., 2002).

Dreyer et al. (2006) discussed the application of the concept of AoP from E-LCA to impact assessment in S-LCA. They proposed a new AoP "human dignity and well being" to supplement the "human health" AoP addressed in E-LCA. Weidema (2006) also suggests including human well being in the AoP. Similarly, the Guidelines state: "…the ultimate goal of S-LCA technique is to promote improvement of social conditions throughout the life cycle of a product, human wellbeing is a central concept" (UNEP, 2009, p.22).

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The overall application of the LCA methodology is seen in figure 1

Figure 1:. Illustration of the application of the S-LCA concept to the life cycle of dairy products (adapted from (Grieβhammer et al., 2006).
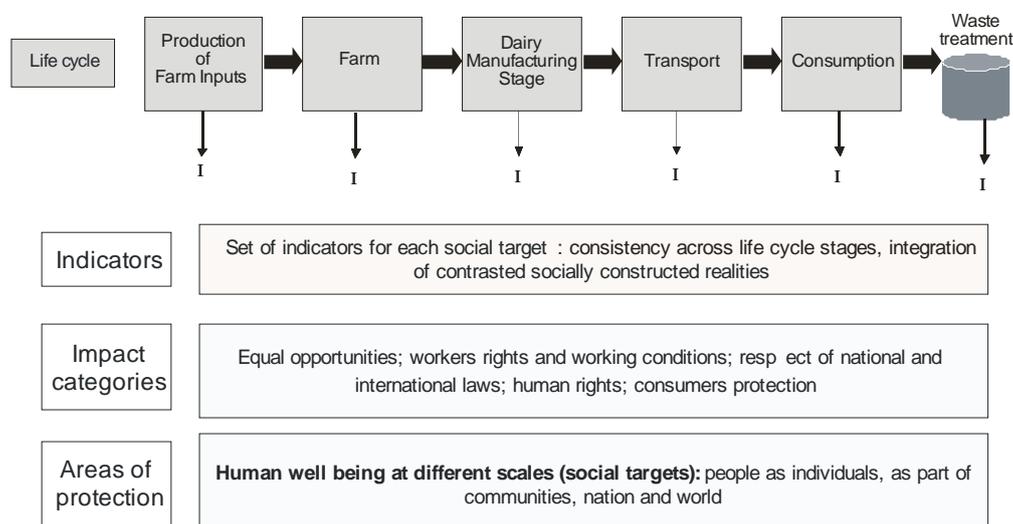
This diagram follows the standard E-LCA framework with each step of the product life cycle assessed by indicators relevant to impact categories in the Area of Protection (AoP). Across the top of Figure 1 are the stages of the dairy product life cycle from cradle to grave, beginning with the production of farm inputs and ending with waste treatment. At the base of the diagram is the AoP, tentatively defined as 'human dignity and wellbeing', for S-LCA. A range of potential impact categories can be identified for this AoP. These may come from a variety of sources; international laws (Human Rights, Labour laws), local laws, social norms regarding wellbeing and dignity etc. For each impact category it is necessary to determine indicators that accurately assess its state.

3.2 Goal definitions in S-LCA studies

The first step in the S-LCA process is to define a clear goal which then shapes how the study is undertaken. This should answer questions such as "why is this S-LCA being conducted? Who is it being done for or who will the audience be? How do they intend to use the results? Two main classes of goals can be identified from past studies; A product, process or company comparison (Methot, 2005; Schmidt et al., 2004), or identification of product or process improvement potentials (Flysjo, 2006; Dreyer et al., 2006; Manhart and Grieβhammer, 2006; Gautier, 2005). The first type of goal is characterised by questions such as 'which of two similar products produced by different processes or companies has the least negative social impacts or the greatest

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social benefits? A S-LCA with this goal will provide an assessment of the social impacts of the product, process or company and allow comparisons with other similar products produced by different processes or companies and provide the necessary information for consumers wishing to make ethical choices regarding their product consumption.

The second goal is designed to answer questions such as 'are there any places, or processes in the production chain that have a negative social impact (or impacts that may be improved), if so who are the victims, where in the chain does it occur and how might it be addressed. This type of goal enables the identification of social 'hotspots' (e.g., breaches of International Labour Laws, human rights etc) in the production chain of a good or service so that the social problem may be become the focus of remedial action by the company involved.

3.3   Scope definitions in S-LCA studies

The main purpose of the scope definition is to delimit the assessment of the study. Thus, it should describe the product system to be studied and define the depth and breadth of the study. The function, or product utility, and its functional unit for the S-LCA analysis (if, and when, appropriate) should be identified. The function or product utility is the use that consumers get from the product. According to UNEP (2009) the functional unit for which comparisons can be made across products must be based on the function rather than the product item. However, this point may be more pertinent to the use phase of the product than the production phase where often the impacts of a specific quantity of the product appear the most sensible functional unit.

The impact categories (including any sub-categories), their indicators and data quality requirements and any study assumptions and limitations should also be described as part of the scope. These are all standard requirements in an E-LCA. In the case of S-LCA, because the AoP is human dignity and wellbeing and S-LCA is about impacts on people, the stakeholder groups whose dignity and wellbeing may be affected by the life cycle of a product or service also need to be identified. The recent Guidelines published by UNEP (2009) identify the following five main stakeholder categories as being relevant to S-LCA: workers/employees, local community, society (national and global), consumers, and value chain actors. They note that further categories might be added such as NGOs, the state, and future generations. The latter would seem particularly relevant in the context of the WCED's definition of sustainable development quoted previously.

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There is a marked division among S-LCA researchers in their approach to scope definition. Some researchers favoured a method similar to E-LCA which focuses on the process of the product development (Schmidt et al., 2004). This method has the advantage of being consistent with and able to take an E-LCA as the starting point for an S-LCA. This approach is consistent with the framework illustrated in Figure 1.

Others S-LCA researchers (Spillemaeckers et al., 2004; Dreyer et al., 2006) questioned the process based approach and suggest that the conduct of the companies should be the main component of the S-LCA analysis. They reason that "social impacts on people in the life cycle of a product have a more clear relation to the conduct of the companies involved in the product chain – and to the way the companies organise and manage their business (Dreyer et al., 2006, p.89). Thus, two companies producing the same products could have the same environmental impacts, as measured by an ELCA, but could have completely different social impacts (e.g., different working conditions and remuneration for workers and different socio-economic impacts for the local community). The company approach shares a considerable similarity to the concept of Corporate Social Responsibility (CSR)

However, Spillemaeckers et al. (2004), and Dryer et al. (2006) point out that, with the conduct of companies approach, there is a problem over how much of the company's total social impacts should be allocated to the process included in the assessed product or service (the company might for example make a number of different products). Dreyer et al. (2006) argued that a share of the total amount of impacts created by the company involved in the product system should be allocated to the assessed product or service. Moreover, the share should be determined by the weight that the company is given in the products or services total product chain. They suggested that the share, or the allocation factor, could be based on something like value creation or the number of labour hours spent.

This division between process or company conduct appears to lead to different methods of setting system boundaries, inventory analysis, impact assessment, allocation of impacts, and developing social indicators. In spite of these differences, in their scope definition, most S-LCA studies identified the Area of Protection (AoP) as being "human dignity and well-being".

It is the opinion, of the authors, that both process and company conduct approaches are necessary and add complementary information. While it is true that much of the social impacts are related to company conduct along the process chain, specification

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of the process chain and associated geographical sites helps to identify the companies involved and the relevant stakeholders at each stage of the process. It is clear that the occupational health and safety of workers at various part of the chain may be an impact of a particular industrial process. Note that company conduct cannot contribute to the analysis of the social impacts of the use of the product by the consumer and, in most instances, will have little contribution to the end of life processes such as disposal.

3.3.1   Setting system boundaries

How system boundaries are set is dependent on the researchers' perspective with respect to a product development (single product) or product comparison approach to the LCA case study. Those with a single product focus suggest that the relevant elements should be the parts of the life cycle that the company can influence directly (i.e., 'hotspots' that the company is able to address). That is, they reason that the company should not be held accountable for what is beyond its influence. In this case, the application of S-LCA implies that only the company and its closest suppliers and distributors are assessed (Dreyer et al., 2006; Methot, 2005), thus setting the system boundaries well short of the entire life cycle. Such an approach has similarities with Corporate Social Responsibility (CSR) where the concern is with the conduct of a specific company and its social impact rather than the social impacts of a product across it whole life cycle. In contrast, researchers who focus on product and process comparisons (Schmidt, et al., 2004), argued that relevant impacts could be located in all part of the chain. Therefore, a full lifecycle assessment, rather than a truncated one, is necessary.

Cut off criteria are required in S-LCA just as they are in E-LCA, to set boundaries. Barthel et al. (2005) proposed the use of a modified E-LCA ISO 14044 (2006) definition of cut off criteria where 'social significance' was substituted for 'environmental significance'. In the ISO 14044 definitions, if the impacts of a process are 'environmentally significant' then that process should be included in the E-LCA. This implies that if the environmental impacts of the process are not significant then it does not need to be included in the analysis as it would make no significant difference to the conclusion. In line with this definition, Weidema (2005) suggests applying the ISO 14044 framework in boundary setting in S-LCA. Thus, the exclusion of lifecycle stages, processes, and inputs or outputs is only permitted (i.e., in theory - data availability may place boundary limitations in practice) if it does not significantly change the overall conclusion of the study.

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3.3.2 Social indicators

Indicators are generally defined at the level of the organization and not at the level of the individuals (Nazarkina and Le Bocq, 2006). Therefore, factors such as individual conflicts between manager and employees are generally not considered. Indicators are 'pointers' to the state of the impact categories (and/or subcategories) being evaluated by the S-LCA. Indicators may be quantitative, qualitative or semi qualitative. These distinctions will be discussed in the next section on indicator types.

According to UNEP (2009), in E-LCA there are two types of impact categories; midpoint and endpoint indicators. This difference refers to the location of the indicators in the causal chain from process to impact. In general, endpoint indicators are considered the most appropriate as an E-LCA impact on the AoP. However, it may be difficult to relate the activities in the product process chain to some endpoint indicators. For example, consider the impact category of climate. The endpoint indicator might be 'the amount of climate change as a function of the life cycle of product X'. This could be difficult if not impossible to measure or calculate. So instead, a midpoint indicator, somewhere along the causal chain between the life cycle processes of product X and climate change, such as, 'green house gases released into the atmosphere during the production and life of product X' might be used as a proxy measure. An impact pathway links the two types of indicators by describing the cause-effect relationship between midpoint and endpoint.

In the case of S-LCA, UNEP (2009, p.70) defines impact categories as: "logical groupings of S-LCA results, related to social issues of interest to stakeholders and decision makers." Most S-LCA studies conducted so far have used midpoint indicators. Only two S-LCA studies, that we have been able to find, employed endpoint indicators (Norris, 2006; Weidema, 2005). Some endpoint indicators suggested for S-LCA include mortality, morbidity, autonomy, safety, security and tranquillity, equal opportunities, participation and influence. In S-LCA, an example of mid and end point indicators might be as follows. Job creation in a local community is ultimately assumed to improve family health conditions through the alleviation of poverty (the impact pathway or causal chain of effect). Therefore, one may consider 'job creation' as a midpoint social indicator for the social endpoint indicator 'local community family health conditions'.

Endpoint indicators have the advantage that they can reflect the potential damage or benefits to the area of protection (AOP). When using midpoint indicators, it is, therefore, important to establish an impact pathway between the mid and endpoint

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categories. Weidema (2006), favouring endpoint indicators, suggests these impact pathways can be established to an acceptable level of accuracy. However, on the other hand, some argue that midpoint categories are preferable to endpoint indicators because they are closer to the stressors and more understandable for decision makers (Grieβhammer et al., 2006). Most of the indicators reported in S-LCA are related to discrimination and physical working conditions. Inclusion of the impact categories concerning other human rights (as appropriate for the scope of the particular S-LCA), appears to be the next priority.

Due to the nature of the social domain, subjective data are sometimes the most appropriate indicators (e.g., workers' perceived degree of control over schedules and working environment). This fact points to an important difference between E-LCA and S-LCA. S-LCA, given subjective criteria, necessarily involves the participation of stakeholders for both the definition of appropriate social indicators and indicator data collection (UNEP, 2009). Whereas, in E-LCA indicators are generally determined top down by experts, in S-LCA it is important to also determine relevant indicators using a bottom up approach with stakeholder participation. Using a bottom up approach to social indicators also enables essential local or site specific cultural and social norms to be accounted for in the assessment of social impacts. Unfortunately, such participative processes increase the complexity and difficulty of conducting S-LCA and gathering the necessary data, thus creating extra costs in terms of both time and finances.

Weidema (2006) identify some useful properties of indicators for their effective use in S-LCA These properties are (1) the indicator should allow quantification of the extent (incidence or prevalence) of any effects, (2) and the indicator should be capable of capturing the duration and the severity of the aspect under consideration. He argues that the QALYs (Quality Adjusted Life Years) is an indicator with these properties and propose its use as a single score, similar to the concept of direct moneterisation in cost benefit analysis. The current authors, while considering QALYs a useful and relevant indicator/impact category for S-LCA, consider that, as a single indicator, it falls significantly short of providing a complete evaluation of the AoP of 'human dignity and wellbeing'.

3.3.2.1 Social indicator typology

Three types of indicators reported in the literature namely, Quantitative (Hunkeler, 2006; Norris, 2006; Weidema, 2006; Nazarkina and Le Bocq, 2006; Barthel et al., 2005; Caneque, 2002), semi quantitative (Dreyer et al., 2006; Methot, 2005; Spillemaeckers et al., 2004), and qualitative (Manhart and Grieβhammer, 2006;

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Gauthier, 2005). In 'The Guidelines', UNEP (2009, p.100) defines qualitative indicators as: "…nominative: they provide information on a particular issue using words. For instance text describing the measures taken by an enterprise to manage stress." Quantitative indicators are described as: "…a description of the issue assessed using numbers: for example number of accidents by unit process." Semi-quantitative indicators are described as: "…indicators that have results expressed into a yes/no form or a scale (scoring system): for example, presence of a stress management programme (yes/no). Qualitative and quantitative indicator results may be translated into semi-quantitative form"

Barthel (2005) suggests using two direct indicators, namely incidence of lethal and non-lethal injuries for measuring the impact category health and safety. Both measures are based on objective statistical sources and are therefore quantitative. When the incidence to be measured is too complex or objective data are not available, some researchers applied a proxy scoring system. Spillemaeckers et al., (2004) measured occupational health and safety by giving scores to 'presence of health and safety training of employees', 'presence of a health and safety committee', 'presence of a formal policy in health and safety' and several other indicators. This would be classified as a semi-quantitative indicator. The sum of the indicators can then be used for the purposes of overall assessment. Such scoring systems "usually seek to standardize the scores for purpose of comparison" (UNEP, 2009, p.100).

The use of qualitative indicators does not set any restrictions on the types of information to include in the assessments. Gauthier (2005) qualitatively measured the impact category "quality, health and safety at work" by specifying the criteria that 'the product should meet the various quality or health and safety criteria in all stages of its life cycle'. As mentioned, an important aspect of indicators is that some measure the impacts directly while others produce more indirect or proxy measurements. Weidema (2006) suggests a method to obtain proxy measures from the reverse compilation of available data sources. Nazarkina and Le Bocq (2006) then applied this methodology to develop a proxy measure for use of child labour. Due to the scarcity of regional or national child labour statistics they assume that children are either in school or working during day hours. As a result, a rough proxy indicator measurement of the total extent of child labour in the region can be made on the basis of statistics from education (i.e., number of children attending school in the region) and demography (i.e., number of school age children in region).

3.4   Inventory analysis

The objective of the inventory analysis is to collect and analyse relevant information (inventory indicators), identified during the scope definition. The literature indicates some disagreement among researchers on the type of information to gather for S-LCA. Some researchers argue that a method similar to E-LCA, where input and output data created for a large number of processes is often used, is not applicable in the case of S-LCA (Dreyer et al., 2006; Spillemaeckers et al., 2004). These researchers argue that impacts in the S-LCA context are due to the conduct of the company rather than due to the nature of the industrial processes.

As previously noted, this group of S-LCA researchers claim that companies that produce the same products can have the same environmental impacts as measured in E-LCA but can have completely different social impacts. Therefore, they recommend that social impacts be considered in relation to the behaviour of the company towards its stakeholder's i.e. making use of generic process data irrelevant or difficult to apply in real life examples. These researchers advocated detailed and site-specific investigations. However, different approaches were also evident in the way that social impacts were measured with the application of both direct and proxy measurements. Several other authors (Weidema 2006; Manhart and Grieβhammer, 2006; Schmidt et al. 2004; Barthel et al. 2004), while acknowledging the importance of site specific data in S-LCA work, in contrast claimed that generic data from statistical data bases could give a rough estimate on several social impacts (e.g., the child labour proxy measurement cited above).

Norris (2006) and Hunkeler (2006) applied a single impact category as a basis of social assessment. Norris (2006) estimated mortality and morbidity based on the contribution of the production of a particular product or service towards increased GDP. He exploited the statistical relationship between GDP and mean life expectancy, which shows a very high positive correlation for countries with small GDP (however, mean life expectancy has a non-significant relationship for high GDP countries). Hunkeler (2006) used labour hours as a mid-point indicator for social impacts. He used characterisation factors to relate labour hours involved with endpoint impact categories like the ability to afford health care, education, and housing.

The flexibility of using generic data is very high. The single indicator approaches by Norris (2006) and Hunkeler (2006) are very useful techniques. However, the relation between these highly aggregated single indicators and actual social impacts has to be carefully interpreted to avoid misrepresentation of actual effects in real life situations.

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Also, it is clear that such single indicators only cover a sub-set of the domain of the AoP; human dignity and wellbeing.

In our view, although gathering site-specific data can be a very difficult task, it is important to gather as much site specific and related product specific social data as possible for the assessment. Where specific data is not available, or is commercially sensitive, proxy measures or general statistical data may be utilised. The authors consider this dual approach the most helpful to begin assessing social impacts.

3.5   Impact Assessment

In this step of an E-LCA, inventory data are translated into impacts by following four steps, namely classification, characterisation, normalisation and valuation of impacts. However, the Guidelines for S-LCA do not discuss normalisation or valuation of impacts but rather progress from the characterisation phase to an interpretation of the social significance phase (UNEP, 2009). We shall follow this framework. The Guidelines note that: "impact assessment methodologies are under development and S-LCA is an *open* field for future research." (p.69).   Below we briefly describe the classification and characterisation steps as used in E-LCA, and discuss as pertains to S-LCA, followed by a discussion of interpretation of the social significance of the impact assessment.

3.5.1   Classification

Classification in E-LCA is normally performed by assigning inventory results to impact categories (ISO 14044, 2006). However, in S-LCA, there is concern over whether to follow the E-LCA approach, or to classify according to the impacted stakeholders (Grieβhammer, (2006). The current authors consider that it is essential to account for both stakeholders and impact categories. Excluding either would result in significantly different final S-LCA results, thus violating the criteria (in the discussion on study scope) regarding what may permissibly be excluded from an S-LCA.

In the Guidelines for S-LCA, UNEP (2009) defines both stakeholder categories and impact categories (relevant to stakeholders) and adds subcategories as the midpoint and endpoint indicators composing the inventory indicators. The Guidelines define the classification step in S-LCA as: "…the part where the inventory results are assigned to a specific stakeholder category and/or impact category" (p.72). As mentioned previously, UNEP has agreed upon a minimum list of stakeholders, including workers/employees, local community, consumers, society (national and/or global) and value chain actors. Given that S-LCA is being developed as a tool for sustainable development, and that the WCED's definition of sustainable development specifically

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refs to the protection of the needs of future generations, the current authors consider it important to also include future generations in the minimum stakeholder list.

Impact categories in S-LCA are defined as "…logical groupings of S-LCA results, related to social issues of interest to stakeholders and decision-makers" (UNEP, 2009, p.70) Some suggested impact categories for S-LCA include human rights, working conditions, health and safety, cultural heritage, governance and socio-economic repercussions (UNEP, 2009). Subcategories "…represent impacts within an impact category" (UNEP, 2009, p.71). A range of potential subcategories are presented in the Guidelines. These include such things as: fair salary, working hours, equal opportunities, health and safety, social security and benefits, cultural heritage, respect for indigenous rights, community engagement, contribution to economic development, respect for intellectual property rights etc. Some subcategories may be relevant to some stakeholder categories but not to others.

The Guidelines give an example of the information data flow: stakeholder category – worker, impact category – working conditions, subcategory – social security and benefits, inventory indicators: percentage of employees covered by 1) health insurance, 2) retirement insurance, 3) paid maternity leave, 4) legal contract, etc. (UNEP, 2009). Aggregation (and perhaps weighting) of the inventory indicators is required to meaningfully determine the subcategory impact. Likewise, aggregation of subcategories is required to determine the meaning of an impact category. The next step, characterisation, deals with the aggregation process.

In the S-LCA studies reviewed, the impact categories considered were mostly related to direct impacts on workers and society. None of the studies assessed the consumer impacts at the use stage. Very few impact categories were discussed with respect to the use stage. Grieβhammer et al., 2006 noted that the use stage is very difficult to assess and emphasized the importance of the definition of the functional unit in this context. They note that the function of the product or service should be defined in detail, both in quantity and quality in order to show qualities such as time requirement, convenience and prestige. Dreyer et al. (2006) suggest including impact categories for the use stage based on established product categories. Grieβhammer et al. (2006) indicate that to the extent possible, the impact categories on the use stage should be chosen in accordance with internationally recognised texts on consumer impacts.

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3.5.2 Characterisation

The purpose of characterisation in E-LCA is to aggregate the inventory results within the same impact category (ISO 14044, 2006). To do this, the inventory data need to be converted into common metric. For example, Weidema (2006) used an endpoint indicator called quality adjusted life years (QALYs) in the process of characterisation of inventory values. He related the inventory data through impact pathways to this endpoint. His idea was to calculate all impacts as a reduction in the average well-being, denoted as quality adjusted life years (QALY). To calculate the QALY he employed some indicators with specific characteristics namely: severity, or impact factor, and an average duration of the impact concern. The total reduction in well-being was calculated by summing the multiplications of incidence, severity, and duration values of each indicator.

Barthel et al. (2005), in their study, included three impact categories comprising 16 indicators. The indicators in each impact category had the same unit allowing for a simple summation of indicator scores resulting in a total measure for each impact category. Spillemaeckers et al (2004) emphasized the fact that impact categories are complex in measure (i.e., multifaceted) and claimed that up to eight indicators are needed to reasonably express impacts. The Guidelines note that in S-LCA: "Characterisation models may also be more complex [than E-LCA], involving the use of additional information such as performance reference points. Performance reference points may be internationally set thresholds, or goals or objectives according to conventions and best practices. Performance references need to be transparent and documented" (UNEP, 2009, p.72).

Hunkeler (2006) offers another variation in approach to S-LCA. As mentioned previously, he related one indicator, the number of working hours along the production chain to several impact categories. He considered four impact categories namely, housing, health care, education, and necessities. Hunkeler assumed that salary earned from working hours may be spent on improving condition in these four impact categories. He estimated the characterisation factors by calculating the average national costs of housing, health care, education, and necessities and expressed the costs in terms of number of working hours per functional product unit. Then he related the characterisation factors to a product's aggregated contribution towards purchasing power in the four impact categories. The problem with this methodology is that labour intensive activities appear as a more attractive option to improve social welfare than technology intensive labour saving production approaches.

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3.5.3 Interpretation of significance of the social life cycle impact assessment

The Guidelines define life cycle interpretation as "…the process of assessing results in order to draw conclusions" the process has the following objectives: "to analyse the results, reach conclusions, explain the limitations of the study, provide recommendations and report adequately" (UNEP, 2009, p.74). Four steps are defined to help achieve these objectives. 1) Identification of significant social issues such as infringements of human rights or labour laws, 2) evaluation of the study in terms of completeness regarding all the relevant crucial issues and, consistency and appropriateness of the methodology with respect to the defined goal and scope, 3) conclusions and recommendations based on the goal and scope of the study, and 4) reporting on the involvement and participation of stakeholders in the particular case study (UNEP, 2009).

4. Limitations of S-LCA

S-LCA is a very new process with few S-LCA studies having been conducted. Those that have been done have generally been quite limited in goal and scope and have used a range of different approaches. There is much debate regarding the appropriate methodology. Authoritative and systematic guidelines have only just been published (mid 2009) and these admit that considerable future work is still required both methodologically and in terms of tools and databases to facilitate the process. At present, conducting a comprehensive S-LCA would be prohibitively expensive and pragmatically difficult due to the lack of database tools and the inaccessibility of much required data (UNEP, 2009).

Other limitations exist due to the nature of social phenomena and effects, human values are necessarily involved, quantification can be difficult, the aggregation of data in a social context is not well understood – particularly for qualitative data - which is likely to be common in S-LCA. Causal chains, an essential component of LCA are often not well understood in the social realm. The inclusion of stakeholders in the process is different from E-LCA and may result in difficulty in obtaining participation as well as introducing additional elements of bias, and extra cost overheads in terms of both time and money. Practitioners require skills not only in LCA but also in social science, Corporate Social Responsibility, social impacts assessment (UNEP, 2009).

No-one (as far as we are aware) has yet attempted to include the use phase in S-LCA, and yet surely, the use phase is the primary reason for the existence of a product or

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service. To neglect this phase would seem to be a spectacular oversight. However, most S-LCA researchers agree that the use phase is particularly difficult to address. With regard to the use phase, the Guidelines state: "Assessing the use phase represents a major challenge. The accent in method development so far was placed on production, distribution and end-of-life aspects; therefore, use stage aspects require further development. Thus, with regard to the assessment of the usability and satisfaction of the users, it may be better assessed through other tools or become a future field of research for S-LCA" (UNEP, 2009, p.78).

5. S-LCA methodology: Cheese production in New Zealand

The main objective of this part of the study was to think through how to conduct a S-LCA on the impact of cheese production in New Zealand. Cheese production was selected for two reasons: first as it complements the environmental assessment of agricultural products with an assessment of the social performance of agricultural products over their whole life cycle (Bassett-Mens, Ledgard & Boyes, 2009). Second because the E-LCA provides a good background to begin thinking about how to approach a S-LCA case study. Overall, the two studies could be combined to fortify the sustainability assessment of pasture-based products by taking account of social impacts from a life cycle perspective.

We chose to employ the UNEP and Society of Environmental Toxicology and Chemistry (SETAC) framework (Figure 1) to integrate social aspects into LCA (Grießhammer et al., 2006). This was primary because it seems a sensible proposition to retain a strong commonality between E-LCA and S-LCA and despite its lack of explication it was the only attempt at a framework available at the commencement of this project.

5.1 Goal of the study

The ultimate goal of this research project was to develop a methodology and local expertise capable of answering questions such as: Do NZ pasture-based products (dairy products, lamb, beef meat, wool) have a comparative advantage in terms of environmental and social performance compared to their locally produced equivalent in their furthest markets (UK, USA)? This was an exploratory project focussed around capacity building. Therefore, to make the project feasible and realistic the goal of the study was limited to the exploration of a framework for S-LCA of cheese production in

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New Zealand from entering the farm gate (i.e., arriving on farm) through to the consumer.

5.2 Scope of the study

We have considered both production process & company specific activities along the lifecycle from the farm gate (i.e., arriving on farm) to the consumer. At the main raw material (milk) production stage of the cycle, the primary activity is dairy farming where a heterogeneous group of producers are involved. In this study, we treat all the producers and milk production activities together as one company producing the raw material milk for the production of cheese. We recognise that on-farm processes are far from identical, however the aggregation was made to simplify the process.

5.3 Functional unit

One kg of Cheese was selected as the functional unit in this study to allow a comparison with Bassett-Mens et al. (2009) E-LCA. Additionally, this definition is compatible with the development of a method to compare the impact of New Zealand cheese production with similar cheese production processes in countries such as the UK. The need to think of potential social impacts generated through the production of one kg of cheese is not an easy thing to consider, At times it has seemed absurd, however, as the concept of functional unit is central to E-LCA it is likely to remain.

As a consequence, those practicing S-LCA will have to apply a standard functional unit. However, the functional unit may require adaption to make sense in the use phase and in order to make comparisons between different products at that stage. As noted in the Guidelines an appropriate definition of the functional unit is essential for comparison of impacts at the use phase (UNEP, 2009). We had considerable difficulty defining a functional unit for the use phase and make the following tentative suggestion. A possible definition for a functional unit appropriate at the use phase might be 'the nutritional and aesthetic value obtained from 1kg of cheese'.

5.4 Allocation of impacts

In this step, we established the relationships between activities associated with the production process and company specific activities with different social impacts. Areas we considered impacted are shown in Figure 2. The allocation of impacts could be based on impact share allocation by percentage (after Dreyer et al. 2006) as discussed previously.

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5.5 System boundaries

In this study it is appropriate to focus on all socially significant impacts from both company and production specific activities as per ISO 14044 requirements for E-LCA.

5.6 Social indicators

The main criterion for selecting social indicators was relevance to the area of protection (AOP); human dignity and well being. We are in agreement with other S-LCA authors that this is the key AoP for S-LCA. We put a considerable amount of effort into the development and elucidation of a framework (Figure 2) which indicates the detailed information required for different stakeholders at different sites and scales to calculate a proper measurement for AoP. Our framework bears similarities to the methodologies of Labuschagne 2005 and Kolsch et al., (2008) from which it was partially derived. While a little different in presentation, it also bears strong similarities to the framework later developed and published in the Guidelines.

It is constructed in a stakeholder format which Kolsch et al., (2008) believe allows the indicators to be developed in a meaningful way and helps communication of impacts across the groups. It provides a starting point for a discussion around trade-offs and can clearly indicate where the benefits and costs of particular activities lie. It is also consistent with the fact that social impacts are impacts on people.

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Figure 2: Framework to assess the social impacts at different life cycle stages (adopted from Labuschagne and Brent, (2006) and Kolsch et al. (2008)).
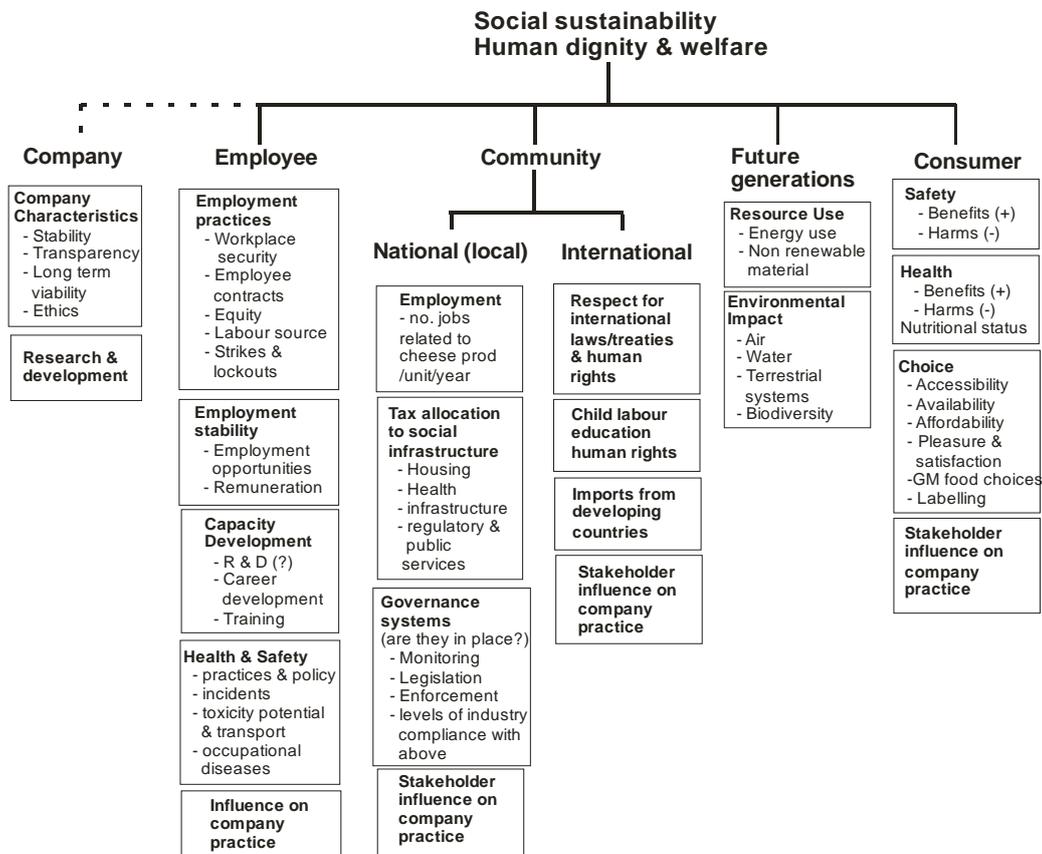
The framework (Figure 2) has 6 subgroups: company, employees, the national and international community, future generations and the consumer. Although developed before the Guidelines, this framework is quite consistent with both the stakeholder groups and the impact categories defined there.

Labuschagne (2005) suggests that the employee category is concerned with how an organisation treats and engages with its employees. Table 1 contains a description of each indicator in the employee category group by impact categories

Table 1: S-LCA indicator framework: A description of indicators relevant to the Employee stakeholder category grouped by impact categories.

EMPLOYEE	
Indicator	**Description/discussion**
Employment Practices	
Work place security	Labuschagne (2005) describes this in terms of what disciplinary and security practise the company uses on its staff and ensuring these do not violate human rights.
Employee contracts	Presence or absence of employment contracts – contracts in place is assumed to be the ideal
Equity Issues	All people should be treated with equal fairness and provided with equal opportunities. This indicator needs to measure equality in the work place (after Labuschagne, 2005)
Labour source	Where does the labour come from? This indicator needs to be around paid verses forced labour. Labuschagne (2005) discusses levels of paid verses forced and child labour with respect to this measure (pg 47). There are a number of international conventions regarding this issue.
Strikes and lockouts	Kolsch, et al. (2008) suggest recording labour disputes with 10 or more employees with a loss of more than 1 days worth of work time. Freedom to associate could be an alternative indicator
Employment Stability	
Employment opportunities	Career progression, ability to move jobs turnover rate could be important
Remuneration	Equity issues here as well as actual amounts paid for work. This could be tied to the average wage or minimal wage.
Capacity Development	
R & D	By producing new products (through R & D) a company stays in the market place as it has future products in the pipeline. This would affect individuals' jobs but also influence long term company viability. This indicator could possibly be moved to the company stakeholder category.
Career Development	Labuschagne (2005) discusses this in terms of developing staff for the positions that the company will require in the future, it involves looking at a company's training and development of employees. This has been put here because it benefits the employee through developing their skill set which they may choose to utilise within a different company at some future point.
Training	Availability of on the job training

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EMPLOYEE	
Indicator	**Description/discussion**
Health & Safety	
Practices and policy	Does the company have health and safety policies, practices and procedures in place to protect staff. Do they have health and safety training? Do they have external auditors?
Accidents and incidents	How many – how serious. From Labuschagne (2005) Kolsch, et al. (2008) also add fatal work accidents
Toxicity potential & transport	This idea is discussed by Landsiedel (2003) and involves subjective ranking of effect of chemicals used in production combined with the amounts used and potential exposure to develop a toxicity potential value per unit of product. This would be a lot of work for this project simply because of the scale of chemicals used and the need to extract the data from each product Material Safety Data Sheet.
Occupational diseases	What diseases and what % of work force are affected. This requires thought on what an occupational disease actually is and whether or not they can be directly attributed to a particular job. This is going to be very difficult to use as few links have been made between disease and occupation.
Influence on company practices	
Employee influence on company	Level of participatory democracy in the company. It is assumed to be a good thing that employees have the ability to influence their workplace. The level at which this occurs is clearly open to debate.

With respect to community stakeholders, Labuschagne (2005) makes the distinction between local community who are in the immediate area and those who live at a distance but benefit from macro-social performance. However, because New Zealand is quite small and as we have already amalgamated dairy farmers into a single company we also combine local and national community. This is more closely aligned with the approach of Kolsch et al. (2008) as they have used local and international community as stakeholders. A description of the relevant indicators is in Table 2.

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Table 2: S-LCA Indicator framework: A description of Indicators relevant to the Community stakeholder category group by impact categories.

NATIONAL COMMUNITY	
Indicator	**Description/discussion**
Employment	
No. jobs related to the functional unit	This Kolsch, (2008) works it out as working years to account for all workers (i.e., part time & seasonal)
Company determined impacts on the wider community (deliberate impacts or those which are a side effect of production) these ideas are really from Labuschange (2005) who talks about benefits and harms which are unrelated to the final product or the employee.	
Impact on wellbeing	Altruistic donations within the community, sponsorships etc. Or external impacts on aesthetics or noise levels etc … Labuschagne (2005) suggests counting complaints over company operations as a way of considering potential impacts
Tax allocation to social infra-structure (although how this is spent is not determined by the company)	
Housing	All these indicators would be related to the amount of benefit which the community gains (that can be attributed to the functional unit) from the tax take spent on each sector
Health	
Infra structure	
Regulatory and public services	
Governance systems	
Monitoring, Legislation, Enforcement, Industry compliance	A company would either comply or not so a checklist may be the most appropriate way to ensure that a company meets these criteria. Note that these standards might represent a minimum acceptable level and for S-LCA it may be necessary to take into account performance above the minimum.
Influence on company practice	
Influence of local community	Do community organisations at the national or local level have any ability to influence company practices.

The inclusion of future generations as a stakeholder category is due to the adoption of sustainable development concepts into life cycle thinking. As future generations (i.e., those who are not born yet) are always considered as stakeholders in sustainability definitions we believe that they should be included in the S-LCA framework. To date, other S-LCA authors appear to define future generations as those who are not yet in the work force.

We do not agree with this definition as it is not consistent with sustainable development definitions. However, we do not know exactly how to measure the impacts on those who are not yet born, other than by using biophysical parameters (e,g, the availability of non-renewable resources, planetary biodiversity, and environmental pollution). Therefore, we put this idea out for discussion. We appreciate that relating the functional unit of a product to these indicators will be

extremely complex and it is unclear to us how this might be operationalised. Description and commentary on the indicators for the stakeholder category Future Generations is in Table 3.

Table 3: S-LCA Indicator framework: A description of indicators relevant to Future Generations stakeholder category by potential impact categories.

FUTURE GENERATIONS	
Indicator	**Description/discussion**
Resource use	
Non renewable materials	Use of non-renewable materials as a contribution to the depletion of the total resource available
Environmental impacts	
Air	This is straying into the area of E-LCA but decisions made by a company do effect the choices available to future generations
Water	
Terrestrial systems	
Biodiversity	

The Consumer as stakeholder is poorly explicated in S-LCA literature. It is about the affect of company practices, or the product itself, and the use of the product on the Consumer. The indicators will be determined to some extent by the nature of the product (Kolsch et al., 2008). Table 4 offers a description of some potential indicators for the stakeholder category Consumer

Table 4: S-LCA indicator framework: A description of Indicators relevant to the Consumer stakeholder category by impact categories.

CONSUMER	
Indicator	**Description/discussion**
Safety	
Benefits & harms	What are the potential safety issues with the product?
Health	
Benefits & harms	Is the product beneficial or harmful from a health perspective?
Choice	
Accessibility	Is the product easy to obtain?
Affordability	Is the product suitably priced?
Palatability	Does the product taste OK?
Pleasure & satisfaction	Does the consumer drive pleasure/satisfaction from the product?
GM food choices	Do they have alternatives to GM products or are their choices constrained?
Labelling	Is the product suitably labelled with regards to it component parts or ingredients?
Traceability	Can the product and processes be traced back from consumer to cradle?
Stakeholder influence on company practices	
Consumer influence	Do consumers have the ability to influence how the product is produced, distributed, used disposed of (i.e., over the products life cycle)?

Another point which we have not resolved is the company as a stakeholder. The company is more than just its employees. It is an entity in its self and possesses some unique characteristics which are independent of the other stakeholder categories. How to manage this stakeholder category is something which requires further consideration. Note that the Guidelines do not include this exact stakeholder category. Instead they propose a stakeholder category which they call 'Value chain actors'. Unfortunately, UNEP (2009) does not define 'value chain actors' in the Guidelines. We assume that it includes companies in the product production chain and decision makers who influence value chain behaviour. We provide an initial attempt at description of potential indicators for the Company stakeholder category in Table 5.

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Table 5: S-LCA Indicator framework: A description of Indicators relevant to the Company stakeholder category by impact categories.

COMPANY	
Indicator	**Description/discussion**
Company Characteristics	
Stability	How stable is the company in terms of size and operations?
Transparency	Compliance with international accounting practices and regulatory requirements. Transparency of processes.
Long term viability	A company needs to make money to ensure its long term survival. How healthy is the company? The goal of a company is to make money for its shareholders.
Ethics	Does the company operate in a way which meets the ethical expectations of the national community? Of the international community?
Research and development	
Engagement in R&D	Steps taken to ensure the company has new products or services to sell in the future. The long term viability of a company is dependent on the R&D taking place. Labuschagne (2005) places this within the employee stakeholder category. It is about the amount of money the company puts into developing new products new processes etc. An investment in innovation, so to speak.

As well as defining the appropriate indicator it is also important to consider the critical values (i.e., a threshold or standard) of these social sustainability indicators. To do otherwise, would render many of the numbers meaningless because they could not be placed in context nor easily judged as either "good" or "bad" (or requiring action or being acceptable). For example, if there were 0.1 fatal accidents/kg of cheese, but the acceptable level is 0.001, then there is clearly a problem. Without this standard, the actual number cannot be fully interpreted.

5.6.1   The importance of critical levels for indicator meaning

It is important to gather reliable indicators reflecting the current and critical levels of issues to be included in the social impact assessments. The main concern here is how to set the critical value. It can either be policy based (e.g. international conventions) or science-based (e.g. critical load concepts). As indicated by Walter and Stutzel (2009), policy-based critical values are adequate if targets are, at least to some extent, negotiable.

Policy based critical values are, however, not adequate where biophysical realities are involved that are not negotiable. For instance, at some tipping point most environmental sustainability issues are not negotiable and thus need science-based critical values. Walter and Stutzel (2009) suggest that science based critical values should be used wherever possible. If not possible, Walter and Stutzel recommend

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policy based critical values as a substitute, but this should be emphasized explicitly in order to ensure transparency. However, in the sustainability literature it is recognised that, for environmental goods, society may wish to implement a standard that is significantly better than a critical system tipping point. Societal values may be represented by policy based standards that are set higher than biophysical tipping points.

Due to the current paucity of available databases relevant to S-LCA, rather than quantification, normalisation and statistical aggregation of inventory indicators, as is the best practice standard in E-LCA, we suggest that, at least at this early stage of development of S-LCA, a 'checklist' approach might be more pragmatic. Under the checklist approach, state inventory indicators would be checked for a pass/fail against the 'critical value' or standard assigned to each indicator. Of course, this assumes the existence of an agreed upon critical value for the indicators. While such critical values are defined in some stakeholder and impact categories (such as working conditions) at both local and international levels, for many of the impact categories and indicators identified above there are currently no agreed upon critical values. A brief example of the form of a possible checklist tool for S-LCA is shown in Table 6 below for the stakeholder category of Employee and the impact category of Employment Practices.

Table 6: Example of an S-LCA indicator inventory checklist for Employee stakeholder category and Employment Practices impact category.

Employee / Employment Practices/ Indicator	International requirements		Local requirements	
	Critical value (CV)	Meets CV (yes/no)	Critical value (CV)	Meets CV (yes/no)
Workplace security				
Employment contracts				
Equity issues				
Labour source				
Strikes and lockouts				

5.7 Social impact assessment

This is as far as our work has progressed. The next stage of the S-LCA process for New Zealand cheese would involve applying the social impact assessment framework (Figure 2 and Tables 1 through 6 to the processes and companies at each stage of the life cycle of cheese production. Although we suggest that at this stage of development of S-LCA, a checklist approach is the most pragmatic, we envisage that at some future

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stage, when methodology is further formalised and suitable database tools exist to aid with inventory analyses, as is the case in E-LCA, a more quantifiable approach might be possible.

Below, we briefly discuss and present potential equations for quantification in S-LCA. However, the quantification procedure below requires normalisation of inventory indicator data. As previously mentioned, normalisation, while being a procedure available and sometimes used in E-LCA, is not mentioned in the UNEP S-LCA guidelines. We give a brief definition and illustration of normalisation
before presenting the quantification procedure.

5.7.1 Normalisation

Many methods of E-LCA allow the impact category indicator result to be compared by a reference (or Normal) value. This means the impact category is divided by the reference. The reference may be chosen, but, in E-LCA, often the average yearly environmental load in a country or continent, divided by the number of inhabitants, is used as the reference. After normalisation, the impact category indicators all get the same unit (usually 1/yr), which makes it easier to compare them. Normalisation can be applied on both characterisation and damage assessment results.

Normalisation in S-LCA could potentially be performed in a similar manner to its application in E-LCA (Grieβhammer, 2006; Weidama 2006; Schmidt et al., 2004). For example, Labuschagne and Brent (2006) calculated the normalisation factor as the inverse of the target state of the impact category. This measurement is related to the social objectives (e.g. the critical level or normative standard defined by society as desirable) of the impact category being assessed. Weidema (2006) suggested normalising current average level of life expectancy by comparing with maximum life expectancy.

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5.7.2   Quantifying social impact assessments

To conduct a quantified social impact assessment of, for example, cheese production in New Zealand, one would initially evaluate the framework describe in Figure 2 and attempt to assess the following formula (Labuschagne and Brent, 2006) for each life cycle stage of the cheese production.

$$SII = \sum_{C}\sum_{X} Q_x C_c N_c S_c$$

Where:

SII- Social impact indicator

Q_x- social impacts due to the production process or company activity.

CC- Characterisation factor for an impact category. A similar indicator like QALY could be accommodated in the social impact calculation procedure described by Weidema, 2006.

Nc- a normalisation factor calculated as the inverse of the target state (critical level) of the impact category

Sc – impact category's relative importance measured as a ratio of current and target social state. Defined by Labuschange, 2006; Walter and Stutzel, 2009) as:

$$\frac{\text{actual impact level of sustainabilty issue}}{\text{Critical level}}$$

Walter and Stutzel (2009) argue that, if Sc (which they call the Severity Ratio (SR)) is greater than 1, then the issue is relevant for sustainability because it is currently unsustainable. They further claim that if SR is less than 1 then it is 'not unsustainable' (which they note is different from being 'sustainable') in the given context and, therefore, not a relevant sustainability issue. We dispute this latter claim. We note that the formula for SR does not take into account the temporal dimension but defines SR only at a point in time. Only if SR is constant (or is decreasing) over time, would the claim that the issue is not unsustainable be valid. However, if, under business as usual, SR is increasing over time (i.e., the numerator in the above ratio is increasing over time), then eventually the ratio will become greater than 1. This shows that business as usual is not able to be continued indefinitely into the future without reaching an unsustainable level. Thus, under business as usual conditions, the issue is not sustainable.

We propose the following measurement as a substitute for the impact category measure (Sc) in the above equation. We define a time horizon (T_s) where (T_s)

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ranges from current (T_C) to future time (T_F) for sustainability issues and we introduce the following formula: (below, following Walter and Stutzel (2009) we substitute the term *SR* for Sc)

$$SR = \frac{L_f}{L_{cR}}$$ (1)

Where,

L_f - Level of sustainability issue of concern in the future time (T_F)

L_{CR} - Critical level of the sustainability issue

We can estimate the expected level of sustainability issue of concern in the future time (T_F) as follows. If, we assume that the change in the sustainability issue is a continuous function, such as most environmental phenomenon, we can estimate the change in the issue by employing equation (2). When the sustainability issue in question is not continuous but is a discrete function, such as is the case in many social issues we can use the equation (3) to estimate the change in the issue.

$$Lf \;=\; L_{cui} \pm \partial \int_{Tc}^{Tf} \Delta \; t$$ _____ (2)

$$Lf \;=\; L_{cui} \pm \sum_{T_c}^{T_f} \Delta$$ _____ (3)

Where

L_{cu} - Current level of the sustainability issue

Then in case of continuous changes of sustainability issues:

$$SR = \frac{L_{cu} \pm \Delta \partial \int_{Tc}^{Tf} t}{L_{CR}}$$ _____ (4)

In the case of discreet changes of sustainability issues:

$$SR = \frac{L_{cui} \pm \sum_{T_c}^{T_f} \Delta}{L_{CR}}$$ _____ (5)

The above-modified equations, (4) and (5), incorporate the rate of change of the issue in question, thus enabling an estimate of the future level of the sustainability issue. The interpretation of the SR measurement in terms of sustainability depends on the particular issue being measured and the way we want to define the critical level. The

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meaning of the SR in terms of sustainabilty has to be understood by considering the relative change in the current level of the sustainability measure compared with the critical level of the sustainability measure. In the case of environmental sustainability, if the SR ratio is close to one this indicates that the sustainability issue is reaching critical levels. This is because environmental sustainability is primarily focussed on preserving states of the world (environmental value objects) that already exist and which generally have much higher values than the critical levels. In contrast, social sustainability sometimes includes states of the world (social value objects) that are largely aspirational for much of the world's population. Thus, the meaning of the sustainabilty indicator value has to be interpreted accordingly.

6.   Conclusions and recommendations

S-LCA is still very much in the developmental phase. When we started this project a few studies had been conducted and a few papers written on potential methodologies. There was no standardised procedure to conduct an S-LCA, nor any authoritative guidelines. Therefore, before we could apply S-LCA to New Zealand cheese as a case study, it was necessary for us to develop an appropriate methodology. In the meantime, just as this project was nearing its final days, official Guidelines were published by UNEP (2009). Fortunately, there is considerable conceptual similarity between the framework that we developed for this project and that produced by UNEP. As might be expected, there was a little difference in the terminology and slightly different emphases on some aspects.

Both our work and the UNEP Guidelines reveal significant difficulties in conducting S-LCA studies, given the current level of development and lack of adequate database tools for data management and inventory analyses. However, despite its teething problems and the immature state of the science, it is clear that S-LCA has the potential to contribute significantly to the eco-efficiency and sustainable production and consumption of products from a social perspective. Together with E-LCA and Life Cycle Costing (LCC), S-LCA is a tool that can help inform decision making for sustainable development.

A significant aspect of this project has also been the building of capability in AgResearch regarding S-LCA. The early loss of Dr Claudine Bassett-Mens from the project deprived the team of its leader and the only E-LCA specialist and was a real blow to our capability. However, before leaving Dr Bassett-Mens imparted as much of her knowledge as we could absorb and we have continued to work with her through the presentation of a paper at the 8th Ecobalance Conference in Tokyo 2009. In

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conjunction with Dr Bassett-Mens the project team has also written and submitted a paper for peer review and publication in a special issue on 'developing sustainable products, processes and services' of the *International Journal of Product Lifecycle Management*.

The project team has developed an AgDocs site which acts as a repository (http://content/sites/ags/ags001/default.aspx) for the information that the team has amassed during the course of the project and for the project team's outputs. S-LCA will continue to grow in importance and relevance as the sustainability imperative becomes ever more urgent. Our recommendation is that AgResearch continue to support this new growing field of knowledge. Its use and applicability to agriculture and food will continue to develop and AgResearch now has the capacity to integrate such work in other project when an appropriate fit exists. However, defining critical levels and gathering inventory data will remain difficult for some time to come. It will require continuing efforts at, and experience with, S-LCA in a wide range of different circumstances order to develop it into a mature scientific tool for aiding the sustainability imperative.

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