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Tracking down Social Impacts of Products with Social Life Cycle Assessment

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Abstract

An important aspect of sustainable development is the social impacts from the consumption of goods and services. A recently developed method for social life cycle assessment (S-LCA) assesses the potential positive and negative social impacts along a product's life cycle, while avoiding shifting negative impacts from one part of the supply chain to another. This thesis evaluated the applicability of S-LCA in three case studies, as well as a way of introducing an ethical perspective on the distribution of social impacts among stakeholders.

The case study of laptop computers identified workers and the local community as the stakeholders at greatest risk of negative social impacts, with China, Russia, Saudi Arabia, Thailand and Brazil being most prone to these impacts. A case study of vehicle fuels identified some fossil and some renewable fuels with high or very high risks of negative impacts, suggesting a need for strict procurement requirements on social performance for all types of vehicle fuels. A study of e-waste recycling in Pakistan revealed negative social impacts on workers and the community, while decreasing poverty by providing employment.

By performing a social hotspot assessment using S-LCA methodology, much can be learned about the potential social impacts associated with a product's life cycle, and potentially important aspects that would otherwise have been neglected can be identified. Some methodological issues of S-LCA requiring further attention are:

Indicator relevance. Impact pathways between indicators and performance assessment on social issues must be examined and improved.

Aggregation and weighting of impacts and indicators. With major uncertainties still present, results must be transparent, but also aggregated for the purposes of interpretation and communication.

Assessment of the use phase. To be more complete, S-LCA methodology needs to be complemented with an assessment of the use phase.

Introduction of context. Identifying the context of relevant stakeholders in different parts of the life cycle would allow identification of the greatest leverage in improvement of social conditions.

Sammanfattning

En viktig del av hållbar utveckling är att hantera social påverkan från konsumtionen av varor och tjänster. Social livscykelanalys (S - LCA) är en metod som syftar till att bedöma positiv och negativ social påverkan av produkter under hela deras livscykel och samtidigt undvika att bara flytta negativ påverkan från en del av livscykeln till en annan. Denna avhandling utvärderar S - LCA i tre fallstudier, samt undersöker hur fördelningen av den sociala påverkan på olika intressentgrupper kan bedömas ur ett etiskt perspektiv.

I en fallstudie som utfördes på en laptop identifierades arbetstagare och lokalsamhället som de intressenter, som löper störst risk för negativ social påverkan. Länder som Kina, Ryssland, Saudiarabien, Thailand och Brasilien var de som var mest kopplade till denna påverkan. En fallstudie kring fordonsbränslen visade att av de bränslen som bedömts uppvisade både en del fossila och en del förnybara bränslen höga eller mycket höga risker för negativ social påverkan, vilket tyder på att strikta upphandlingskrav gällande social prestanda behövs för alla typer av drivmedel. En studie av återvinning av elektroniskt avfall i Pakistan uppvisade påtaglig negativ social påverkan på arbetstagarna och lokalsamhället, samtidigt som återvinningen gav sysselsättning som minskar fattigdomen.

Genom att använda S-LCA vid bedömningen av en produkt finns det mycket att lära om potentiell social påverkan från produktens livscykel. Viktiga aspekter, som annars riskerar att missas, kan nu identifieras med S-LCA. Metoden är dock inte färdigutvecklad, och metodfrågor som behöver ytterligare uppmärksamhet är:

Relevanta indikatorer. Kopplingen mellan indikatorerna och den påverkan man försöker mäta måste undersökas närmare och förbättras.

Sätt att aggregera och väga ihop påverkan. Med tanke på de osäkerheter som ännu så länge finns kring metoden måste resultaten hållas transparenta, samtidigt som sammanfattande resultat behövs för tolkning och kommunikation.

Påverkan i användningsfasen. För att bli mer komplett, måste metoden kompletteras med en bedömning av social påverkan i användningsfasen.

Sätta resultaten i sitt sammanhang. Utgångsläget för dem, som berörs av en produkts sociala påverkan avgör vilken hävstångseffekt en förbättring av de sociala förhållandena kan ha, och kan därmed påverka vilka åtgärder som bör prioriteras.

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List of papers

Paper I: Ekener-Petersen E, Finnveden G (2013) Potential hotspots identified by social LCA—part 1: a case study of a laptop computer, Int J Life Cycle Assess, 18(1): 127-143.

Paper II: Ekener-Petersen E, Moberg Å (2013) Potential hotspots identified by social LCA—part 2: reflections on a study of a complex product, Int J Life Cycle Assess, 18(1): 144-154

Paper III: Ekener-Petersen E., Höglund J., Finnveden G. Screening social impacts of fossil fuels and biofuels for vehicles. Submitted to Energy Policy

Paper IV: Umair S., Björklund A., Ekener-Petersen E. Assessing Social Impacts of Informal Recycling of Electronic ICT Waste in Pakistan with a Life Cycle approach. Manuscript based on paper accpeted to and published in the proceeding of the ICT4S conference in Zurich, February 14-16 2013

Paper V: Arushanyan Y., Ekener-Petersen E., Finnveden G. Lessons learned – Review of LCAs for ICT products and services. Comput. Industry (2013), http://dx.doi.org/10.1016/j.compind.2013.10.003

Paper VI: Ekener-Petersen E, Larsson A., Finnveden G., Sandin P. Operationalizing and Incorporating Ethical Considerations Into a Tool for Multi-Criteria Decision Making. Submitted to the special section 'Operational Research and Ethics' of the journal EURO Journal on Decision Processes

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1 Introduction

1.1 Background

Sustainable development is commonly framed by the well-known definition in the report 'Our Common Future', also called the Brundtland report (Brundtland 1987), in which it is described as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It is based on "the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given". Sustainability is usually said to be divided into an ecological, an economic and a social part (Littig and Griessler 2005). It is often suggested that the least focus in society has been directed towards the social part (ibid.). However, the Brundtland definition of the concept of needs emphasises that priority should be given to the poor. Thus, it already establishes the social dimension as an indispensable part of sustainable development.

The three dimensions of sustainability are commonly portrayed as separate, hierarchically equal, entities. However, this approach has been criticised, with critics claiming that portraying the social and economic dimensions as separate entities strengthens the idea that the economy can be treated separately from the social context, within which all economic activities in fact are performed (Lehtonen 2004). Moreover, the model does not give any guidance on how to handle potential conflicts between the different objectives of the different dimensions (ibid.). Another way of portraying them is the bioeconomy model of circles, where the outer, environment circle surrounds the social, which in turn surrounds the inner economic circle (ibid.). This implies that the social dimension controls the economic, but is subject to the environmental dimension.

How can these dimensions be understood? Understanding of the economic dimension is not addressed here, but ecological sustainability can be seen as an absolute prerequisite for the continuous existence of human civilisation. There are potential disastrous consequences of eroding natural capital and destroying ecosystem services (Rockström et al. 2009). The goal of ecological sustainability is thus to sustain the natural capital and ecosystem services that we are dependent on for our survival and which are crucial to our civilisation. Social sustainability seems less straight-forward to understand and frame. What would the goal of social sustainability be on a societal or planetary level?

Searching the literature to get a better understanding of social sustainability, it becomes clear that consensus on a theoretical base is lacking. There are also different ideas on whether social sustainability should be viewed as a state, i.e. a description of a (future), desired society, or as a development orientation, which would then be more in line with the Brundtland definition. However, some key concepts have been put forward by different scholars in which social sustainability is said to:

- Be about **equity** (intra- and inter-generational) (Lehtonen 2004; Ballet et al. 2013)
- Be about **adaptation** (Faber and Jorna 2011)
- Be about creating and developing **well-being** (Ballet et al. 2013; Bijl 2011; O'Riordan 2012)
- **Be layered** (an individual and a collective level) (Lehtonen 2004; Bijl 2011)
- **Be reflexive** (affected by us while we examine it) (Lehtonen 2004; Bijl 2011)
- Involve **mutual interaction** with the ecological system (Rogers et al. 2012; Boström 2012).

An interesting perspective is the term sustainability. Social sustainability indicates that there is something to be sustained in a social perspective. There are different ideas in the literature on what is to be sustained, for example:

- **Healthy and satisfying ways of living, human well-being** (Rogers et al. 2012)
- **Resources** such as economic, social and cultural **conditions, efforts and values** (Littig and Griessler 2005; Stiglitz et al. 2009)
- **The social system** as a provider of conditions for human life (Missimer 2013).

Adger (2000) defines the term social resilience as the ability of human communities to withstand external shocks to their social infrastructure, e.g. environmental, social, economic or political disturbances. This indicates a link between the social dimension and the other dimensions.

Biart (2002) claims that long-term development only calls for a minimum of social requirements, drawing a line between what is desirable, i.e. what we might normally think of as social sustainability, and 'true' sustainability, which only encompasses these minimum requirements. Thus, social sustainability as we tend to think of it seems to encompass improvements rather than sustaining the present status (Bijl 2011). In the social capital approach, where the level of social sustainability in society can be seen a stock of social capital, that very stock of social capital can fluctuate. Thus, there is a possibility for future societies to possess more of it than we do today – more trust, less inequality etc. (ibid.). Consequently, it is not just a matter of continuing the present status, but also of aiming for the social cohesion to increase or improve. (Marcuse 1998) states that: "No one who is interested in justice wants to sustain things as they are now". This is also confirmed by the Millennium Development Goals (UN 2005), which call for improvements rather than sustaining something.

Missimer (2013) examined the concept of social sustainability with the aim of extending the social dimension of the Framework for Strategic Sustainable Development (FSSD). This framework currently consists of four principles for sustainability, three of which address the natural environment and only one the social system. She proposes five new principles to replace the previous social principle in the framework. These would read: "for social sustainability in a system people are not subject to systematic barriers to 1) personal integrity; 2) influence; 3) competence; 4) impartiality and 5) meaning". However, these principles mainly address the minimum social requirements for long-term development as defined by Biart (2002), discussed above. When striving for a flourishing society far above minimum requirements, an active positive contribution for improving social sustainability is probably needed. How to frame that in the FSSD – or in other approaches - is so far a seemingly unanswered question. Yet, barely meeting the basic requirements still seems to be an unfulfilled task, so action could begin there for a start.

Social sustainability can be addressed from many different angles. One of these is from the viewpoint of the responsibility of organisations. Business organisations are often specifically addressed, such as in the area of Corporate Social Responsibility (CSR). Initiatives and tools such as the UN policy initiative for sustainability policies and practices entitled Global Compact (GC 2011), the sustainability reporting framework Global Reporting Initiative (GRI 2013) and the certification standard for decent workplaces SA 8000 (SAI 2800) are all directed towards the business community and may be used to improve the performance of CSR in a company. In 2010, ISO launched its guidance standard on social responsibility,

ISO 26000 (ISO 2010). This comprehensive document addresses all types of organisations and largely encompasses the above-mentioned initiatives. It gives rich guidance on practical actions in relation to the issues addressed. Within an organisation, when the aim is to address social impacts regarding new technologies, an Ethical Technology Assessment (eTA) has been proposed (Palm and Hansson 2006). Further, for assessing projects, plans, programmes or policies, a Social Impact Assessment (SIA) can be used to provide information on social issues to be considered in the decision-making (IOCGP 2003). The SIA supports prior assessment, appraisal or estimation of the likely social consequences of a proposed action (ibid). It is therefore above all a suitable tool in the public sector, as it can be used by authorities to assess whether the planned action is in line with policies and goals. It also facilitates public involvement in public projects or plans (ibid). Thus, the infrastructure in people's daily lives, i.e. housing and transport, could be subjected to a SIA.

Still, an important aspect of social sustainability in people's daily lives is the social impacts from the consumption of goods and services. To achieve improvements in this area, the concept of Sustainable Production and Consumption (SPC) has been put forward. The importance of this issue has been acknowledged in international agreements since the Earth Summit in Rio 1992 and it is now integrated into EU policy by the Sustainable Consumption and Production Action Plan 2008 (EC 2008). There are several definitions of SPC. In the Oslo Symposium on Sustainable Consumption, as cited in Dolan (2002), sustainable production and consumption was defined as "the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations" .

When addressing SPC, there is always a supply chain involved. A life cycle perspective is therefore required to avoid the shifting of negative impacts from one part of the supply chain to another. A possible approach could then be to turn to the area of supply chain management (SCM). This research field has recently been complemented by the more specific field 'sustainable supply chain management' (SSCM). However a recent review of the literature on SSCM (Ashby et al. 2012) concluded that relatively less focus is placed on the social dimension. Moreover, the way in which social impacts are defined and addressed in SSCM is quite limited, mostly focusing on workers' issues, and the focus seems to be more on management processes within companies than on identification of important social issues and methods to address them.

Another possible approach when addressing the social impacts of goods and services is social life cycle assessment, S-LCA. This methodology is under development, starting from the established methodology of LCA (hereafter referred to as environmental LCA or E-LCA for reasons of clarity). A first major step in development was the issuing of the UNEP/SETAC S-LCA Guidelines (Benoit and Mazijn 2009; Benoit et al. 2010), hereafter called the Guidelines. S-LCA as framed in the Guidelines addresses a broader scope of social impacts. S-LCA is now being tested in case studies (Dreyer et al. 2010a, Paper I; Foolmaun and Ramjeeawon 2013; Ciroth and Franze 2011; Franze and Ciroth 2011) and is the subject of a lively discussion in the research community (Dreyer et al. 2010b, Paper II; Jørgensen et al. 2009; Jørgensen et al. 2010; Zamagni et al. 2011; Jørgensen et al. 2012; Parent et al. 2012; Jørgensen 2013).

The relationship between S-LCA and SPC was examined in a recent study (Parent et al. 2012) which found that the social dimension of SPC is rather neglected. However, they

concluded that an S-LCA "can support the SPC' goal of improving enterprises' behaviours in identifying areas of improvement for producers and to guide consumption of products (consumer goods of intermediary products) that will encourage the modification of enterprises' behaviours." (Parent et al. 2012). They also underlined the importance of a life cycle perspective, as the enterprises in need of modified behaviour may occur in any phase of the life cycle, even outside the so called sphere of influence (GRI 2013). One main merit of a life cycle perspective is its ability to prevent negative impacts being shifted along the life cycle (Baumann and Tillman 2004).

An interesting path of development for S-LCA is its potential integration with other assessments aiming at combining environmental, economic and social assessments into one common assessment of sustainability. The merit of this is to avoid suboptimisation when improving life cycles, which is an obvious risk when using the methodologies in three separate assessments. Different approaches have been proposed, among them Life Cycle Sustainability Assessment (LCSA) as proposed by Klöpffer (2008), where LCSA = LCA+LCC[1]+S-LCA. There have also been some practical attempts to develop sustainability assessment frameworks, such as the Life Cycle Sustainability Analysis developed within the EU project CALCAS which also addresses the meso level, i.e. the set of technologies and products, and macro level, i.e. taking an economy-wide perspective (Van Der Giesen et al. 2013). The aim is to take account of impacts from product systems on more aggregated levels, for example when several product systems are dependent on the same (limited) resource. In a globalised world, where supply chains are world-wide and intertwined, it becomes increasingly relevant to address higher level social impacts too. Assessing these higher levels will probably require different models than E-LCA/LCC/S-LCA, such as input output analysis of the different spheres (Van Der Giesen et al. 2013).

Another interesting initiative is PROSUITE, an EU project aimed at sustainability assessments of new technologies (PROSUITE 2013). It proposes a common structure for impact categories for all three sustainability perspectives, defined here as Impact on human health, Impact on social well-being, Impact on prosperity, Impact on natural environment and Impact on exhaustible resources. One useful feature is that human health impacts, presently included in both the environmental and social assessments, are included as a separate impact category alongside the environmental and social impacts, reducing risk of double-counting.

Sustainable production and consumption can only make a difference if incorporated into decision making at all levels in society. The major challenge for the research community is to find tools that are practical and use-friendly, enter common use and achieve positive outcomes for social sustainability. This thesis attempts to help meet this challenge by examining S-LCA methodology in a number of case studies. The ultimate target is to devise methodologies that allow SPC considerations to be integrated into existing structures for management and procurement, as well as individual purchasing decisions.

1.2 Aim

The overall aims of this thesis were to examine and evaluate the application of Social Life Cycle Assessment as a methodology for considering social issues from the production and consumption of goods, to examine different ways in which the methodology can be applied

[1] LCC = Life Cycle Costing, a method for assessing cost in a life cycle perspective.

and to study methodologies for adopting an ethical perspective on how social impacts are distributed among stakeholders.

The S-LCA methodology, as proposed in the Guidelines, was tested in the three case studies described in Papers I-IV, while Papers V and VI address related tool and issues. Specific aims of the individual papers were:

Paper I **Potential hotspots identified by social LCA – Part 1: A case study of a laptop computer**

The aim of this study was to identify social hotspots in a case study assessing a generic laptop using S-LCA methodology according to the Guidelines.

Paper II **Potential hotspots identified by social LCA – Part 2: Reflections on a study of a complex product**

This study examined the usability and applicability of the S-LCA methodology, based on experiences from the laptop case study in Paper I. Main issues considered were whether the gathering of data and other information is feasible and straightforward to perform, whether the method provides added value and relevant results and how these can be presented.

Paper III **Screening social impacts of fossil fuels and biofuels for vehicles**

The aim of this study was to assess a broad range of social and socio-economic impacts from both biofuels and fossil fuels on a generic level by applying S-LCA methodology and using data from the Social Hotspot Database (SHDB) (Benoit-Norris et al. 2012).

Paper IV **Assessing Social Impacts of Informal Recycling of Electronic ICT Waste in Pakistan with a Life Cycle approach**

This study analysed the social impacts of informal electronic waste recycling in Pakistan, using the framework of S-LCA as described in the Guidelines. Data were collected in a field study by a co-author of the paper.

Paper V **Lessons learned – review of LCAs for ICT products and services**

In this paper, some lessons learned from the LCAs conducted on ICT products and services were synthesised to create a common knowledge base. The paper has a focus on Environmental LCA but also includes literature on S-LCA.

Paper VI **Operationalizing and Incorporating Ethical Considerations Into a Tool for Multi-Criteria Decision Making**

The focus in this paper was on developing a structured approach to assessing the ethical performance of the risks emanating from different decision alternatives, integration of these ethical aspects into a multi-criteria decision analysis (MCDA) framework and application of the framework in a case study on destruction of ammunition.

2 Methods

The research presented in this thesis is directed towards sustainable production and consumption, focusing on the social impacts and taking a life cycle perspective. A social impact has been defined by the Interorganizational Committee on Guidelines and Principles

for Social Impact Assessment as “the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society.” (IOCGP 2003).

A life cycle perspective means considering the impacts of the complete value chain of a product, from raw material extraction, through production and use of the product until final disposal. Finnveden and Moberg (2005) evaluated different environmental system analysis tools and concluded that environmental LCA is the most appropriate methodology when assessing the environmental impacts of products. The same can be argued when assessing the social impacts of products. Therefore, Social Life Cycle Assessment (S-LCA) was the main method used in the case studies described in Papers I-IV. The method is evaluated in section 3.2 of the thesis.

2.1 Social Life Cycle Assessment, S-LCA

2.1.1 Background

S-LCA has developed from environmental LCA (E-LCA), which addresses environmental impacts. O’Brien et al. (1996) first raised the idea of complementing E-LCA with social life cycle assessment. The debate took off again in the early 2000s, evolving around issues such as how it should be integrated or aligned with E-LCA methodology (Klopffer 2003; Weidema 2006). Different indicators have been proposed, such as additional employment (Hunkeler 2006), Quality Adjusted Life Years (QALY) (Weidema 2006) and health impacts (positive and negative) (Norris 2006) . Site-specific assessments have also been suggested, as the impacts relate to company conduct (Dreyer et al. 2006).

In 2009, the longstanding discussion among researchers in the field resulted in release of the Guidelines (Benoit and Mazijn 2009). These were developed within the Life Cycle Initiative, a cooperation between the United Nations Environmental Programme (UNEP) and the Society of Environmental Toxicology and Chemistry (SETAC). The Guidelines may be viewed as the result of what could be agreed regarding S-LCA methodology at the time and thus do not completely cover all outstanding issues on S-LCA. The S-LCA methodology as framed in the Guidelines was chosen in this thesis, as it is the result of a broad, global, transparent and open process involving many relevant stakeholders from the public, academic and business sectors. S-LCA is an assessment technique that aims to assess the social aspects of products and services and their potential positive and negative impacts along their life cycle. S-LCA does not provide information on whether a product should be made or not. It can only provide elements of thought for a decision on production of a product.

S-LCA is based on E-LCA, with some adaptations, and was developed in accordance with the ISO 14040 and 14044 standards for E-LCA (ISO 2004). E-LCA and S-LCA share the life cycle perspective, considering the full life cycle of products. In principle, the full life cycle encompasses extraction and processing of raw material, manufacturing, distribution, use, reuse, maintenance, recycling and final disposal. The main difference between S-LCA and E-LCA is that E-LCA addresses environmental impacts, whereas S-LCA addresses social impacts, i.e. impacts on human beings and the society.

2.1.2 The area of protection

In S-LCA, the impacts are assessed in relation to an area of protection (AoP), which in the Guidelines is suggested to be human well-being. The impacts on the AoP are assessed in connection with the stakeholders and/or impact categories affected. The Guidelines suggest five different stakeholder categories: Worker, local community, society, consumer and value chain actor. However, the consumer stakeholder is only considered in situations of retailer interaction, whilst other impacts on the consumer during the use phase are not included. Each stakeholder is associated with a number of subcategories, including for example child labour, fair salary, health and safety, local employment, cultural heritage and corruption. The impact categories proposed in the Guidelines are: Human rights, working conditions, health and safety, cultural heritage, governance and socio-economic repercussions. The relationship between stakeholder categories and impact categories is not clarified in the Guidelines, nor is the relationship between impact categories and subcategories. As there is a defined relationship between stakeholders and subcategories, the stakeholder category approach was chosen in this thesis.

2.1.3 Data collection

There are two different, or consecutive, approaches in the methodology: An assessment of a generic product chain s and/or a specific assessment of the actual product chain for a specific product. The generic studies often aim at identifying hotspots. Social hotspots can be used for highlighting potential risks of violations and risks to brand reputation, as well as revealing opportunities for social improvements (Benoit-Norris et al. 2011). When performing a generic study, data on national, regional and/or sector level are more often used.

The first step in both approaches is to define the product system. In the case of a generic study, international, national and/or sector data are generally collected for this purpose. In the case of a specific study such data may also be collected, but the main data source would be interviews and data collection at site level. Methodological worksheets have been prepared in connection with the Guidelines (Benoit-Norris et al. 2011). These are intended to support S-LCA practitioners by providing more information on subcategories and suggesting inventory indicators and data sources for data collection for each stakeholder category and its associated subcategories. Several indicators and related data sources may be proposed for each subcategory. The type of data suggested is a mix of qualitative, quantitative and semi-quantitative measurements from many different sources. Moreover, the Social Hotspot Database (SHDB), which contains generic data for S-LCA hotspot assessment, has recently become available (Benoit-Norris et al. 2011).

2.1.4 Activity variable

In order to relate data collected to the product assessed, the relative magnitude of the activity in each process in the life-cycle must be known. The total activity required in the product life cycle has to be distributed among the life cycle phases. The Guidelines suggest using an activity variable, i.e. a measure of process activity or scale which can be related to the production and disposal of the product, e.g. worker hours or value added. The importance of the collected data for a specific part of the life cycle can then be determined by relating the data to this activity variable. The activity variable can be either in absolute terms (e.g. working hours) or in relative terms (e.g. share of total working hours for the product).

2.1.5 Impact assessment

There is an obvious need to present the results from the life cycle inventory (LCI) in a comprehensible way. Producing large tables with huge amounts of data which cannot be related to each other makes interpretation difficult and limits the usefulness of the results. Instead, an impacts assessment method is needed. However, clear-cut guidance on impact assessment and aggregation in S-LCA is not provided in the Guidelines. One approach, the Life Cycle Attribute Assessment (LCCA), was proposed prior to the publication of the Guidelines (Andrews et al. 2009; Norris 2006). Since then, a few more methods have been presented for assessing the results in an S-LCA related to the Guidelines (Paper I, Ciroth and Franze 2011; Franze and Ciroth 2011; Norris et al. 2012; Hsu et al. 2013). Two main approaches can be distinguished, one using a relative assessment and the other one assessing absolute levels by performance reference points. Performance reference points are for example internationally set thresholds.

2.2 Case study methodology

As one of the aims of Papers I-IV was to evaluate the S-LCA methodology proposed in the Guidelines, the use of case study methodology seemed relevant.

Case studies are studies conducted on a complex and contemporary functioning unit, where one or a few study objects are investigated in their natural context (Johansson 2007). The products chosen as case study objects in this thesis, a computer laptop and vehicle fuels, are complex (especially the laptop), were investigated in their natural context (in representative generic value chains) and are of current relevance. Another important aspect of case studies is that of learning (Flyvbjerg 2006). As the S-LCA methodology is recent and immature, learning is an important part of the achievement in these cases. To confirm the relevance of case study methodology and the study design, the following questions have to be answered (Johansson 2007):

1. Why am I using this case?
2. How generally applicable are my results?
3. How do I know that my results are valid? Do I use triangulation?

Why am I using this case?

In Papers I-IV, the S-LCA methodology was applied to a laptop computer, vehicle fuel and informal e-waste handling. A laptop seemed a relevant, yet demanding, product to use and can be regarded as a critical case, i.e. having strategic importance in relation to the general problem (Flyvbjerg 2006). In the context of the thesis, this meant that if S-LCA proved to be applicable and feasible for analysing such a complex product, it is likely to be applicable to other, less complex products as well. Furthermore, a laptop is a common product that many people can relate to and is produced in large numbers, with a large turnover, so it has a large impact on society. In the case of vehicle fuel, this is already a heavily discussed topic in society, with social aspects already on the agenda especially for biofuels. Further, many people are affected when it comes to choosing what kind of car to buy and what kind fuel to use in their car. The assessment of informal e-waste handling was motivated by a general idea of severe neglected social impacts in this sector and the belief that an S-LCA approach could be useful to illuminate these impacts.

How generally applicable are my results?
Generalisations from case studies are based on reasoning of three different kinds; deductive, inductive and abductive (Johansson 2007). In this thesis, a form of inductive reasoning from a theory and a case was used. The theory was that S-LCA is possible to apply for the identification of social impacts from products, the gathering of data and other information is feasible and straightforward to perform and it proves to be usable by providing relevant results and new knowledge. This was then tested in the different case studies (Papers I-IV).

The results in Papers I-III are generally applicable since in addition to being critical, the cases they describe were performed on a generic level, with generic value chains and data, and are thus valid for a range of products with similar value chains. Moreover, as stated above, there is some likelihood that a methodology successfully applied to a complex product can also be applied to a less complex product. The e-waste study (Paper IV) was a specific study only covering a part of the life cycle, and one can assume there are many other spots where informal recycling of e-waste takes place, in Pakistan and in other developing countries. Similar conditions in many developing countries when it comes to social issues suggest that the results may be applicable to those countries. However, the main aim in Paper IV was not generalisation, but increasing knowledge of the specific case.

How do I know that my results are valid? Do I use triangulation?
One aim was to examine and evaluate different methodologies. To do this, there needs to be some criteria to evaluate them against. For the laptop study and the vehicle fuel study, the criteria set were: i) Is it at all possible to conduct and finalise a generic case study using this methodology? (applicability); ii) is it reasonable to do it, considering the efforts put in and the results obtained? (feasibility); and iii) are the results plausible (reliability)?

The applicability was simply assessed by observing whether it was possible to finalise the studies or not. The feasibility was determined by a subjective discussion on the 'cost' and 'benefits' of the studies: how much resources in terms of time and money had to be put into the study to get the result, and how useful was the result? As regards the reliability, it is difficult to evaluate a methodology when there is no absolutely true answer available with which to compare. Therefore, it cannot be determined whether the methodology gives the "correct answer". This is because the social (or environmental impacts) of a single product cannot be studied empirically. Instead, one must rely on models that can connect impacts to the products studied (Heijungs 1998). When developing models, one needs to make methodological choices that are sometimes purely technical, but sometimes include value choices, the correctness of which cannot determined (Finnveden 2000; Hofstetter 2000; Tukker 1999). However, the methods can be studied and it can be determined whether they contain any logical errors. Methods and data can also be assessed to see whether they are compatible with the best scientific standards, and results can be analysed to see whether they seem reasonable or not (Ahlroth and Finnveden 2011). The latter of these approaches was chosen and triangulation was applied to assess the same issue from another angle, in order to check whether the results were similar or at least comparable.

The triangulation in the laptop study was conducted by comparing the results of the laptop study with issues previously regarded as important social problems related to ICT products. Firstly, a comparison was made with the expected results stated by the reference groups before the study. Secondly, the results were compared with the issues raised on this topic in the public media. To triangulate the results in the vehicle fuels study, a systematic literature

survey was conducted on scientific papers and reports, looking for publications that dealt with social aspects associated with the production and use of vehicle fuels.

In the e-waste study, the results are reliable in that they are observations in the field. However, field observations can be distorted due to the impact on the observer, or due to tendencies among those observed to conceal facts or even give untrue information under certain circumstances. With the e-waste study being a field study, the only option was to try to assess the truthfulness of the respondents in that study.

2.3 Ethical assessment

It may seem important not only to assess the impacts, as is done in S-LCA, but also to consider the distribution of impacts on different groups in society. The impacts can be of different types, such as social impacts, environmental impacts, risks, economic costs and various types of benefits. The distribution of impacts can be said to be an ethical issue. It focuses on equitable distribution and other aspects of fairness, and is often overlooked in socio-economic analysis. Therefore, an ethical consideration of the distribution of risk was explicitly included in the decision analysis presented in Paper VI. As regards methodology for the ethical assessment, it was based on the three-party model proposed by Hermansson and Hansson (2007). This tool aims to provide an ethical analysis of risks and focuses on the ethical relationships between the three critical parties that are present in almost all risk-related decisions:

- The decision maker
- The risk-exposed
- The beneficiary.

A number of questions are proposed to provide a systematic characterisation of the ethical aspects of risk, including issues such as voluntariness, consent, intent and justice (Hermansson and Hansson 2007). The tool was tested and evaluated in a case study previously, using destruction of ammunition as the case (Alverbro et al. 2011). The results indicated that future generations and people living in countries affected by climate change are important from an ethical perspective, as they are exposed to risks without having any influence, and often have neither benefit nor compensation for risk exposure (Alverbro et al. 2011). In Paper VI, the ethical analysis was further developed and complemented with approaches based on internationally established targets and agreements.

2.4 Multi-criteria decision analysis (MCDA)

Multi-criteria decision analysis (MCDA) was used in Paper VI to examine how ethics can be integrated into decision-making, in that case alongside cost, safety and environmental issues. MDCA can be regarded as a toolbox containing different methods (Zhou et al. 2006; Dodgson et al. 2009; Jeswani et al. 2010). What they all have in common is that they provide aid in clarification of the various options with regard to how they contribute to meeting the stated criteria (sometimes referred to as objectives or attributes), and that they require the decision makers to express their values and preferences. Their contribution to the decision-making situation is that they help decision makers manage large amounts of complex information in a systematic way and reveal the relative weighting between the different criteria for the decision (Dodgson et al. 2009).

In the case study, an MCDA method that is integrated into a software tool was chosen. The method is based upon multi-attribute utility theory (Keeney 1993), but relaxes the requirement for precise estimates of weights and utilities, and has been developed over recent decades at Stockholm University and Mid Sweden University (see e.g.Larsson et al. 2005; Danielson and Ekenberg 2011). This method is particularly appropriate for dealing with decision-making situations with uncertain or imprecise data and where data are available in various formats, which strongly applied to our decision-making situation with highly imprecise properties of the underlying value assessments for all criteria. The tool has features that allow the decision maker to avoid stipulating weights at an early stage, and rank-ordered weights can be used (Riabacke et al. 2009). The approach allows decision makers to state their criteria weights in vague terms by means of interval statements or rankings. The statements are then translated into linear constraints, since in order to support decision evaluation methods aiming to discriminate between alternatives with imprecise statements, the methods seeks to find a series of maximum differences in utility between alternatives under different preconditions. It also seeks to allow simultaneous comparison of all alternatives, providing informative rankings of the alternatives.

In Paper VI, a criteria hierarchy model that explicitly separates the fundamental, or high-level, criteria from the low-level criteria subject to assessments was employed. When an outcome is obtained for the different areas, the decision maker must prioritise between them in a structured way. A rather simple model (SWING), relevant for an application with unsure data in various formats, was chosen. In short, the SWING weighting technique evaluates the impact for each criterion when swinging from the worst performance to the best available alternative for each criterion. Rank-ordered weights, modelled in the form of linear constraints, are then assessed.

3 Results

Below, the results from the included papers are summarised.

3.1 The potential development of S-LCA based on the factual development of E-LCA (Paper V)

To understand S-LCA and what it may, and perhaps should, contain, it can be useful to depart from the well-established methodology of E-LCA and look for common methodological issues. In Paper V, a review of E-LCA and S-LCA studies on ICT products and services was presented. As might have been expected, considering that the Guidelines were issued only in 2009, only a few scientific papers and reports were found on the application of S-LCA in the ICT sector. However, there was a large amount of research on the application of E-LCA in the ICT sector. Some of the conclusions with relevance for S-LCA are:

1. Energy use and global warming potential are the main focus in E-LCA on ICT, while other environmental impacts are not as well studied. This could conceal important impacts in other life cycle phases, such as end-of-life. This result may be transferred to S-LCA, where many studies so far have limited their scope to encompass social impacts on workers (Jørgensen et al. 2008). This limitation might in the same way give a skewed picture on where in the value chain the most severe impacts occur.

2. The rapid technological development of ICT is a source of variability in E-LCA. The results of S-LCA on ICT may also be affected when the rapid change alters the production process technology and/or the choice of suppliers, which in turn affects the social impacts on workers and the local community, for example.

3. Differences in the data used, such as different data sources, lack of data or uncertain data, may increase the variability in results in S-LCA, as it does in E-LCA according to the literature. In fact it may increase the variability even more, as the access to common databases for social impacts is much more limited than for environmental impacts. Although there are some benefits with many scholars collecting their own data, the individual data sets produced also lower the comparability of the results.

4. Considering the use phase of ICTs, there are potential positive indirect environmental impacts regarding CO_2 emissions, such as reducing travel and using digital services instead of physical products. However, more knowledge needs to be gathered on the so-called rebound effects, and environmental policies have to be designed to ensure that ICT applications make a beneficial contribution to environmental outcomes, while suppressing rebound effects. In S-LCA, there are potential positive direct effects even without including the use phase, such as job creation. The potential positive effects may be even greater if the full use phase is included in S-LCA, which has not been done yet for methodological reasons. Considering the often qualitative indicators of social impacts, aggregating negative and positive impacts is a greater challenge than is the case for example with CO_2 emissions.

3.2 Evaluating S-LCA methodology in case studies

In the three case studies described in Papers I-IV, different S-LCA methodologies were applied to different types of products.

3.2.1 Laptop case study (Papers I-II)

In the case study described in Papers I and II, a generic hotspot assessment was conducted on a laptop computer according to the methodology in the Guidelines. Hotspots can be defined as "unit processes located in a region where a situation occurs that may be considered a problem, a risk or an opportunity, in relation to a social theme of interest. The social theme of interest represents issues that are considered to be threatening social well-being or that may contribute to its further development." (Benoit and Mazijn 2009).

A simplified product system from resource extraction to end-of-life of a generic laptop computer was assessed. The impacts were assessed in relation to the AoP human well-being and affected stakeholders. The social impacts from the actual use of the product and production of electricity or transport were not included. Methodological worksheets (Benoit-Norris et al. 2011) were used for guidance on inventory indicators and data sources for data collection. Country-specific data were collected and entered into a spreadsheet. In order to relate the data collected to the product assessed, each country's share of the activity performed within each phase was defined and its percentage activity was calculated. The countries were divided into colour-coded groups as regards the extent of activity within each phase and assessed according to their performance in each subcategory. A new method for impact assessment of hotspots was developed. Countries with the most extensive activity and those with highly negative values for possible indicators were highlighted. Any country with combined high values in both dimensions was identified as a hotspot (Figure 1). The results were not further aggregated, in order to promote transparency. The process was guided by regular meetings in a reference group, composed of representatives of the stakeholder groups.

Stakeholder	Subcategory	Indicator	Unit of measure	China	Thailand	US	Saudi Arabia	Germany	Source	Worldmax and min of indicator	Mean and limit for the 25% highest (lowest) values
Worker	Equal opportunities /Discrimination	Women in Labour force	Female working percentage as % of male working percentage	88	83	85	27	87	The World Bank, CPIA	max 100; min 12	56 and 34
	Social Benefits/Social Security	Social Security Expenditure	Spending as % of GDP	5.33	4.74	14.79	0.21	26.17	ILO	max 29.40; min 0.08	7.41 and 14.74
Local community	Access to material resources	Changes in Land Ownership	Publicly owned forests %	68	88	43	98	53	FAO Global Forest Resource Assessm 2010	max 100; min 0	25 and 50
		Levels of Industrial Water Use	Annual freshwater withdrawal by industry, % of	25.7	2.5	46	3	67.9	World Bank, Water Resource Management	max 85; min 0	42.5 and 63.75

Figure 1 Section of the spreadsheet used in Paper I (adapted, for illustrative purposes only). Pink (dark) columns indicate countries with very high activity in the phase; blue (medium) indicate large activity; and yellow (light) indicate moderate activity. The black circles illustrate values in the highest quarter of impact globally, indicating severe impacts, while grey circles illustrate values in the second highest quarter of impact globally, indicating quite severe impacts.

The assessment described above was done separately for each phase. The next step was to distribute the activity among phases by an activity variable. The purpose of an activity variable is to relate all the phases in the product system to each other, ranking them by

significance. Due to lack of data, an activity variable to use for this distribution could not be calculated. Instead, an estimated activity variable was calculated and used, but as a final check only. The most significant phase indicated in this check was manufacturing and assembly, closely followed by resource extraction and refining and processing. These were the phases already containing the most severe impacts, and thus the result would not have been altered had our estimated activity variable been used in the actual assessment. As there was no indication that an activity variable in this case would change the outcome, no distribution among phases was done.

The results of the assessment revealed some hot countries, some hot issues and some hotspots, all indicating a substantial risk of negative social impacts in the product system of a laptop. The hotspots, identified as the subcategories where very high activity countries displayed potentially severe impacts, are shown in Table 1.

Table 1 Hotspots identified in the laptop case study (Paper I)

Stakeholder	**Subcategory**	**Countries involved with potentially severe impacts**
Worker	Social benefits/social security	China, Russia, Saudi Arabia, Thailand
	Working hours	Brazil, Bolivia, Thailand
	Freedom of association and collective bargaining	China, Thailand
Local community	Access to immaterial resources	China, Bolivia, Russia, Saudi Arabia
	Safe and healthy living conditions	China, Saudi Arabia, Thailand
	Community engagement	China, Saudi Arabia, Brazil, Bolivia, Thailand
	Delocalisation and migration	China, Brazil
	Cultural heritage	China
	Respect for indigenous rights	Brazil

The assessment thus identified workers and the local community as the stakeholders most at risk of negative social impacts.

The results in the laptop study were triangulated using the expectations of the reference group and were found to be sufficiently similar. However, the impact on the local community was more strongly highlighted in our study than expected by the reference group. Furthermore, the countries targeted in the expectations were not fully the same as those identified in the results, although there was a substantial overlap. Likewise, there was an overlap regarding phases in the life cycle expected to be and found to be most critical, but no exact match between the expectations and the findings. The comparison with media-highlighted issues also produced quite similar results, although e-waste handling in West Africa was not identified as a hotspot in the study as the flow of illegal e-waste from Sweden was estimated to be quite small.

It is interesting to note that the potentially most affected stakeholder groups were workers and local community. For workers this was fairly well expected, as this is the most frequently addressed area by the research community when assessing social impacts.

Jørgensen et al. (2008) summarised the social indicators addressed in 11 different S-LCA studies and grouped these indicators to stakeholders in alignment with the Guidelines. This exercise showed that of all indicators relating to stakeholder workers, 10 out of 11 studies covered at least one of them. In other words, only one study did not address workers' issues at all. Of all the other indicators taken together, at least one of them was found in seven studies, i.e. four studies only addressed worker stakeholders (Jørgensen et al., (2008). This suggests that workers are the most frequently addressed stakeholder group in S-LCA studies. In the media scanning performed in Paper I, workers' issues were also found to be those most frequently addressed and, as it turned out, workers were also the focus in the reference group. The results in Paper I can generate some more attention in the future for social impacts on the local community and other related issues identified in the study, such as access to immaterial resources, safe and healthy living conditions, community engagement, delocalisation and migration, cultural heritage and respect for the rights of indigenous peoples.

In the methodological reflections presented in Paper II based on the laptop case study, the S-LCA methodology was found to be feasible and useful. The study showed it is possible to conduct a hotspot S-LCA on a generic complex product using the Guidelines, even though data collection was impaired by lack of data and low data quality. By handling many relevant issues within one study, using a systems perspective on the product life cycle, knowledge can be gained. However, the methodology faces some major challenges. The definition of relevant indicators, data availability, impact pathways, activity variables, results presentation and possible aggregation, the handling of stakeholder context and the restricted assessment of the use phase were identified as major issues to deal with in future studies. Communication, and hence use of the results, is a crucial issue to enable the outcome of a study to result in actions that actually improve human well-being.

3.2.2 Vehicle fuels case study (Paper III)

The case study described in Paper III was a generic S-LCA conducted on fossil and renewable vehicle fuels. In principle, this study was also based on the S-LCA methodology as proposed in the Guidelines. However, the Social Hotspot Database (SHDB) (Benoit-Norris et al. 2012) was chosen for data collection.

The approach in SHDB is based on the Guidelines, and the data are made available in a pre-defined structure. The SHDB contains social data on country or sector level, the latter depending on availability and relevance in the 57 sectors covered. The data are displayed as assessed level of risk (low, medium, high or very high risk) for each sector/country and indicator, grouped into their related themes and categories. The definition of the assessed level of risk is done individually for all indicators. In many cases the range of possible results were divided into four quarters, where the lowest quarter were defined as "low risk", the second lowest as "medium risk", etc. In other cases more or less obvious transitions were defined as low, medium, high, and very high risk. In a few cases also calibration against literature or consultation with experts were used. As a risk perspective is taken, potential positive impacts are handled by being inversed in their negations, e.g. employment is assessed as the level (and thus risk) of unemployment in the area

The fuels selected for the case study in Paper III were diesel and petrol produced from imported crude oil from Russia, Norway and Nigeria. Biofuels included ethanol from Brazilian sugar cane, French wheat and maize and US maize, together with rapeseed biodiesel

originating from Lithuania. The product system of the selected vehicle fuels was defined and the production chains were simplified to consist of three main steps: 1) Production/cultivation, 2) refining/processing and 3) transport. These steps reflect the main phases of a generic production chain applicable to both biofuels and fossil fuels. As our assessment had a broad scope, data were collected on all categories, for all the related themes and all available indicators in the SHDB. The result was for each fuel in each phase an assessment of the risk level for all indicators, resulting in a total of almost 3300 data points.

The next step was to aggregate the data for each country/sector combination. This was done by counting the number of risks per country/sector. The reason for this approach was that it is transparent and easy to understand, in contrast with some more complicated, constructed weighting and valuing systems. Only high and very high risk indicators for each combination were counted. Thus, the medium and low risks were not covered in our assessment. Conducting a generic assessment aims in general at finding hotspots, and it was therefore concluded that the high and very high risks are of most interest to the user.

The outcomes of the assessment, i.e. counting the high and very high risk indicators, were summarised in tables listing the social themes contributing to high and very high risks in each fuel chain. They were also displayed in various graphs, e.g. one that illustrates the total number of risks for each fuel chain assessed (Figure 2).

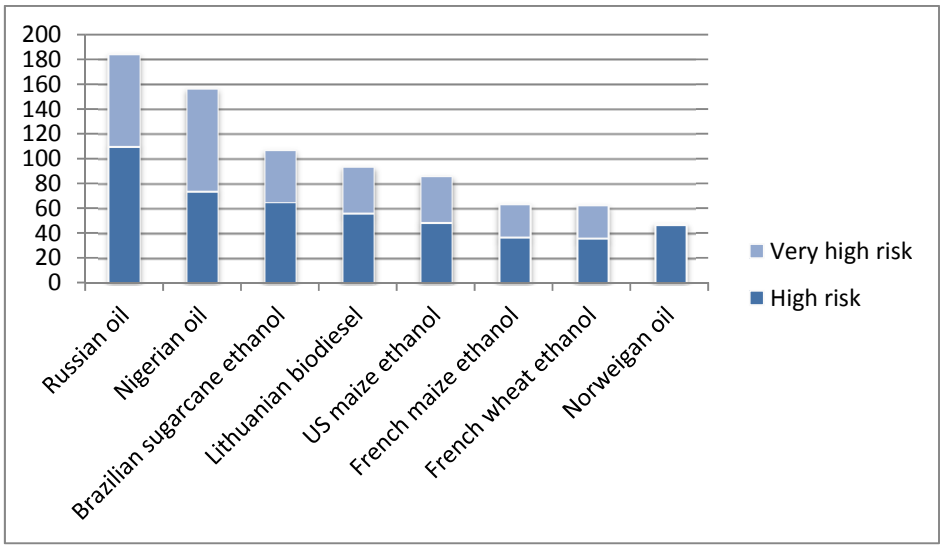

Figure 2 Total number of very high and high risks identified per fuel chain (Paper III).

As there are three phases in each fuel chain and 137 indicators in total in the SHDB, the highest possible number of risks for a fuel chain is 3 times 137, i.e. 411 risks. To get such a score, all indicators in all phases of a fuel chain would have to show high or very high risks. From Figure 2, it can be seen that the number of risks varied greatly between the different fuel chains, from about 180 in total for Russian oil to about 40 for oil from Norway. This indicates that there is good reason for applying as strict demands when purchasing fossil fuels as is already done when purchasing biofuels, in order to minimise negative social impacts.

Other interesting results were found following a split by social category and by phase for all fuel chains (Figure 3 and Figure 4), displaying the most crucial issues and the most potentially impacting phases for vehicle fuels overall. It is clear from these graphs that labour issues, followed by human rights and health and safety, are the most risk-laden issues for vehicle fuels in general. Regarding the most impacting phase, all three phases assessed in Paper III appeared to be equally influential.

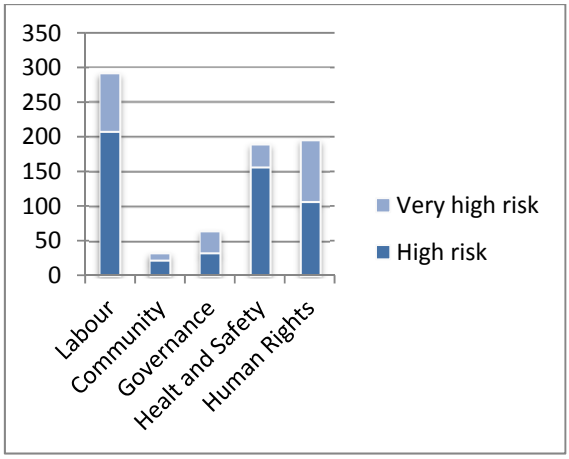

Figure 3 Total number of high and very high risks in all assessed fuels chains combined, per social category

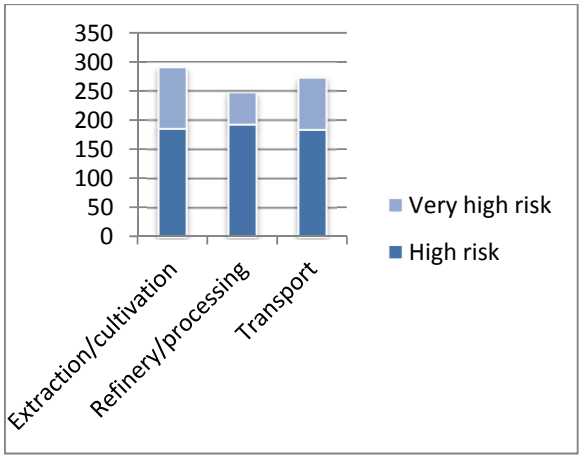

Figure 4 Total number of high and very high risks in all assessed fuels chains combined, per life cycle phase

It should be noted that the results must be interpreted with care due to some limitations owing to the simplifications made in the product system, the use of SHDB for data collection and impact assessment, and the choice of aggregation method. Still, it can be seen that among the different fuels assessed in this study, various fossil fuels and renewable biofuels displayed a substantial number of high or very high risks of negative social impacts. Thus, the assessment clearly showed that there are risks for negative social impacts from fossil fuels, at the same levels as for biofuels. Overall, the country of origin seemed to be more importance that the nature of the fuel, as the most risk-related and the least risk-related product system in our assessment referred to the same type of fuel: The highest number of risks was identified for fossil oil from Russia and Nigeria, whereas oil from Norway displayed the lowest number of risks in the assessment.

Using S-LCA methodology can enable policymakers to identify where the most severe social impacts occur in the value chain, and policies can be adapted accordingly. A screening S-LCA like this can be used to identify potential risks. The results from the present study show that labour issues, followed by human rights and health and safety, are the most risk-laden issues for vehicle fuels in general. By performing more thorough assessments, the schemes can be adapted to include the criteria and indicators that are the most relevant and associated with the highest risks of negative social impacts for specific fuels and/or origins.

3.2.3 E-waste case study (Paper IV)

The case study in Paper IV assessed the informal recycling of e-waste from the ICT sector in Pakistan applying the S-LCA perspective. This informal e-waste recycling system covered the service chain from the point of arrival at one of the many informal recycling sites in Pakistan, until the item is either (1) refurbished and sold as second-hand electronics, (2) dismantled, recycled and sold as raw material, (3) sent to formal recycling, or (4) finally disposed of.

For inventory data collection, a field study was conducted by a co-author at sites in Pakistan where general electronic waste recycling is carried out. Data were collected through observations during field visits, informal conversational interviews and with the help of open-ended questionnaires.

The impact assessment method used was based on one developed by (Franze and Ciroth 2011), which in turn is based on the Guidelines. It evaluates the social impacts of each subcategory, defining whether the subcategories affect one or more of the impact categories. The outcome of this assessment per impact category is then summarised in an overall impact, in our adapted version of the model expressed as: negative (yellow), very negative (red), positive (green), and indifferent (white).

Table 2 shows stakeholder category, subcategory, summary of the existing situation, corresponding impact category and overall impacts as a total rating. It can be seen that this process mainly revealed potential negative or very negative social impacts, except for the subcategories wages, equal opportunities/discrimination, local employment and contribution to economic development, which gave positive results.

Table 2 Impact assessment of e-waste handling, expressed as total rating per subcategory and related stakeholder category

			Impact category				
Stakeholder category	**Subcategory**	**Status in summary**	**Health & safety**	**Socio-econ. repercussions**	**Human rights**	**Develop-ment of country**	**Total rating**
Worker	Working hours	74 hrs +	-	-	-	+	Negative
	Child labour	Yes	-	-	-	-	Very neg.
	Health and safety	Extensive negative impacts	-	-	-	-	Very neg.
	Social security	No	-	-	-	No imp.	Very neg.
	Forced labour	Not seen	No imp.	No imp.	No imp.	No imp.	Indifferent
	Wages	More than $2.7/day	No imp.	+	No imp.	+	Positive
	Equal opportunities/ discrimination	Equal opportunities, no discrimination	-	+	+	+	Positive
	Freedom of association	No	-	-	-	-	Very neg.
Local community	Safety and health	Yes	-	-	-	-	Very neg.
	Community engagement	No	-	-	-	-	Very neg.
	Local employment	Yes	+	+	+	+	Positive
Society	Public contribution to sustainable issues	No	-	-	-	-	Very neg.
	Contribute to economic development	Yes	+	+	No imp.	+	Positive
Value chain actors	Promote social responsibility	No	-	-	-	-	Very neg.
	Fair competition	No	No imp.	-	No imp.	-	Negative

Our experience from using the Guidelines on informal activities as part of a value chain was that some of the listed subcategories are hard to apply under these circumstances, particularly for the stakeholders society and value chain actors. The actual term 'informal sector' implies that it is characterised by a lack of formal relations with actors outside its limits. Thus, there are no data on the relationships with suppliers and society as a whole, whereas for workers and local community data could be collected on-site through interviews. Still, some of the negative social impacts in the value chain of a product may very well originate from informal activities at the outer ends of the value chain. This needs to be considered when further developing the Guidelines. The risk of the exclusion of these parts of the value chain due to problems with data collection and irrelevant indicators, resulting in non-identification of severe social impacts, should be considered.

3.3 Assessing ethics as an integrated part in risk-related decision-making (Paper VI)

The three case studies described above all applied S-LCA methodology to assess a wide range of social impacts related to products. In the fourth case study (Paper VI), a different approach was taken. The ways in which some identified risks were distributed among the affected groups were examined, i.e. the ethics in risk-related decisions-making. Decision-making may affect other stakeholders than the decision maker or may have societal impacts not affecting the decision maker at all. These impacts may be interdependent and thus need to be addressed simultaneously. In a previous study a framework for integrated assessment including five areas (environment, safety, ethics, cost and integration) was developed (Alverbro 2010). It is intended for use on a policy level, where site-specific information is lacking. The ethical part of the assessment utilises the three-party model developed by Hermansson and Hansson (2007).

In Paper VI, the ethical analysis in the decision-making framework was extended. The three-party model by Hermansson and Hansson (2007) was divided into a two-part assessment: the distribution of the actual risks and benefits among actors (distributional fairness); and the ability to influence the decision and to access relevant information, a prerequisite for influence (procedural fairness). It was also complemented with questions on how the assessed items contribute to or counteract some international agreements in this area; the United Nations (UN) Universal Declaration of Human Rights (UDHR) (United UN 1948) and the UN Millennium Development Goals (MDGs) (United UN 2005). An example of a scoring system was also developed so that the ethical assessment could be considered alongside the others in the integrated assessment. The refined framework tool was tested in a case study on the destruction of ammunition, as used previously (Alverbro et al. 2011). Different possible methods of destruction were compared; open detonation, modelled with and without recovery and recycling of metals, incineration in a static kiln with air pollution control combined with recycling of metals, modelled with two different levels of air emissions, and a combination of incineration with air pollution control, open burning, recovery of some energetic material and recycling of metals. However, it should be noted that the way in which the ethical assessment was performed, with the use of a scoring system, was intended as an illustrative case only.

On assessing distributional fairness, which is about the distribution of the risks and benefits, these were found to be quite unfairly distributed, scoring 4 on a scale from 2 (very unfair) to 6 (fair), and were the same for all alternatives studied. For procedural fairness, which is about influence on the decision-making, two alternatives, open detonation with two different approaches to metal recycling, proved to be quite fair, with a score of 9, while the other alternatives were almost fair, with a score of 11 on a scale from 4 (very unfair) to 12 (very fair). The high scores on procedural fairness in this case were interpreted as the result of strong Swedish legislation on labour rights and on the right to a public hearing. The difference between the alternatives that scored lower and the other alternatives was due to the fact that the local community was more affected by open detonation than the other alternatives, and this group was assumed to have less information about, and less influence on, the decisions on destruction method than employees.

Our assessment of whether the five options contributed to, or counteracted, the MDGs found that open detonation (both options) counteracted them on two items, incineration in a kiln (high emissions) counteracted them on one item, incineration in a kiln (low emissions)

was neutral and the combination option contributed to achievement of the MDGs. Four possible risks of breaches of human rights were identified for open detonation (both options), while for the other alternatives only one possible risk of breach was identified.

The integrated assessment was done using multi-criteria decision analysis (MCDA) based on multi-attribute utility theory. The existing reference group of the project, which consisted of representatives from industry, government agencies, research institutes and academia, was asked to act as the decision maker and carry out the prioritisation required in MCDA.

In this specific case, the prioritisation process led to the largest priority being set on the environmental aspect, while ethics was given the lowest priority. This was due to the fact that the destruction methods did not differ much with respect to the ethical aspects, and ethics thus did not alter the outcome of the assessment in a significant way. Despite this, using this tool for assessing ethics was found to add value, as it raised perspectives that would otherwise have been neglected. In the case study, it was concluded that a combined alternative including recycling of metals and energetic materials had clear advantages over open detonation.

The outcome of this work indicated that the framework for ethical assessment added value in the total assessment, as a ranking of the methods could be made on ethical grounds and the outcome could in principle be considered in the total assessment (although not in this case due to the priorities of the decision-makers). It is also a way of highlighting ethical considerations in decision-making.

Assessments of this kind always bring the issue of values into the discussion. Certainly, many of the aspects considered in Paper VI, such as fairness, are dependent on values. Therefore it is important to clarify upon whose values the assessments are based. In the best case, there are globally, or almost globally, agreed values to be used, which can be found in international agreements and conventions, such as the Rio Declaration on the environment and the UN UDHR. It was found that for environment and personal safety, as well as for the parts of ethics that are based on UN documents, this requirement was fulfilled. For other aspects in the ethical assessment, such as fairness, the concept employed arguably represents mainstream ideas of what fairness comprises. In the prioritisation step, it was the values of the decision maker that were reflected, and they are also meant to be reflected. This is an inherent part of decision-making.

4 Discussion

4.1 Reflections on the S-LCA studies in Papers I-VI

The three different case studies conducted using S-LCA methodology all used different methodological approaches. In the laptop study, our own approach was applied, while the e-waste study made use of the approach developed by Franze and Ciroth (2011). The approach integrated in the SHDB and developed by Benoit-Norris et al. (2012) was applied in the vehicle fuels study. This offers a good opportunity to compare the features of these different approaches. Below some of the reflections made during this work are discussed and the approaches are contrasted and compared.

4.1.1 Methodological issues

4.1.1.1 The relevance of a generic study

In two case studies out of three, generic studies were conducted. This means that generic data was collected instead of site-specific, as is normally done when assessing a generic product. Generic data are typically collected at country, region and/or sector level. The usefulness of generic studies with data at this level is sometimes questioned (Dreyer et al. 2006; Jørgensen et al. 2009). Dreyer et al. (2006) emphasise the importance of making site-specific assessments, as they claim that the performance on social indicators is more closely related to the conduct of specific companies in the value chain than to the production processes. This could be a valid claim. However, one might as well argue that although there will inevitably be companies with differing conduct in a country, the country and sector context will have a strong impact on the performance at the company level. The legislation and the cultural and normative values in a country or region will influence the organisational practice. This view is also implicitly supported by Dreyer et al. (2010b) in their description of contextual adjustment, where they state that "the frequency and severity of violations reveal the topicality of the issue in the actual context, since they are product of norms and customs in the concerned environment". Moreover, Macombe et al. (2010) argue for assessments at sector or industry level rather than site level if the purpose is to provide information in a sector perspective. In that case, a generic assessment may give better information, as it evens out possible extremes at the site level (ibid).

The suitability of the different approaches is influenced by the aim and the scope of the study. Jørgensen et al. (2012) propose three different uses of S-LCA: 'Lead firm S-LCA' for managing internal social issues in the value chain; 'consequential LCA' for choosing between alternatives; and 'educative S-LCA' for communicating social performance to the market (e.g. labelling). For a lead firm S-LCA, a generic assessment may be a good choice. Getting site-specific information is time-consuming and may limit the possible scope. In order to cover the full life cycle, which is important using a life cycle approach (Weidema 2005), a generic assessment may sometimes be necessary. Furthermore, there may be no need to choose. A generic hotspot study may be a first step, facilitating the decision on where to put the emphasis in site-specific assessments in a second step. Moreover, as suggested by Parent et al. (2012), a generic study may be enough for setting criteria in a labelling programme aiming at securing a certain level of social performance of all potential suppliers of a product. The hotspots identified in the generic life cycle of the product indicates the typical social issues in the supply chain of that product, and will be unavoidable criteria to include in the labelling scheme. Generic and site-specific assessments will thus most likely have different scopes, aimed at answering different questions.

However, it can be discussed whether a specific S-LCA would always be the logical next step following a generic hotspot assessment. When hotspots are identified in the value chain, they are located in some country/region and for some sector. It may thus seem that the life cycle perspective is no longer needed, and that some other methods would be more appropriate to examine this hotspot in more detail. One such method might be Social Impact Assessment (SIA), addressing projects and plans, as described in section 1.1.

When conducting a generic study addressing sector level impacts, the result becomes less uncertain when there is access to sector-level data rather than using country-level data. For instance, when seeking data on the occurrence of child labour in a country, it may very well be the case that the use of child labour is concentrated to one or a few sectors. The sector under assessment might actually use no child labour at all. In the laptop study, sector-level data were in general not available, unfortunately. In the vehicle fuel study too, despite using the SHDB, data were in some cases available only on country level. The possibility to use more sector-level data would be a substantial improvement when conducting generic studies of this kind in the future.

4.1.1.2 Defining the scope of the study

It is sometimes argued (Jørgensen et al. 2009) that the system boundaries should be drawn where the influence of the main firm stops, which would in many cases be long before raw material extraction at one end and waste handling at the other.

Jørgensen et al. (2012) argue that lead firm S-LCA, in contrast to educative and consequential S-LCA, should only include the parts of the life cycle that the supply chain manager may influence, given that the lead firm S-LCA is only about improving how companies manage their working conditions. The inclusion of processes beyond these will not provide the supply chain manager with any information that can be used for improving the social conditions.

This demonstrates a company perspective, where the leverage of the company in the value chain is decisive for the scope. However, the leverage of a particular firm is not necessarily what should define the most urgent needs in society. One may take a more societal viewpoint, defining the scope of the assessment in relation to social responsibility as advocated in the Social Responsibility Guidance standard ISO 26000 (ISO 2010), addressing the responsibilities of organisations. Following the actions of different NGOs and behind them ultimately consumers, companies may even be expected to take this responsibility. Such issues raised to date include for instance child labour for picking cotton in the textile industry and the extraction of conflict minerals in the electronics industry.

It has been shown that processes of an informal nature are more likely to be present at the outer ends of the supply chain (Dreyer et al. 2006), and it may also be assumed that negative social impacts prevail in such environments with less societal control and influence. In the case of conflict minerals, the targeted activities are found at suppliers located very far away from the producer of electronics, often in artisanal mining of an informal nature. Thus, they are not likely to be part of a producer's value chain management system if the system boundaries are set based on influence. Consequently, it may be appropriate to conduct generic assessments of the complete value chain, to identify hotspots that might be situated at its outer ends. This might even be expected in studies claiming to adopt a life cycle perspective. In a paper by Parent et al. (2012), it is suggested that the influence of the producer along the life cycle can be realised by a market incentive. Moreover, as

demonstrated in the Better Cotton Initiative for garment retailers (BCI 2013) and the work done by the EICC (EICC 2013) and GeSI (GeSI 2013) in the electronics sector in addressing mineral extraction, there are in practice real opportunities for companies to deal with issues at the outer ends of their value chain by working together. This stresses even more the importance of conducting hotspot assessment for social impacts in the full life cycle.

4.1.1.3 The choice of social issues

There are numerous and varied aspects of human well-being, as demonstrated in section 1.1 in this thesis. Hence, when conducting an S-LCA, it is critical to define which social issues to include in the assessment. The Guidelines propose a list of social issues. In addition, there is a proposed list of linked indicators in the methodological worksheets (Benoit-Norris et al. 2011). These lists were used in the laptop study and in the e-waste study, where the chosen methodology (Franze and Ciroth 2011) was based on these documents.

The issues included in the SHDB are not the same as in the Guidelines, so a comparison was made between the two to identify the differences. The conformity between the Guidelines and the SHDB for two of the stakeholder categories where the discrepancies appeared most significant is displayed in Table 3.

Table 3 Cross-references between subcategories in the Guidelines and social themes in SHDB for the two stakeholder categories Local Community and Society

Stakeholder	**Subcategories in the Guidelines**	**Social themes in the SHDB**
Local community	Access to material resources	Hospital beds, drinking water, sanitation
	Access to immaterial resources	-
	Delocalisation and migration	Migrant labour
	Cultural heritage	-
	Safe & healthy living conditions	Human health issues
	Respect for indigenous peoples' rights	Indigenous rights
	Community engagement	-
	Local employment	Unemployment
	Secure living conditions	-
Society	Public commitments to sustainability issues	-
	Contribution to economic development	-
	Prevention and mitigation of armed conflicts	High conflicts
	Technological development	-

For workers' issues, the correlation was almost complete. However, for the other stakeholders (local community, society, consumer and value chain actors) significant discrepancies were found, mainly consisting of less coverage in the SHBD than in the Guidelines. As the use phase was excluded from the assessment in this study, the differences for consumer stakeholders was not important. The limited number of issues related to the value chain actor stakeholder was not seen as a problem either, as our assessment was mainly aimed at factors affecting policy on a societal level. However, for the local community and society stakeholders this difference might be troublesome. As can be seen in Table 3, fairly substantial differences were identified. It means that for those stakeholder categories, some of the social impacts deemed important in the comprehensive process of producing the Guidelines will not be assessed when using the SHDB.

The access to material resources subcategory is of particular interest when assessing vehicle fuels, as these have significant impacts on local resources and the local environment. For example, access to arable land is not covered in the SHDB. The same applies to immaterial resources, where issues such as land rights are missing. These findings raise the question of whether the social issues covered in the SHDB can be regarded as sufficient. Our conclusion was that some important issues covered in the Guidelines are missing in the SHDB, and that the SHDB would benefit from being complemented with some additional impacts to correspond better to the issues covered in the Guidelines.

Also of interest is the comparison between the social impacts of vehicle fuels addressed in the literature and the subcategories listed in the Guidelines. In general, there was coherence between them, and the social impacts found in the Guideline were mostly also addressed in the literature, albeit sometimes under other headings. Looking at the correlation in the other direction, one aspect found in the literature but not explicitly covered in the Guidelines was 'power relations in society'.

Power relations relate to the concept of fairness. The ethical assessment applied in Paper VI, uses three different roles; the decision maker, the risk-exposed and the beneficiary. These may be seen as roles with different access to power. If the role of the risk-taker is assigned to an individual or a group that is neither the decision-maker nor the beneficiary, the power is distributed in a way that increases the risk of an unfair outcome. In S-LCA, an assessment with human well-being as its ultimate goal and related to documents such as UDHR and MDGs, the pursuit of fair outcomes can be assumed. Thus, power relations should be considered in S-LCA. Looking at the way the methodology is built up, it seems that the notion of fairness, and thus power relations, in fact has been considered. It even appears that the very idea behind the methodology is actually based on awareness of power relations. The integration of ethical consideration in the Guidelines are more thouroigly discussed in section 4.5.

In summary, the fairly good correlation between the literature review and the Guidelines indicates that the coverage of the issues proposed in the Guidelines is satisfactory on the whole. This applies at least for the impacts from vehicle fuels, which were the issue covered in the literature review.

4.1.1.4 Impact pathways for indicators

In collecting data in a generic study, it is of great importance that the inventory indicators proposed give relevant and sufficient information on the social impacts on a specific

subcategory, and ultimately a relevant selection of social issues linked to the AoP. For the indicators suggested in the methodological worksheets (Benoit-Norris et al. 2011) and used in the laptop study, the pathways between the social impact and some of the proposed indicators were not always clear, raising the issue of their relevance and completeness. The need for analysing and improving impact pathways between indicators and the AoP in S-LCA is also emphasised by Jørgensen et al. (2010). To assess this more thoroughly, a rough grouping was made of the unclear indicators in the methodological worksheet into three types of impact pathway problems:

1. Indicator is not relevant for impact in an obvious and straightforward way.
2. Indicator is relevant for impact, but may not measure the scope of the impact sufficiently.
3. Indicator could be relevant for impact, but there are several steps in the pathway which are not clarified, making the evaluation and understanding difficult.

Type 1 indicators can be exemplified by the indicator 'number of rules and regulations involved when building a warehouse' for the issue 'presence/strengths of laws on construction safety regulations', defined for the subcategory 'safe and healthy living conditions' for the local community stakeholder. While the presence of such rules probably indicates increased safety, the number of rules may not. In that case there may be other interpretations, such as "many rules imply a country with heavy bureaucracy", or maybe even "elevated risk of corruption".

The problematic indicators found were mostly of type 2 or 3. An example of type 2 is the indicators for the subcategory 'access to material resources' related to the local community stakeholder. Level of industrial water use, changes in land ownership and access to improved sanitation all seem relevant for measuring the impact, but may not sufficiently capture all aspects of it. A type 3 indicator can be exemplified by 'international migrants as percentage of the population', which is proposed as a measurement for the subcategory 'delocalisation and migration', linked to the local community stakeholder. What is probably meant to be measured with this indicator is how well migrant workers are integrated into the local community. However, the pathway between performance and the proposed indicator is not self-evident, as it only measures numbers. Still, a risk is indicated since a large percentage of international migrants would lead to severe impacts if their reception and treatment were unacceptable.

The relevance of the proposed indicators was also found to differ between stakeholder categories. It seems that for the worker stakeholder, the indicators are often easily captured and understood, with a straight-forward, and quite often quantitative, relationship to the subcategory. This may be a consequence of the worker stakeholder being more addressed so far in society. There are also international agreements on the expected social conditions for this stakeholder, such as the ILO Conventions (ILO), which define quantitative levels and goals and make statistics on these available. For the local community stakeholder, the impacts are more elusive vis-à-vis the indicators, as several of them are qualitative.

Altogether, the set of inventory indicators suggested was found to be helpful and time-saving in data collection. However, the indicators should be further developed and modified to represent the total performance of a subcategory in the best possible manner. When some indicators seem less relevant or are difficult to interpret, there is a risk that the

related subcategories, or even stakeholders, will not be considered. This could lead to a subjective choice of subcategories, which is not in line with the purpose of the methodology.

4.1.1.5 Limitation regarding the use phase

The potential social impacts considered in the Guidelines regarding the use phase are limited to those resulting from the interrelations with the consumer and companies involved in the life cycle of the product, mainly retailers. However, many additional social impacts can be imagined in the use phase. These should be assessed as well to make S-LCA more comprehensive and relevant. This need has been reported previously by e.g. Jørgensen et al. (2009). In addition, Zamagni et al. (2011) point out that "the product cannot be analysed in isolation, neglecting the consequences that might arise from its introduction to the market". Indeed, for a laptop, there may be many positive social impacts during the use phase, such as improved access to information for disadvantaged people. This, as well as some potential negative impacts, could alter the picture of the social impacts from a laptop. In the Guidelines, the assessment of the use phase is pointed out as an area for possible future development. An intermediate possibility, proposed by Dreux-Gerphagnon and Haoues (2011), could be to consider the ethical acceptability of the product in the goal and scope phases. At a minimum, this would identify products with clear negative social impacts during the use phase. On a general level, that would be cluster munitions, anti-personnel landmines, and chemical and biological weapons classed as illegal by the Ottawa Treaty, the Convention on Cluster Munitions, the Chemical Weapons Convention and the Biological Weapons Convention. In addition, depending on cultural context, additional merchandise could be agreed on to be excluded on a national level. In Sweden that might be for example products such as cigarettes and weapons, while countries in other cultural spheres may choose to exclude others. Still, generally applicable methods for assessing the use phase are highly desirable. A first step would be to screen other disciplines for useful approaches.

4.1.2 Practical issues in implementing the methodology

4.1.2.1 Data collection

The data collection in our laptop study (Papers I and II), based on the proposals in the methodological worksheets (Benoit-Norris et al. 2011), was substantially impaired by lack of data. In the vehicle fuel study too (Paper III), despite using a database specifically dedicated to collecting data on social issues, data were sometimes missing.

It is important to consider the way lack of data is handled. In the studies in Papers I-III, information was made available to the reader on all indicators with no data. In the e-waste study (Paper IV), where data collection was of a different kind, with qualitative data collected in the field, any data deficiencies were clearly pointed out. This is important, as an assessed item not associated with negative impacts may in fact be missed only due to lack of data. In reality, it might very well be an important hotspot.

As discussed above, the lack of important issues may also impair the results. In Papers I-III, the assessment of coverage of social issues in the SHDB in the vehicle fuels study and the triangulation in the laptop study with stakeholder expectation and media coverage did not indicate any important issues missing.

When choosing to use a database for data collection, the limitation of the database is transferred to the study. For example, in the SHDB used in our vehicle fuels study, the sector-level data were rather roughly divided and sometimes not available at all, referring

the user to country level data. Furthermore, the choice of issues and related indicators within the database was fixed. On the other hand, substantial advantages can be obtained using a public database. Most apparent is the time- and resource-saving aspect, as collection of data on social issues is very time-consuming. The time-use ratio for individual data collection and the use of a database for collecting the same data was estimated to be 10:1, based on experiences described in Paper I. In addition, by using a database that is made available by subscription, one might expect more resources to be devoted to thorough quality assurance of the data by the providers, and potentially erroneous data would possibly be revealed faster by a larger number of users. Furthermore, it offers the possibility to compare methodological choices in different studies, as variability emanating from different data sources can be eliminated.

It can be argued that in the trade-off between the drawbacks and advantages outlined above, the use of databases is in many cases beneficial. It allows for a screening analysis, identifying the potential negative social impacts with a reasonable amount of resource input as a first step on the path towards optimising value chain management in monitoring and handling the most severe social impacts. It further enables policy makers on a limited budget to get broader and more comprehensive knowledge on social issues than would otherwise be the case, and thus a better foundation for policy decisions.

Lastly, there might be a more individual perspective on this issue. Flyvbjerg (2006) emphasises the aspect of learning when conducting case studies. This came apparent to me after having finished the arduous data collection for the case study on a laptop (Papers I and II). I found that the learning that took place when I ploughed through all these data sources, gaining first-hand experience of the selected indicators and their corresponding data, was invaluable for me in really getting to know my subject. This is thus an argument for carrying out one's own data collection, at least when approaching a new research area.

4.1.2.2 Placing the results in context

As mentioned previously, a perspective on the extent to which stakeholders are benefiting from social improvements is still lacking in the methodology. The potential positive and negative consequences of a change in the social impact are dependent on the starting point and thus the context. Context could be the overall economic situation in the area or the average situation of the workers in the sector or country. In utilitarian theory it has long been recognised that the marginal utility of an income increase decreases with higher income (Layard et al. 2008). Correspondingly, reduced unemployment in a country with weak institutions probably has a more beneficial overall impact on human well-being than the same reduction in another country with a higher level of social security (Jørgensen et al. 2010).

Some work has been done where the context has been considered in the area of S-LCA, but from a different angle. One example is the work by Dreyer et al. (2010b), who adopted a company perspective and related context, i.e. the external environment determining the risk of negative impacts, to the level of managerial effort requested by the company to achieve acceptable outcomes. Jørgensen (2010) also discusses context, focusing on its impact on the validity of S-LCA due to context-related differences in valuations of various aspects of human well-being. While both these studies are relevant discussions on S-LCA, they still do not address the problem raised above.

Considering the difference in potential improvements of the AoP due to context is consistent with the text on sustainable development in the Brundtland report (Bruntland 1987), which emphasises the needs of the future generations as well as of the world's poor. This perspective should be considered in future development of impact assessment methods, as it offers a possibility to move more rapidly towards the improvement of social conditions in poor areas. Ignoring the context-dependency of the impacts on different stakeholders is the same as saying that the impacts, positive and negative, have the same effect on human well-being for all individuals, regardless of their current status. This is not supported in the literature and efforts should therefore be made to find ways of integrating context adjustment into S-LCA. A fruitful way to address this topic might be to look to other research disciplines for methods of relating findings to context. One way that might be of interest is the use of 'equity weights'. This is an issue being discussed in the discourse on the social cost of carbon, a research area aimed at informing climate change action, and the introduction of equity weighting is indeed contested by some (Hope 2008). Basically, it is about giving different weights to individuals depending on their per capita income when assessing benefits; above unity weight for those with below average income and below unity weight for those with above average income, with the magnitude of the weight depending on inequality aversion. A similar reflection is found in Daw et al. (2011), who concluded that the same ecosystem services have different effects on the well-being of different beneficiaries due to context, reflecting local, social and personal factors. Those authors propose stakeholder analysis as a tool for handling these issues. The above approaches may work as a starting point in developing methods considering context when assessing social impacts in S-LCA.

4.2 Comparison of the outcome in papers I-II with other S-LCA studies on laptops

There are other studies on the social impacts of laptops with which our study in papers I-II can be compared, for example that by Ciroth and Franze (2011) and that by Benoît et al. (2012). As no specific impact assessment method is proposed in the Guidelines, all these studies applied different methods developed by each research team. The Ciroth and Franze (2011) and Benoît et al. (2012) studies are described briefly below regarding the methods applied. The different methods are also described in greater detail in section 4.3.1. A third laptop study is also available, that by Manhart and Grießhammer (2006). However, it was limited to the production phase, excluding for example resource extraction and waste, and only looked at China, and it was therefore excluded from the comparison.

4.2.1 The studies

The Ciroth-Franze study had a slightly different layout to ours, as they made a specific assessment of a named laptop, thus also gathering data on-site. Their impact assessment method used performance reference points for assessing the data, scoring them on a scale with positive, indifferent and negative social impacts in six levels. The result was communicated with numerical scores and colour codes on a green-yellow-red scale.

The Benoît et al. study had a more similar layout to ours. They conducted a generic assessment, identifying social hotspots. These were identified by the level of risk of negative social impacts based on country/sector data related other country/sector data, all assessed in the SHDB. However, in contrast to our study, they employed an activity variable, worker

hours, to distribute the activity in the life cycle between phases and relating the collected data to this distribution, which was done just briefly in our study. Thus, they related the social hotspot assessment to a generic laptop supply chain.

4.2.2 The results

Looking at the outcome of those two studies and of Paper I, some interesting differences were found (Table 4).

Table 4 Comparison regarding basic approach and outcome of three S-LCA studies on laptops: Paper I, Ciroth and Franze (2011) and Benoît et al. (2012)

	Paper I	Ciroth & Franze (2011)	Benoît et al. (2012)
Type of study	Generic	Specific	Generic
Data collection	Desk-top collection from global sources (mostly internet)	Disassembly of product, desk-top collection from global sources (internet), questionnaires, interviews	SHDB (based on global sources), review of certifications, standards and initiatives
Activity variable	Estimated, only as final check	No	Yes, worker hours
Most impacted stakeholders	Workers, local community	Workers, local community and society	Not discussed
Most impacting phase	Resource extraction, refining/processing, manufacturing/ assembly	Resource extraction, waste	Manufacturing, resource extraction, retail
Most impacted social issues (not listed in order of importance)	Worker Working hours Freedom of association and collective bargaining Social benefits/social security Local community Access to material resources Safe and healthy living conditions Society Community engagement Delocalisation and migration Cultural heritage Respect for indigenous rights	Worker Working time Freedom of association and collective bargaining Child labour Forced labour Fair salary Health and safety Discrimination Social benefits/social security Local community Access to immaterial resources Access to material resources Safe and healthy living conditions Community engagement Society Public commitments to sustainable issues Technology development Local employment Public commitment to sustainable issues	Worker[2] Excessive working time Freedom of association Child labour Forced labour Low wage rates Health and safety Society Fragile legal system Protection of indigenous peoples' rights

[2] Most impacted issues only put forward in a sub-study on China. Relating of issues to stakeholder group is done by the author of this text

		Prevention and mitigation of conflicts Value chain actors Technology development Corruption Respect of intellectual property rights	
Most impacting countries (not listed in order of importance)	China, Thailand, Saudi Arabia, Brazil, Bolivia, Russia	Not clearly stated	China, Mozambique, India, Cameroun, Tanzania, Indonesia, Vietnam, Philippines, Thailand, South Central Africa
Presentation of results	Data in open worksheets with identified hotspots displaying negative impacts per country/sector, summarising hotspots in tables	Colour-coded scheme displaying impact assessment (from positive to very negative), raising negative hotspots in interpretation text	List of highlighted countries and sectors, spider plots on highlighted social issues

Social issues. The Benoît et al. study differs from the other two when it comes to the most impacting social issues captured (Table 4). Their assessment is based on their own list of social issues, while the other two are based on the issues listed in the Guidelines. The difference in outcome may in part be due to the differing lists of social impacts.

Stakeholders. The social issues in the Benoît et al. study are not related to a particular stakeholder. To get more comparability for the purposes of this thesis, I made a retrospective linking to stakeholder, based on the structure in the Guidelines (Table 4). According to that linking, the most impacted stakeholders seem to be workers and society in their study. Assuming this classification is correct, it is noteworthy that the Benoît et al. study does not capture any issues related to the local community stakeholder, which was one of the most impacted stakeholders in the results of the other two studies (Table 4).

Phases. All three studies identified resource extraction as an important phase, and our and the Benoît et al. study identified manufacturing. In the Benoît et al. study also retail emerged as important, not present in the two others. A possible explanation is the use of the activity variable worker hours in their assessment. It may very well be the case that this phases use a large share of the worker hours in the life cycle, thus putting extra weight on the negative social impacts there.

The Ciroth and Franze study in turn was the only one identifying waste. The reason our study not capturing waste was that the flow of informal e-waste out of Sweden was estimated to be less than 1%. Further, it is interesting to note that in the Benoît et al. study, recycling and disposal were identified as having a high impact in the complementary literature review and media campaign, in contrast to the SHDB assessment. Similarly, the triangulation in Paper I of the results with issues focused on in the media showed the same difference.

Our study was the only one identifying refining/processing. A possibly reason for this may simply be differences in the way the phases were delimited.

Countries. The most impacting countries identified, apart from China in first place, were rather different between the Benoît et al. study and Paper I (Table 4). One reason may be that the computer materials considered were different, or that the use of an activity variable put more emphasis on certain phases and thus on the countries involved in those phases. In the Ciroth and Franze study, the most impacted countries were not clearly defined.

The Ciroth and Franze study generally captured more items as regards different hotspots (stakeholders, phases, social issues). The reason might simply be that those authors judged the useful number of hotspots to select differently. Notably, their study was the only one that also captured issues related to the value chain actor stakeholder. In Paper I this stakeholder was not assessed due to lack of data. This may be explained by the fact that Ciroth and Franze conducted a specific assessment, including gathering data at company/site level, and with the real value chain actors identifiable.

The differences described above might be somewhat surprising, as the same product was assessed with the same methodology. The reasons behind these differences have not been analysed in any great detail, but a plausible contributing factor is that the methodology is immature and not fully defined in all its parts, leaving room for different ways of application and the use of different impact assessment methods, as seen above. Furthermore, the products assessed may seem to be the same, but there are several options for making different choices, for example concerning system boundaries, assumptions on the material content to include, the use or non-use of an activity variable etc. Finally, the reliability of Paper I was reduced due to data gaps and data quality issues, which further increased the probability of variable results. As noted, no in-depth evaluation of the differences was performed, so the reflections above are just initial thoughts. It would be interesting to look more thoroughly into these issues, in order to draw conclusions on the way forward in developing the S-LCA methodology and, in particular, the impact assessment methods.

4.3 Reflections on the use of different impact assessment methods in Papers I-IV

As already noted, there is no suggested impact assessment method for social impacts in the Guidelines. Therefore, different researchers have developed their own impact assessment method. In the three case studies described in Papers I-IV, three of the different impact assessment methods developed to date were used. They are the same three methods used in the laptop studies referred to above, where the outcomes of these laptop studies were compared. In this section, the differences in the actual methods are discussed. The three methods, all based on the Guidelines but developed independently, show both similarities and differences.

4.3.1 The different methods

In the first case study, on the laptop, a method developed by ourselves was used (Paper I). The method is described in greater detail in section 3.2.1 In short, the qualitative and quantitative data collected were entered into the same impact assessment process. The qualitative data were then converted into semi-quantitative data by a scoring system with three levels of severity. The same scoring system was used for the quantitative data, which were assigned a level of severity depending on position on the scale of existing values for all countries on that indicator in the data source used. The activity level of the actors within each phase was also considered. The distribution of activity among phases should ideally be considered as well. The results are presented as worksheets with all collected data visible, as well as the result of the assessment showing the hotspots identified.

In the second case study, on vehicle fuels (Paper III), the impact assessment used was that developed by Benoit-Norris et al. (2012) and incorporated in the SHDB. Thus, the data collection was conducted and the impact assessment method was defined by the modellers of the database. Looking at their approach, the impact assessment method builds on the distribution of the selected data in relation to all collected data for that indicator, which is in many ways similar to our approach. They calculate the amount of worker hours for each process, relating countries and sectors to each other within a phase. This can be compared to our identification of high activity countries in the phases. They also use this information to relate countries and sectors to each other between phases. In their social hotspot assessment, the characterisation is done by identifying the level of risk for negative social impacts, corresponding to our identification of potential severe impacts and hot issues. As in our model, they combine these to identify sectors and countries most at risk. In their case, this comprises a multistep assessment, where the value chain activities requiring most worker hours are identified in the first step and the activities (sectors and locations) most at risk of social impacts are ranked next.

The third case study, on e-waste handling (Paper IV), used the impact assessment method developed by Franze and Ciroth (2011) in a study of cut roses. Their assessment method identifies more or less negative and positive social impacts, communicated with colour codes in a green-yellow-red scale. However, they later applied the model in an assessment of a laptop, using a slightly refined version (Ciroth and Franze 2011), which was addressed above in section 4.2. The reason for using the first version in our case study was that this is the only version presented in a scientific paper. It is also slightly less complicated, which corresponded better to the level of detail in our study. However, their laptop study presented a more recent version of their method, which is addressed in the discussion below.

In the refined version (Ciroth and Franze 2011), the assessment is based on qualitative data, for which qualitative performance reference points are constructed, based as much as possible on external sources. Furthermore, the assessment is divided into two parts. The first of these is called performance assessment, corresponding to what was labelled impact assessment in our model, but which in hindsight was more of an assessment of performance. The second part is what they call impact assessment, where the consequences (impacts) of the performance are assessed. This approach, to move one step further by assessing the data on the impacts categories proposed in the Guidelines, was not done in Paper I or in the SHDB. Ciroth and Franze (2011) first scored the performances and then the impacts, and integrated these two assessments into a final score.

The differences between the three studies in this thesis (Papers I-IV) and the assessment methods employed in each of them are displayed in Table 5.

Table 5 Comparison of three different impact assessment methods developed for S-LCA and employed in the case studies described in Papers I-IV of this thesis

	Laptop case study (Papers I and II)	Vehicle fuels case study (Paper III)	E-waste case study[3] (Paper IV)
Type of study	Generic	Generic	Specific
Data collection	Desk-top collection from global sources (internet)	SHDB	Field trip
Type of data	Quantitative and qualitative	Quantitative	Qualitative
Data processing	Transferring quantitative data into semi-quantitative by scoring	None	None
Type of assessment[4]	Assessing performance	Assessing performance	Assessing both performance and impact
Weighting impacts	No	No (slightly in Social Hotspot Index[5])	No
Assessment of collected data by relating them to:	The position on the scale of all possible values	The position on the scale of all possible values	Performance reference points[6]
Aggregation	No	Yes, but non-aggregated data available	No
Presentation of results	Data in open worksheets with identified hotspots displaying negative impacts per country/sector	Graphs displaying the number of risks of negative impacts per type and origin of fuel	Colour-coded matrix displaying negative and positive impacts
Potential uses of results	More detailed assessments of identified hotspots for value chain managers, increased knowledge among stakeholders	Updating and refining policies and regulations on vehicle fuels and on the future vehicle fleet. Increased knowledge among stakeholders	Increased knowledge for value chain managers and among stakeholders

4.3.2 Ways of assessing impacts

In the method employed in Papers I and II, the social impacts in different countries are compared with each other. A relative assessment of the data is made in defining its position on the scale between the best and the worst performance on a particular issue. A similar approach is used in the SHDB, as employed in the vehicle fuels study (Paper III). A problem with this type of relative assessment might occur if the scale is very narrow and the impacts

[3] Comparison based on a later version of this method (Ciroth and Franze 2011) than that employed in this study
[4] Classification of the assessments done by the author of this text
[5] Social Hotspot Index is one feature in the SHDB, but this feature was not used in this assessment
[6] "Internationally set thresholds or goals or objectives according to conventions and best practices" (Benoît and Mazijn 2009)

are all severe, indicating that all actors are performing unsatisfactorily. In that case some serious social impacts will not be included in the result. At the same time, for another issue with a broader scale, less severe impacts may be highlighted, undermining the aim of finding the hotspots.

In the Guidelines, there is a proposal to use performance reference points, i.e. "internationally set thresholds or goals or objectives according to conventions and best practices" (Benoit and Mazijn 2009). By drawing a line, different for all issues, on what is the acceptable level for this particular issue, the problems outlined above can be avoided. However, for many of the indicators it will be difficult to find such reference points if aiming at a quantitative assessment. In these cases, other assessment approaches, such as the relative approach described above, may be needed as a complement. If so, having indicators assessed with a mix of approaches would probably complicate interpretation of the results. Moreover, it may transpire that using those thresholds identifies far too many hotspots or issues to address. To be useful, this type of assessment must identify a limited number of issues. Ciroth and Franze (2011) used performance reference points but their assessment was based on qualitative data, for which constructing qualitative performance reference points seems more workable, albeit a fairly subjective task. The impact assessment model in its first version (Franze and Ciroth 2011), where the assessment is conducted on the impact categories, was employed in our e-waste study (Paper IV). The assessment of the qualitative data was based on our own thoughts. As this was a specific assessment and the data were mostly qualitative and collected on-site, this kind of performance reference points were deemed feasible for use in that study.

The revised version (Ciroth and Franze 2011), involving performance assessment and impact assessment, seems like a richer approach to assessing impacts. However, the pathway from performance assessment to impact assessment in the model is based on those authors' own thoughts, making it rather subjective and difficult to examine. In our model, the poor performances identified for a certain country on a certain subcategory, such as high levels of child labour, are just assumed to result in negative social impacts, i.e. they are seen as potential social impacts. That is equally subjective and difficult to discuss, but somewhat less resource-demanding. In fact, there appears to be little added value with the two-step assessment, since the difference in ratings going from performance assessment to impact assessment in the 21 assessments conducted was very small (average difference less than 1%). Moreover, the number of positive and negative differences in this comparison was about the same, showing 10 positive and 11 negative differences. Thus, the performance assessment and the impact assessment seem to follow each other quite closely, indicating that our assumption on the link between low performance and negative social impact is reasonable. Thus as long as the impact pathway is missing, there is no real added value to using this type of two-step impact assessment in our view.

4.3.3 Ways of handling negative and positive impacts and the use phase

The fact that social impacts can be both positive and negative places special demands on the aggregation method. One approach for allowing positive and negative data, as well as data with different entities, to be aggregated is to construct indices. However, when positive indices are aggregated with negative they may balance each other out and information on the existence of both positive and negative impacts may be lost. A limited trial was conducted using this approach in our laptop study, in the process of developing our methodology (Paper I). However, reflecting on the outcome, it was concluded that far too

much detail was lost in the aggregation process. In our approach, positive data were handled instead by inverting the issue, i.e. measuring lack of positive impacts. For example, the social benefit/social security indicator, in itself a positive matter was measured by the expenditure on this item, with negative impacts identified for low expenditure.

In the approach by Ciroth and Franze (2011), the negative and positive impacts are handled by assigning them values on a scale of positive integers (from 1 for positive to 6 for very negative impacts). Thus, they can be aggregated without the risk of the presence of both negative and positive impacts resulting in zero. Furthermore, an average can be calculated taking them both into account. The average, a positive figure between 1 and 6, then rates the total impact on the same scale. Still, very negative impacts may be concealed if aggregated with several positive ones. To handle this problem, a calculation of the standard deviation could be used.

An interesting difference can be seen in the way impacts are considered to be positive. In our view, positive impacts are only those related to issues that may add value in themselves, such as job creation or capacity building. In the method described by Ciroth and Franze (2011), the absence of a negative issue, such as forced labour, is assessed as a positive impact. However, assessing the absence of a negative issue as positive instead of neutral is questionable. This view on assessing the absence of negative impacts is also supported by Jørgensen et al. (2008): “In relation to forced labour, for example, it would not be possible to obtain a 'good score', but merely to vary from OK (no forced labour) to poorer”.

It is easy to focus more on the negative impacts and hotspots in a generic hotspot assessment. Among the social issues proposed in the Guidelines, the vast majority are related to negative social impacts. Furthermore, methods for assessing the positive impacts integrated with the negative ones are not well developed. However, positive social impacts indicate opportunities for improvement of human well-being, and should therefore also be considered. Taking a broader approach to the use phase could contribute to such a development. This would probably require a different approach than S-LCA, as the features of the social impacts in the use phase appear to be of a different kind. All potential uses of all possible products seem more complicated to fit into one and the same assessment method, such as S-LCA, than is fitting in all potential production and waste handling processes into it. Future research on such an approach could be usefully combined with further development of methods to identify and display the positive impacts in all phases of the life cycle. In this case the context is crucial too, as a positive social hotspot ought to be valued more highly when those in need get a considerable improvement, as discussed before. In the globalised world, the production is typically located in the developing countries, while the majority of the consumption takes place in the developed countries. Thus, including positive impacts in the use phase, those will typically materialise in the developed world to a large extent. This must be considered when making an overall assessment.

4.3.4 Ways of aggregation and safeguarding transparency

The issue of transparency is of great importance when it comes to S-LCA. Firstly, many social issues are quite sensitive in themselves, with a clear political undertone. With a transparent presentation of the results the analysis is opened up for discussion and criticism, hopefully leading to increased knowledge. Secondly, in this early stage of

development of the methodology, the data accessibility, quality and relevance all leave room for improvement. This calls for major provision of transparency and great care in interpretation. At the same time, there is a need for aggregating the results to make them more accessible and comprehensible. As this also brings a greater risk of concealing and losing important information, it is a delicate task to balance those needs against each other.

In our laptop study, different aggregation options were tested but it was found that the complexity of the data in their original format was much more informative and interesting. Thus, the data were not aggregated, but kept in the original format, only highlighting the hotspots and other interesting aspects. Not aggregating but transparently presenting some major findings arguably allows all stakeholders to see for themselves the data on which the interpretation is based. This maximises the transparency and the possibility for stakeholder review and evaluation of the results.

When the aim of the S-LCA is to compare different products, aggregation may be needed to obtain comparable results. Thus, in the vehicle fuels study some aggregation was done (Paper III). The results were aggregated by counting the number of risks per fuel chain and the outcome was displayed graphically, making it easier to grasp and compare. However, this form of aggregation has its drawbacks. In theory, one fuel chain might have high and very high risks only in areas deemed less important by the user, whilst another chain may have high risks only in areas seen as very important. In that case, that kind of counting exercise will give a skewed result. However, in our case, transparency was maintained for the basic data. Users may look at what kind of risks are listed for the country-sector combination of interest and make a judgment of the relevance themselves. Another problem of this aggregation method may be that all risks are treated the same, not distinguishing between more or less severe risk. In reality, some risks are likely to have more severe potential impacts than others. However, trying to value one risk to another on a general level is difficult as it involves value judgments. Such value judgments may vary substantially between different groups of people and between different locations, and are thus questionable to apply on the results on a general level.

Another possible approach for aggregation is to use multi-criteria decision analysis (MCDA), which may be particularly beneficial when prioritisation is required. There is a demand for weighing all data together in one way or another to facilitate decision making. The main features of MCDA are that it offers techniques for weighing a range of different criteria in a structured and transparent way when making a decision. In an S-LCA, there is a wide range of social issues to consider, measured by quantitative, qualitative or semi-quantitative indicators, mixing positive and negative impacts, making it tailored for aggregation by MCDA. Such an approach would also allow decision makers to express and be transparent about their values in prioritising among the subcategories.

4.4 Criticisms of S-LCA

In the research community concerned, there is heated debate on the future of the S-LCA methodology. One argument is that the tool does not improve social conditions (Jørgensen 2013; Jørgensen et al. 2012). Another view is that there are no benefits from attributing social impacts to products, as they are more related to company conduct (Dreyer et al. 2006).

4.4.1 S-LCA as a decision-making tool achieving desired outcomes

In an editorial, Jørgensen (2013) addresses S-LCA and raises some critical questions as to whether the tool is doing its job, which is assumed to be providing decision support that "would thereby lead to more socially beneficial situations than decisions made without the S-LCA". Indeed, the AoP human well-being implies that the ultimate goal of using the methodology is to protect or improve social conditions for people globally. A case where the presence of child labour in the supply chain led to plant closure is taken as an example of increased negative social impacts when the workers lost their jobs (ibid.). However, a properly conducted S-LCA would have captured the positive impacts from jobs created at the plant, and balanced it with the negative impacts. S-LCA aims at informing the decision maker about the potential negative and positive social impacts in the life cycle of the product in question, providing a basis for decision making that balances the different social impacts. Among positive social impacts are the jobs created by the production, so this should be considered in an S-LCA. Admittedly, the handling of positive social impacts needs to be improved in current S-LCA methodology. However, this does not mean that the methodology cannot be developed to deliver its intended function in balancing positive and negative impacts.

Furthermore, the Guidelines state that "S-LCA does not have the goal nor pretends to provide information on the question of whether a product should be produced or not. S-LCA documents the product utility but does not have the ability nor the function to inform decision-making at that level. It is correct that information on the social conditions of production, use and disposal may provide elements for thoughts on the topic, but will, in itself, seldom be a sufficient basis for decision." (Benoit and Mazijn 2009). This is valid also for decision-making on moving the production and the associated potential risk of plant closure.

If a producer chooses to relocate production due to negative social impacts, this may actually improve the AoP human wellbeing on an aggregated level. It seems likely that the production closed down at one plant will be replaced with production at another plant. That means that the same number of jobs could be created at another supplier, possibly with better social performance. Thus, on an aggregated level, one could claim that social performance could be improved over time as the producers move production to suppliers with increasingly better performance on social conditions. However, this does not take into account the immediate negative impacts on the individual level and the distribution of impacts among groups following this structural change.

A similar view is expressed by Parent et al. (2012), who discuss the potential for S-LCA (in practice the whole concept of LCSA, as they also address environmental issues). They conclude that a market incentive which may be sent through the life cycle stepwise from supplier to supplier has the ability to change the enterprises' behaviour in the life cycle, and that "LCT [Life Cycle Thinking, *my note*] reinforces the liability for social performance …outside the sphere of influence" (Parent et al. 2012). They also address the issue of handling the potential trade-off between the initial immediate increase in negative social impacts and the social gain in the overall system, an issue that should not be ignored.

Furthermore, in a dynamic analysis, moving production from one supplier to another may very well lead to a change in conduct at the first supplier, in trying to secure a new contract (or win back the old one). Moreover, the producers may use the knowledge gained on social

impacts from using S-LCA to work together in sector organisations, setting the same high demands on social issues on suppliers. One producer may also have considerable leverage by being high-profile, a large buyer or paying better, and thereby getting the suppliers to accede to its requests. All in all, there seem to be several mechanisms that could work in favour of social improvements from the use of S-LCA.

In this context SIA could be a useful tool to use following up on an S-LCA, to assess different options for making social improvements based on the findings in the S-LCA. In the process of assessing different options, SIA may be useful as it can typically include more site-specific information and it may therefore be relevant to complement the S-LCA.

4.4.2 Product-related impacts

One discussion regarding the merits of S-LCA concerns the benefits that can be obtained from relating the social impacts to a specific product. At present, many corporations work with social impacts related to their products through value chain management. In this approach, the social impacts are not attributed to the various products produced but related to the suppliers. They start from their list of suppliers, beginning with the first tier of supplier, with whom they have a contractual relationship. In the next step, they may address the performance of the supplier of these suppliers, i.e. the second tier. Due to resource constraints and the challenge to influence through contractual relationships in several steps, many companies will only work with their first, second and sometimes third tier of suppliers. Working their way from the centre towards the periphery, it may not be possible to work all the way out to resource extraction or waste handling. This may be problematic, as the most severe impacts may very well be situated at the most distant supplier on their list. For example, in the case of conflict minerals, the targeted activities are found at suppliers located very far away in the life cycle, often in artisanal mining of an informal nature. Here, an S-LCA hotspot assessment could help addressing these problems.

In addition to the problems of resource constraints outlined above, that may prevent companies from discovering severe social impacts in the outer end of their supply chain, the perspective of SPC also puts the products in focus. The educative S-LCA described by Jørgensen et al. (2012) may for instance aim to serve as a basis for product labelling. In order to give the consumer information on the environmental and social impacts from the production and waste handling of the product through labelling, the impacts need to be distributed to the products. Thus, if the assessment is to inform the social labelling of a product, it is obvious that the social impacts must be related to the product itself, not to a range of suppliers. Otherwise, the consumer leverage is put out of action, and SPC as a method of improving sustainability is incapacitated.

4.5 Ethical aspects in relation to social impacts

It is not unlikely that the view on certain social impacts differs from one stakeholder to another. Stakeholders may have different, and sometimes conflicting, goals. This may be the case for industry associations and the labour union on remuneration issues, or the local community and the larger society in the extraction of natural resources. How these different priorities are considered and catered for may be seen as an ethical issue. In the S-LCA methodology, this aspect has so far not been taken into account. One way of doing so could be to transfer the work on ethics in risk distribution (Paper VI) to the area of S-LCA, where the risks could be compared with the social impacts. The framework of the ethical assessment in Paper VI is based on identification of the three roles that are frequently found

in decision making; the decision maker, the beneficiary and the risk-taker (Hermansson and Hansson 2007). In another useful approach, Daw et al. (2011) work on the concept of ecosystem services and their role in poverty alleviation. They identify issues of concern with the prevalent aggregated approaches for calculation of the costs and benefits of ecosystem services. Among these, the issues that seem relevant for ethical aspects on social impacts in S-LCA are 'the distribution of costs and benefits between groups, especially rich and poor' and 'the possibilities for various groups to take part of the benefits depending on their access to social relationships, institutions, capabilities, rights and various capitals'. In addition, Daw et al. (2011) outline concerns about 'the usefulness of the benefits due to context, reflecting local social and personal factors', which is addressed in the section on context dependency.

Combining the works above, ideas may be found for ways to assess the distribution of product-related social impacts among the stakeholders involved in S-LCA. Daw et al. (2011) propose conducting a stakeholder analysis to map the access to benefits and the burden of costs. As a test, a rough stakeholder analysis of a typical life cycle is made below. The producer (viewed here as the owner of the company) has agency over the business strategy as well as the production facility, and is thus clearly a decision-maker. Society may also be seen as a decision-maker, generally having the power to issue legislation and setting up rules for the production. Considering that the main goal of a corporation is to create profits for its shareholders, the producer is probably also the main beneficiary, together with other shareholders. The stakeholders are beneficiaries too in that they partake of the positive social impacts caused by the production in various ways. Considering that the producer is not listed among the stakeholders in an S-LCA, it seems that none of the negative social impacts included in the assessment are assigned to the producer. Indeed, there are many other impacts not addressed in an S-LCA that may affect the producer. Yet, the choice of stakeholders in S-LCA seems to rely on the assumption that the producer is not the risk taker for the social issues considered here. The role of risk taker is instead typically awarded to the various stakeholders listed, in particular workers and the local community as indicated in our laptop study. The conclusion of this rough test of a stakeholder analysis is that the different roles are generally split up in a way that clearly puts the producer in a beneficial position as decision-maker and beneficiary, while the risk-taking stakeholders are also beneficiaries, but do not have any substantial decision-making power. The assignment of roles between the producer and the stakeholders in a production system, as displayed in Table 6, is considered to be typically more or less the same in all product life cycles.

Table 6 Rough test of assessment of the roles assigned to different actors in a typical life cycle

Actor	**Decision-maker**	**Risk-taker (social impacts)**	**Beneficiary**
Producer	x		x
Stakeholders			
- Worker		x	x
- Local community		x	x
- Society	x	x	x
- Consumer		x	x
- Value chain actor		x	x

As concluded above, the test indicates that the asymmetry of a production system is generally the same and known and the distribution of cost and benefits, the first of the concerns mentioned by Daw et al. (2011), is visible (although on a rough scale).

There are numerous ways for the producer to lessen the negative impacts and to compensate those affected. This can involve the workers getting better remuneration, or the local community getting compensatory investments. In fact, these issues are addressed by different interest organisations such as labour unions and various NGOs. However, the distribution among the different stakeholders is not addressed, as pointed out by Kruse et al. (2009). Thus, a more thorough stakeholder analysis and ethical assessment may be called for to reveal the detailed distribution, as mentioned in connection with the first concern above. The second concern, practical access to benefits, and the third concern, context dependency should also be included in the analysis. The topic of context dependency is addressed in more detail in section 4.1.2.

It may be of interest to weight the different subcategories and/or indicators in S-LCA to identify what could be perceived as the really serious hotspots. One could easily reason that some subcategories are more important than others. In fact, not relating and weighting the impacts to each other may result in a highly skewed result considering the effect on human well-being. The result of an unweighted assessment may even be perceived as unethical, as the different subcategories are obviously of differing severity. This problem is also mentioned by other researchers (e.g.Ciroth and Franze 2011). In the SHDB, some rough weighting is actually done when calculating the Social Hotspot Index, by assigning a factor 1.5 to issues that are considered most important, while others count as 1. However, the choice of issues considered more important than the others is not motivated. As the Guidelines are a global tool intended to be used in many different settings and by people with different cultural backgrounds, it is not evident how to arrive at agreeing on such a prioritisation on a global scale. For example, a study by Kölsch (2009), as cited in Feifel et al. (2010), showed that European values on social aspects differ partly from those in Brazil. Moreover, prioritisation could differ even in the same cultural setting when done within different levels of society (local, regional, national).

There is also an ethical aspect to the handling of negative and positive impacts. If they are allowed to balance each other out, producing a neutral result, this can be a problem as the negative and positive impacts might not affect the same stakeholders. Even if they do, they cannot be assumed to outweigh each other without considering the views of the afflicted stakeholder. For example, suffering from occupational health impacts can most likely not be outweighed by improved take-back practices. One possible way of handling this weighting problem could be the use of MCDA, where there is transparency on the way the weighting is done and where afflicted stakeholders could be asked about their own priorities. Furthermore, an ethical assessment like that described in Paper VI could be useful to analyse and display the ethical aspects regarding fairness.

Social impacts are not very clear-cut to assess. In different contexts they may mean different things for people. The impacts that are to be assessed in S-LCA are clearly based on values. To the largest extent possible, the issues in the Guidelines are based on internationally agreed documents, such as the Universal Declaration of Human Rights (UN 1948), the ILO Conventions etc. Still, even such international agreed documents are by some seen as reflecting Western values (Mouffe 2005). Amartya Sen, as cited in Rogers et al. (2012), in his work on well-being and the concept of capabilities even concluded that

human well-being is person-specific. Thus, policy should focus on making well-being possible by providing freedoms and capabilities to everyone to form his or her own well-being. According to Walby (2012), Sen refused to produce a list of capabilities, as it would deny the possibility of fruitful public participation in shaping that list. On the contrary, Nussbaum (2003) has offered a list of ten capabilities independent of the cultural context, based on Sen's work. Also, Max-Neef (1992) claims that human needs are the same in all cultures, and that only the ways in which these needs are satisfied differ between cultures. Even assuming universal agreement on the importance of human dignity, there may still be differing views on what this concept constitutes and how it can be achieved. As no global agreement on those values can be expected, transparency becomes essential.

Methodology is influenced by values already at the design stage. For example, a set of stakeholders is selected to be considered in the assessment of social impacts, while others are excluded. Furthermore, there are a number of subcategories and related indicators selected for each stakeholder category. Obviously, in all those selections, one or several individuals have a determining impact. Who is deciding, from what position, with which perspective, holding what values and representing whom? In the case of the Guidelines, the selections are agreed upon in a consensus process with wide representation. But is it wide enough? Has anyone ensured that all possible positions in this area are represented? The information in the Guidelines on these issues is limited, although there is transparency on which actors are involved. Moreover, the perspective and aim of the data sources used must be made clear and transparent, and considered when interpreting the outcome. For instance, some indicators proposed in the methodological worksheets (Benoit-Norris et al. 2011) come from business surveys. It can be assumed that the perspective in such data collection is that of the business sector, which may not always coincide with the societal view.

5 Conclusions

5.1 Conclusions from the case studies

5.1.1 Laptop study

The laptop study showed that it is possible to conduct a simplified S-LCA using the Guidelines on a generic complex product (Papers I and II). The study identified workers and the local community as the stakeholders most at risk of negative social impacts, with social benefits/social security, working hours and freedom of association being important issues for workers. The local community was mostly affected by access to immaterial resources, safe and healthy living conditions, community engagement, delocalisation and migration, cultural heritage and respect for the rights of indigenous peoples. The countries showing up as potentially important were China, Russia, Saudi-Arabia, Thailand and Brazil. These are generally less frequently mentioned in relation to ICT products, which may illustrate the added value of the life cycle perspective.

5.1.2 Vehicle fuels study

The use of the SHDB and its integrated impact assessment method in the vehicle fuels study was useful in this screening assessment (Paper III). One drawback is that some important social issues seem to be missing. The conclusion was that among the different fuels assessed, there seems to be a mix of fossil and renewable displaying high or very high risks for negative impacts. This suggests a need for developing policy so that strict procurement requirements on social performance are set for the purchasing of all types of vehicle fuels, not just biofuels.

5.1.3 E-waste study

The study of e-waste recycling showed that it has mostly negative social impacts for workers and the community, but at the same time helps them in decreasing poverty by providing employment and by playing a vital role in economic development (Paper IV). The results point at a need for raising awareness among the workers, community and government officials on the negative social impacts identified.

5.1.4 Ethical analysis

The qualitative ethical analysis was transformed to semi-quantitative scores that could be fitted into an integrated assessment in an MCDA tool (Paper VI). The merit of this process may be to enable awareness raising and place the focus on ethical issues among decision makers. However, integrating ethical issues into such a tool, which demands some indicative transformation of qualitative values into quantitative figures, may be questioned. The use of this specific MCDA tool served the analysis well in allowing for uncertain and/or imprecise values and estimations.

5.2 Conclusions on methodological issues in S-LCA

The conclusion in this thesis is that the S-LCA methodology is applicable and feasible to apply, even though it needs more refinement. By performing a social hotspot assessment, much can be learned about the potential social impact associated with the product life cycle. The suitability of generic and site-specific assessments is influenced by the aim and the scope of the study. Generic and site-specific assessments will most likely have different scopes, aimed at answering different questions. Thus, there are reasons to conduct generic

S-LCA assessments, depending on the goal of a study. A major benefit of the methodology is its ability to handle the social issues relevant to the product life cycle within one study, using a systems perspective. However, the methodology is too immature and insufficiently robust at present to be used for external comparative purposes such as labelling. This will hopefully change with continuing development of the methodology.

On reliability, the triangulation conducted indicates that the results of the assessments are reasonable, even if the lack of established impact pathways at present constitutes a problem. The choice of social issues in an assessment is decisive for the outcome and its reliability. Our conclusion is that the social issues covered in the Guidelines are satisfactory for all relevant stakeholders in the vehicle study. Some issues in the Guidelines are missing in the SHDB, which would benefit from being complemented with some impacts to better correspond to the Guidelines.

The results of our case study on laptops indicate that some new knowledge on hotspots in a supply chain can be gathered by S-LCA. The e-waste study also produced more detailed information on how the people working with e-waste are affected. New information on the presence of social hotspots in the life cycle of both fossil and biofuels was also found. All this indicates that the S-LCA methodology can provide new insights for stakeholders about social impacts in a product system. The life cycle perspective and systematic approach can help the user identify potentially important aspects that would otherwise have been neglected, and may bring the discussion on the social impacts in the product system one step further by identifying impacts on a more detailed level.

In setting the system boundaries, the leverage of a particular firm cannot be allowed to define the most urgent needs in society, as the negative social impacts may prevail at the outer ends of the life cycle. This stresses the importance of conducting hotspot assessment of social impacts in the full value chain. There are also in practice real opportunities for companies to deal with issues at the very end of their value chain by working together.

Data for the studies were collected both directly on-site and from a database. When choosing to use a database for data collection, the limitations of the database are transferred to the study. One of these is the fixed format, which reduces flexibility. However, substantial advantages can be gained, the most obvious being the time efficiency. Furthermore, use of database data allows methodological choices in different studies to be compared, as variation originating from different data sources can be eliminated. In the trade-off between the drawbacks and advantages outlined above, the use of databases is in many cases beneficial. However, if learning is considered, the experiences gained from collecting data in the field should not be underestimated.

The impact assessment methods need to be further developed. So far, two main approaches have emerged, one using a relative assessment and the other an absolute assessment by performance reference points. Irrespectively of approach, the way to assess positive social impacts should be paid more attention, especially how to integrate them with the negative impacts in the final outcome. An ethical aspect is that if negative and positive impacts are allowed to balance each other out, an unequal distribution may be concealed as the negative and positive impacts might not affect the same stakeholders. One possible way of handling this problem could be the use of MCDA, where there is transparency on the way the weighting is done, and where afflicted stakeholders could be asked about their own priorities.

The S-LCA aims at informing the decision maker about the potential negative and positive social impacts in the life cycle of a particular product, but does not make the decision. This is still the responsibility of the decision maker and should include other criteria as well, such as environmental issues. Again, the use of MCDA is an interesting approach to this end.

In order to promote increased learning and to be reliable, the results must be transparent. At the same time, the inventory results need to be summarised somehow in order to communicate them in a feasible way. Too much aggregation at this stage should be avoided, as there are many major uncertainties and data gaps. Interpretation should be facilitated in a way that does not conceal the complexity and the uncertainties in the results.

5.3 Issues for further development in S-LCA

The following methodological issues for S-LCA were identified as being in particular need of further attention.

The relevance of indicators. The relevance of some indicators in the methodological worksheets was questioned in our laptop study. The pathways between the indicators and the performance assessment on social issues must be examined and improved. In the next step, the pathways between performance assessments and the impacts on the AoP must be established. This could usefully be done in cooperations between interested researchers, and possibly built into the SHDB.

Aggregating and weighing impacts and indicators. In an S-LCA, there is a wide range of social issues to consider, measured by quantitative, qualitative or semi-quantitative indicators, mixing positive and negative impacts. In addition, there might be a wish to weight the impacts in different ways, e.g. to allow for a greater improvement in human well-being. A possible approach for handling this might be to use multi-criteria decision analysis (MCDA), which provides techniques for weighing a range of different criteria in a structured and transparent way. Such an approach would enable decision makers to express and be transparent about their values in prioritising among the subcategories and might also leave room for taking the values of different stakeholders into consideration.

Assessment of the use phase. A drawback of the methodology is the limited assessment of the use phase. To encourage the business sector to adopt this tool, it would benefit from being complemented with an analysis of the use phase. That would enable the promotion of the potentially positive social aspects of a product in this life cycle phase.

Introducing context. Considering the difference in potential improvements of the AoP due to context is consistent with the concept of sustainable development stated in the Brundtland report, i.e. prioritising the needs of future generations and of the world's poor. In this perspective, impact assessment methods taking context into account are needed as they offer the possibility to move more rapidly towards the improvement of social conditions in poor areas. Identifying the context of the relevant stakeholders in different parts of the life cycle would allow identification of the greatest leverage in the improvement of social conditions.

Linking to LCSA. Finally, the development of S-LCA needs to be linked to the simultaneously on-going development of LCSA. The ultimate aim is to integrate the S-LCA somehow into a wider sustainability assessment. Some of the interesting work going on as regards LCSA is alignment of issues for all three perspectives together, thus minimising the risk of double counting, and the approach for assessing different levels in society.

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