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Social Life Cycle Assessment

State of the art and challenges for supporting product policies

Serenella Sala, Alessandro Vasta, Lucia Mancini, Jo Dewulf, Eckehard Rosenbaum

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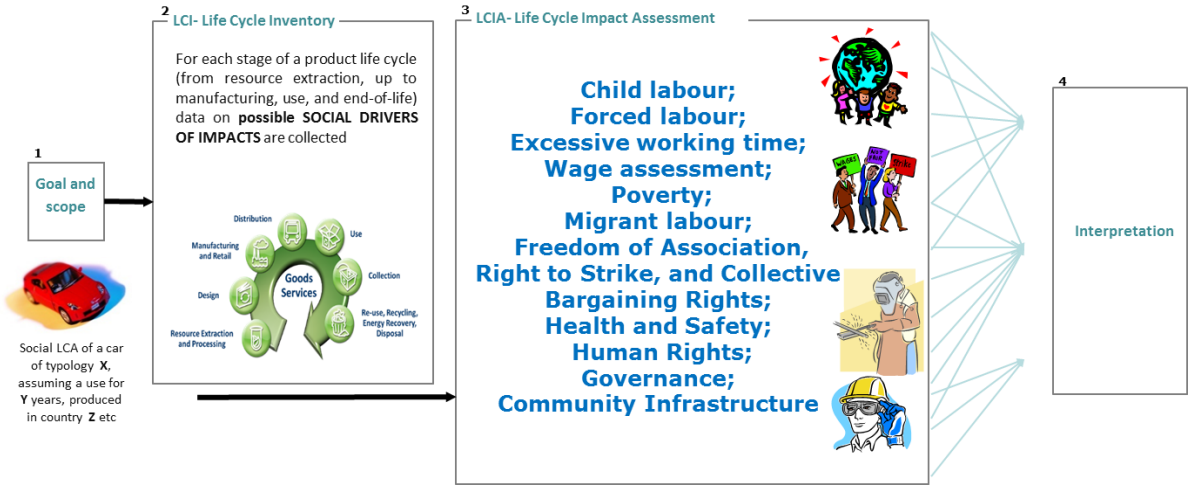
Executive Summary

Social welfare is considered one of the main development goals of modern society. Understanding and assessing what could improve or undermine well-being is a key element in public policies, aiming at improving social and economic benefit while reducing both social and environmental impacts. The appraisal of social impacts and benefit is very difficult and controversial as cultural elements, different values, and lifestyles may affect the way social issues are perceived. Regarding product policies, social impacts along supply chains are increasingly assessed by different stakeholders, such as governments, businesses and NGO's. To assess impact along supply chains, Life cycle-based methodologies have been developed over time. Life cycle assessment (LCA) considers mainly environmental impacts along supply chains, from extraction of raw materials to end-of-life of products. Similarly, social life cycle assessment (S-LCA) integrates traditional life cycle assessment methodological steps while having social impacts as focus. Coupling the assessment of environmental and socio-economic issues may support more comprehensive sustainability assessment of impacts, benefits, and related trade-offs.

A schematic methodological approach of S-LCA is shown below. The basic step of an LCA can be adopted also in S-LCA, namley: 1) defining goal and scope of the assessment; 2) inventory of the drivers which may lead to an impact; 3) impact assessment cbased ib the selection and calculation of proper indicators of impacts; and 4) interpretation of the results.



However, if compared with LCA, the level of methological development, application, and harmonisation of Social LCA is still in a preliminary stage.

Therefore, the present report aims at presenting: i) the state of the art in Social Life Cycle Assessment, illustrating the main theoretical and methodological elements under discussion in scientific literature; ii) the overlaps and the synergies with traditional LCA, towards a common and integrated assessment framework; iii) examples of application of S-LCA methodology at macro scale (EU-28) and at sector scale (Metal sector).

The report is the results of the joint effort of JRC researchers and several external experts in the S-LCA domain, towards a comprhensive illustration of current challenges of S-LCA.

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Abstract

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1. Introduction

Assessing sustainability is becoming common practice in the context of product and territorial policies. Sustainability Science (SS) is considered an emerging discipline, applicative and solution-oriented whose aim is to handle environmental, social and economic issues in light of cultural, historic and institutional perspectives. The challenges of the discipline are not only related to better identifying the problems affecting sustainability but to the actual transition towards solutions adopting an integrated, comprehensive and participatory approach (Sala et al., 2013 a, b).

Terms such as "Integrated Assessment" and "Sustainability Assessment (SA)"[1] are used to label 'new' approaches to impact assessment that are designed to direct planning and decision-making towards sustainable development (SD) (Hacking and Guthrie, 2008). Indeed, sustainability assessment is a methodology that may help decision-makers and policy-makers decide what actions they should take and should not take in an attempt to make society more sustainable (Devuyst, 2001, p. 9). The aim of sustainability assessment is to ensure that "plans and activities make an optimal contribution to sustainable development" (Verheem, 2002).

However, increasing concerns have been voiced in the scientific community regarding whether the various available examples of SA are really comprehensive (Gibson, 2006) and able to judge in a robust and reliable way whether new developments "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Concerns are mainly related to the intrinsic vagueness of the sustainability concept itself (sustainable development is, like social justice, a value-laden concept that has many different dimensions and perceptions), and to the capability of addressing environmental, economic and social issues and their interactions with robust and fit-for-purpose measures (Bohringer and Jochem, 2007).

In order to set a strategic direction for the development at global scale, the United Nations (UN) has recently put forward an Agenda for 2030 (transforming our world) with 17 new sustainable development goals (SDG's) (UN, 2015). Six out of the seventeen sustainable development goals are focused on social issues (1, 4, 5, 8, 10, 11) and two on governance of the transition towards sustainable development (16, 17) (Figure 1).

Figure 1 Sustainable Development Goals (SDGs) (UN, 2015) pertinent on social issues and on governance towards Sustainable Development

At European Union (EU) level, amongst several strategic documents on sustainable development, the Communications "A decent life for all" (EC 2013, EC 2014) tackles the challenges of post- millennium development goals and further include social issues and a framework on how to best integrate EU and international actions. Furthermore the EU has expressed its vision towards the achievement of the SDG's through the recent Communication: A Global Partnership for Poverty Eradication and Sustainable Development after 2015 (EC 2015a). Moreover the EU has been intensely deliberating towards a post 2015 agenda and adopted the latest Council Conclusions on 26th of May

[1] Other synonyms adopted are: "Triple Bottom Line Assessment", "3E Impact Assessment" [Environmental, Economic, Equity], "Extended Impact Assessment", and "Sustainability Appraisal".

2015: A New Global Partnership for Poverty Eradication and Sustainable Development after 2015 (Council conclusions 9241/15).
Building from these policy documents, there is a clear need of robust methods for accounting both status quo and progresses related to social impacts.
Performing SA requires integrating sustainability principles and values in the appraisal of a product, process, project, policy etc., considering the existence of environmental boundaries (i.e., thresholds, and targets) when searching for an overall maximization of societal benefits, as well as moving from mere multidisciplinary to inter- and trans-disciplinary approaches (Sala et al., 2013 a, b). Moreover, any sustainability assessment has enshrined a value-system which affect the way in which the evaluation is conducted and the results interpreted (Sala et al., 2015). Therefore, it is paramount to transparently identify the underpinning values and the cultural elements embedded in the evaluation framework.
Moreover, sustainability of production and consumption systems is increasingly facing multi-faceted and interrelated challenges. Markets are global, supply chains very complex and related environmental and social pressures still not adequately managed and reduced.
In the context of business and policy, environmental and social and economic impacts should be considered as much as possible in an integrated manner, integrating life cycle thinking (LCT) in the assessment and optimisation of human interventions. LCT seeks to identify possible improvements to goods and services (products) by lowering their environmental impacts and reducing the use of resources across all life cycle stages (EC-JRC, 2010). This is fundamental to be able to avoid unintended burden shifting from one impact to another, or from one stage (e.g. production of a good) to another stage (e.g. consumption).
Life cycle based methodologies are useful to compare options, especially when complex supply chains are involved. Indeed, by applying a life-cycle approach, priorities can be identified more transparently and inclusively. For example, policies can be supported more effectively so that the more environmental benefits may be achieved relative to the effort expended.

Life Cycle Assessment (LCA)—due to its systemic approach—is considered to provide a valuable support in integrating sustainability into design, innovation and evaluation of products and services and to related policies. LCA, as a technique, is now used to study not only the impacts of product life cycles but also those that can be assigned to baskets of goods, companies, households, countries, and the planet (Norris, 2014). Life cycle assessment (LCA) considers mainly environmental impacts along supply chains, from extraction of raw materials to end-of-life of products. Similarly, social life cycle assessment (S-LCA) integrates traditional life cycle assessment methodological steps while having social impacts as focus. Coupling the assessment of environmental and socio-economic issues may support more comprehensive sustainability assessment of impacts, benefits, and related trade-offs.

On the policy impact assessment side, this has been recognised, e.g., by the recent inclusion of Life cycle analysis as a tool in the Better Regulation toolbox of the EU Commission (EC 2015b). In fact, more recent methodological developments have aimed at extending LCT to also evaluate social issues (Social Life Cycle Assessment-SLCA) and economic issues (Life Cycle Costing - LCC) towards a complete and comprehensive Life Cycle Sustainability Assessment (LCSA).

Concerning S-LCA, the basic idea is that, beyond environmental impacts, also social impacts could be embodied in products and related supply chains, so a similar structure of analysis could be followed (Figure 2).

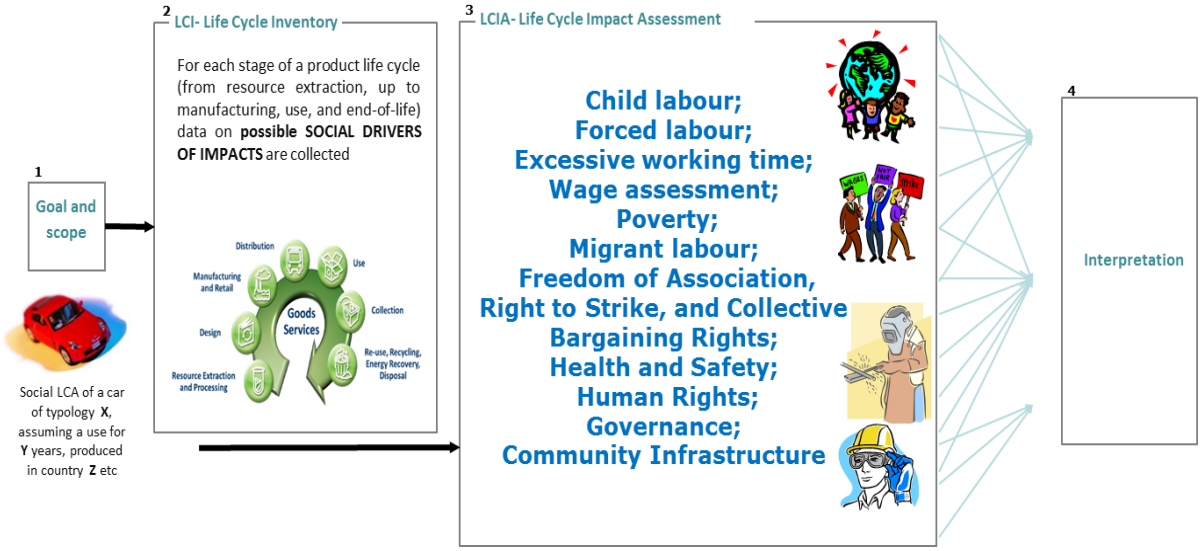

Figure 2 Basic steps of LCA could be adopted also in S-LCA, namely: 1) defining goal and scope of the assessment; 2) inventory of the drivers which may lead to a social impact; 3) impact assessment conducted through the selection and calculation of proper indicators; and 4) interpretation of the results

At the hearth of the assessment, in the life cycle impact assessment step, several social indicators are used to quantify the impacts associated to an intervention. The indicators used in current practice of S-LCA are defined based on available sets of indicators developed in social impact assessment domains. In fact, different actors have developed indicators over time, with different purposes:

- Government institutions (e.g. the list of social indicators adopted in the Human development index (HDI) (UNDP, 2015), the UNEP guidelines for social LCA (UNEP, 2009))
- non-governmental organizations (NGO's) (e.g. indicators for fair trade, see section 2.3)
- Industries (e.g. indicators adopted for social corporate responsibility, see section 2.1)
- Scientific community (e.g. different set of indicators for assessing social-related impact of specific products/ countries/ supply chains)

Some of these indicators already adopted a life cycle thinking approach (e.g. those of the fair trade) whereas other have a different focus, e.g. the social condition of a country (as the HDI and "Beyond GDP"). The scale of application of these indicators has been different, including social performance of country, sectors, organisations, and products (Figure 3). Approaches also vary in terms of being a qualitative versus a quantitative assessment. These elements could be controversial social impacts could be difficult to be translated into a quantitative structure, and several social assessment applied to supply chains are conducted in a semi-quantitative manner in business' reporting.

Notwithstanding the importance of the social impact assessment, the level of methodological development, application, and harmonisation of Social LCA is still in a preliminary stage, if compared with LCA and LCC. Hence, the present report aims at presenting: i) the state of the art in Social Life Cycle Assessment, illustrating the main theoretical and methodological elements under discussion in scientific literature; ii) the overlaps and the synergies with traditional LCA, towards a common and integrated assessment framework; iii) examples of application of S-LCA methodology at macro scale (EU-28) and at sector scale (Metal sector).

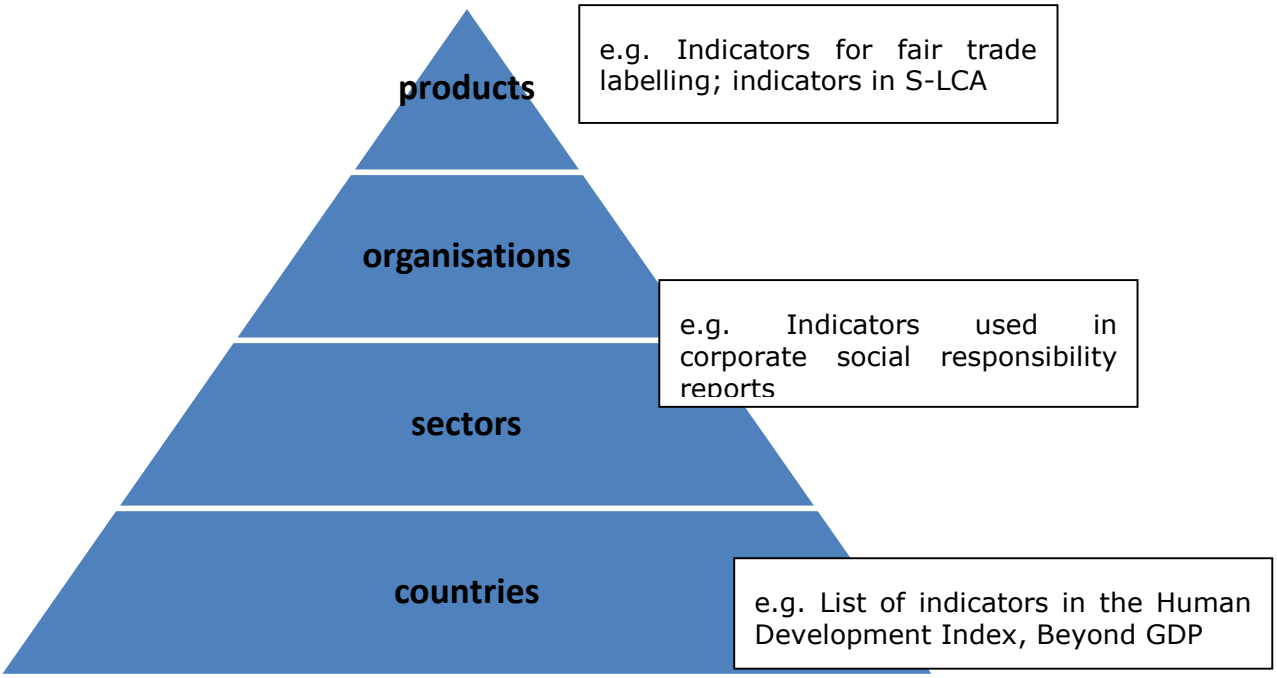

Figure 3 Examples of social impact assessment indicators, developed for assessing impacts at different levels and scales

1.1. Methodological considerations

S-LCA is a set of methods that seeks to assess the potential or real social impacts of a product or service (Chhipi-Shrestha et al., 2014) where social impacts are mainly understood as the impacts on human capital, human well-being, cultural heritage and social behaviour. Applying LCT concepts, S-LCA purports to cover the entire life cycle or at least significant parts thereof and thus (if applicable) the material extraction and manufacturing or production phases, the use phase and, ultimately, the end-of-life phase of a product or a service (UNEP, 2009).[2]

In broad terms, two methodological approaches can be distinguished in social LCA, namely "*performance reference point*" methods and "*impact pathways*" methods. Performance reference point methods focus on living and working conditions of – mainly – workers (e.g. whether there is forced labour, child labour, discrimination and freedom of association or collective bargaining) related to, or occurring at different life cycle phases (Chhipi-Shrestha et al., 2014). The choice of reference points is usually based on internationally accepted minimum performance levels such as International labour organisation (ILO) conventions, the ISO 26000 guidelines on social responsibility (ISO 26000, 2010), and OECD Guidelines for Multinational Enterprises (Parent et al., 2010). Importantly, performance reference point methods do not assume a causal relationship between production processes or technologies and the aforementioned conditions. What these methods do assume is that there is an empirical correlation between production processes mainly characterised in spatio-temporal terms and the occurrence of specific socio-economic conditions.

Impact pathways methods, by contrast, assess the social impacts of a product or a service using impact pathways as characterization models comprised of midpoint and/or endpoint indicators similar to environmental LCA (Parent et al., 2010). These methods are therefore based upon a causal relationship between these processes, for instance emissions of a toxic substance from a furnace, and one or several measures of human well-being such as DALYs (Disability-adjusted life years). Impact pathways methods can

[2] For services, there may be no end of use phase as such, but there may be an end of use phase for products which are used to provide a service. Thus there is no end of use phase for air transport, for example, but an end of use phase for air transport equipment.

thus be regarded as environmental LCA methods focussing specifically on humans and their biological living conditions.
There are two points worth noting in this regard. Firstly, while there is arguable some overlap between environmental LCA and social LCA in terms of the Areas of Protection (AoP), it is also true that human health is not only affected by physical exchanges between the environment and the human-industrial sphere but also by economic exchanges and socio-economic conditions more broadly conceived (Dewulf et al., 2014). Conversely, while a long and healthy life is an important objective in its own right, it must be complemented by a wider set of Areas of Protection (AoP) comprising also human dignity and well-being if it is to be genuinely social (ibid.).
Secondly, different methodological approaches correspond to different contexts in which social LCA tools are being used (Parent et al., 2013). In fact, social LCA methods for policy making purposes may differ significantly in terms of their pros and cons together with their informational and technical requirements and their normative foundations from methods which aim at helping to inform businesses about the social consequences of, e.g., sourcing decisions in their supply chain. As a consequence, there cannot be a one-size-fits-all approach to social LCA.

1.1.1 Social vs environmental LCA

Social and Environmental LCA are both grounded in LCT. Therefore, they share a number of similarities. Key among these is that both approaches – at least in principle – seek to capture the environmental/social impacts of a good or service from the cradle to the grave.
However, there are also a number of important dissimilarities between both approaches. One of them being that social concerns are diverse and their importance is subjective to the context. Contrary to environmental indicators, social indicators are very hard to quantify and their impact changes with the behaviour of the company (Swarr, 2009).
Another key issue in S-LCA is the definition of the functional unit. While this is usually not a problem in environmental LCA (and arguably also not for impact pathway methods as described above), it is less clear for performance reference point methods how to conceptualise the functional unit. The reason is that these methods attribute social impacts through proxies, e.g. working hours or monetary values or a combination of both.
While the advantage of this method is that it can make use of a host of publicly available information – the Social Hotspots Database being the probably most prominent example –, the causal link between the proxy and the social impacts is often tenuous. Moreover, a linear relationship between the magnitude of the social impact and the proxy is assumed and this too has to be taken with caution, in particular for social impacts which are largely qualitative in nature (Chhipi-Shrestha et al., 2014).

1.1.2 Social impact vs social benefits

Unlike in environmental LCA where impacts are mostly negative, social impacts may also be distinctly positive. Therefore, social LCA usually refers to the assessment of the real and potential social and socio-economic impacts of goods or services including positive and negative impacts along their life cycle (UNEP, 2009).
Methodologically, it may be difficult the identification of positive social impacts and there is a possible problem of double counting, for instance of economic and social impacts. Applying the notion of externality, this difficulty can be avoided conceptually by considering as economic impacts all those effects which are properly reflected in prices and associated quantities, whereas social impacts are those effects which are not adequately captured by prices, i.e. where prices are either too high or too low. The problem with this recommendation is that it may look convincing on paper but faces a host of practical problems, not least knowing the economically correct price.

1.1.3 Risks vs concrete realisations

As indicated above, social attributes of (the production of) goods and services can vary across locations, firms or over time. While this is possible for both environmental and social S-LCA, there are reasons to suggest that the phenomenon is more widespread for S- LCA given the looser link between the (physical characteristics of the) product or its

production technology and any social impact thereof. Thus the nature of labour relations or the incidence of child labour (to take just two examples) is more likely to be driven by the legal and institutional framework of the country where production takes place rather than by anything else. Still, even within a country there may be significant differences in this regard at the level of firms or even sectors.

If information about social effects are not available at the level of the product or the service, then social effects may not be attributable with certainty. It is therefore useful to apply the notion of risk. For this notion implies that it is neither possible nor necessary to know for certain the social impact of the production of a specific good or service but that, for policy purposes at least, it suffices if the probability is known with which a product is associated with an externality. In other words, out of a representative sample of similar products, a certain number will exhibit the social impact in question if assessed in detail while the remaining will not. Analytically, using the notion of risk has the advantage that risks so conceived can be used easily as explanatory factors in policy analysis. Thus in line with the idea discussed above that risks emanating from the actions of economic actors may undermine the business model of an enterprise, social risks may also undermine growth prospects or endanger other key policy objectives if perceived risks (rather than concrete realisations of the risk) prompt actors to change their behaviour.

Risk as understood here as an ex ante property in the sense that any specific instance of a good or a service either has some social impact or does not have that impact once it has come into existence. However, prior to undertaking a case study that examines in more detail concrete instances of the product, it is not known whether the product can be associated with the impact in the sense that an investigation of the production facilities along the supply chain establishes that certain social conditions do actually occur. It is only concluded from prior observations that some goods or services of the type in question exhibit the impact in question.

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2. Who and why: the reason for conducting a social impact assessment – Business, Policy and NGO perspectives on S-LCA

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Given the paramount normative importance of social impacts, social LCA as characterised above may be pertinent in a number of fields and for a number of purposes. In the present chapter, the focus will be on public policy and businesses as arguably the main recipients and users of social LCA. The point to be elaborated in more detail is that social LCA may provide relevant information for both policy makers and managers. It may help the former to assess policies in more comprehensive terms and thus contributes towards a better design of policy instruments. And it may assist the latter in the implementation of, for instance, principles and guidelines based on the notion of Corporate Social Responsibility by providing information on the social consequences of business decisions.

2.1 Business

For businesses, be it manufacturers or service providers, the information provided by social LCA tools may serve at least two main purposes. First, it may inform the design and implementation of strategies and actions based on a commitment to the principles of Corporate Social Responsibility. Second, it may help businesses to identify possible risks emanating from actions of the business itself, its suppliers, customers or other relevant stakeholders. The point here is that such actions may have negative social consequences which, if left unaddressed, lead to corresponding adverse behavioural responses which potentially undermine a business models. Both cases will be discussed in turn.[3]

2.1.1 Corporate social responsibility (CSR)

CSR policy is usually regarded as a self-regulatory mechanism whereby a business monitors, and ensures its active compliance with the legal framework, common ethical standards and internationally agreed norms. Arguably, a firm's implementation of CSR goes beyond mere adhering to the *existing* legal framework and involves "actions that appear to further some social good, beyond the interests of the firm and that which is required by law" (McWilliams and Siegel 2001, McWilliams et al., 2006), hence the notion of "active" compliance. CSR refers to the responsibilities enterprises can assume in order to contribute to sustainable development. Business for Social Responsibility (BSR), an organization that assists businesses in contributing more fully to sustainable development, proposed that in order to achieve social responsibility, companies must integrate practices into every aspect of their operations, maintaining that businesses should be "achieving commercial success in ways that honour ethical values and respect people, communities, and the natural environment" and include "a comprehensive set of policies, practices and programs that are integrated into business operations, supply chains and decision-making processes throughout the company" (Benoit and Vickery-Niederman, 2010)

There is a need for implementation of CSR. Indeed, during the last decades, some multinational companies were widely criticized for their labelling social responsibility, including General Electric, Coca-Cola, Nike, Royal Dutch Shell, BP, Nestlé, Richmond, Samsung, and Wal-Mart and Merck. As an example, Most of its factories are located in Asia, including Indonesia, China, Taiwan, India, Thailand, Vietnam, Pakistan, Philippines, and Malaysia. Nike has contracted with more than 700 shops around the world. During the 1990s, Nike faced criticism for use of child labor in Cambodia and Pakistan in factories it contracted to manufacture soccer balls. Although Nike took action to curb or

[3] There is clearly some overlap between CSR and risk management in that pursuing CSR policies may help to avoid certain risks while avoiding unnecessary risks may contribute to CSR policies.

at least reduce the practice of child labor, they continue to contract their production to companies that operate in areas where inadequate regulation and monitoring make it hard to ensure that child labor is not being used. A July 2008 investigation by Australian Channel 7 News found a large number of cases involving forced labour in one of the biggest Nike apparel factories. The factory located in Malaysia was filmed by an undercover crew who found instances of squalid living conditions and forced labour. Nike has since stated that they will take corrective action to ensure the continued abuse does not occur (Milovanovic et al., 2009).

For CSR policies to be implemented successfully, two conditions must be fulfilled. First, an organization must have "the ability to make a change". That is, it must be able to influence either directly or indirectly the behaviour of other actors. This applies of course to the enterprise itself and its staff,[4] but it is also the case for enterprises over which it has some influence or control; i.e. over entities it owns totally or in part, enterprises from whom it buys an important share of their sales, or enterprises with whom the contractual relationship requires certain operating standards and practices to be fulfilled (Global Reporting Initiative, 2005). Second, CSR policies can only be implemented (responsibilities can only be taken seriously that is) if businesses know the consequences of their own actions and that of relevant other actors, where action can refer to all aspects of a business's activities and the businesses over which it exerts some form of control or influence. Such consequences may refer not only to the current state of play (what is caused by current actions) but also to some hypothesised state, which is assumed to results from some hypothesised or planned action or behaviour. After all, an action or a behavioural change that seeks to mitigate some adverse consequences should not result in something equally undesirable. Hence, an "as if" type of analysis is necessary in order to implement CSR policies in practice.

2.1.2 Supply chain and other risks

Managing risks is an important executive responsibility in its own right. It involves first of all the identification of risks and their assessment with respect to the probability of adverse events to occur and the seriousness of such events if they materialise, i.e. their capacity to cause severe damage to a business model. Following that, risk management comprises efforts to minimize, monitor, and control the probability and/or impact of unfortunate events (Hubbard 2009). Thus risk management involves both ex ante and ex post measures.

Risk management so defined covers not only risks emanating from the processes and activities undertaken by the enterprise itself but also (and conceivably even more so) risks resulting from circumstances/behaviours of actors along the supply chain. In fact, if a business does not sell its products directly to the final consumer or customer, then even down-stream actors such as wholesalers, retail-chains or providers of logistic services may be a source of risks in that failure on their part to deliver key services may undermine the success of a business model in very much the same way as do up-stream risks resulting in disturbances to the supply of intermediated goods and services and hence interruptions of the production process.

Risk management may pursue different strategies depending on what is to be achieved (e.g. whether reducing the probability of an event or reducing its impact is the main objective) and where the source of the risks is located. It may involve unilateral actions such as switching between suppliers or taking precautionary measures, but it may also involve a more interactive approach that seeks to address a risk together with the actor who (or whose behaviour or actions) is perceived to be giving rise to risks.

2.1.3 The specific purpose and role of social LCA in a business context

Social LCA can support and inform both CSR policies and risk management. As for the former and to the extent that social conditions are affected by enterprises' behaviours,

[4] This is at the core of the principal-agent-problem. See the seminal paper by Jensen and Meckling (1976).

social LCA can inform enterprises about these effects and thus point to areas of action and intervention. A case in point is the choice of a supplier. If, for instance, social LCA reveals that the working conditions for staff of a particular supplier (or its suppliers further down the value chain) do not meet generally acknowledged standards and norms, then an enterprise can respond by choosing, again supported by social LCA, another supplier whose track record in this respect is better. Obviously, for such a response to be possible information at micro level, i.e. for products or concrete steps in the value chain, is necessary.

Such a direct behavioural response is obviously not called for if social LCA is only able to identify social hotspots, i.e. when an economic activity in a specific sector and/or country is likely (in a probabilistic sense) to be associated with adverse social features such as child labour. Changing a supplier under these circumstances may address a non-existing problem in the sense that a specific (actual or prospective) supplier of the enterprise may not exhibit the socially problematic features to which the hotspot analysis seeks to draws attention. As a consequence, the role of social LCA here is to make an enterprise aware of these risks and prompt it to respond by seeking more information in order to initiate, if necessary specific risk management measures.

As for risk management in its own right, the specific role of social LCA can be seen in the fact that ethical standards and internationally agreed norms which are insufficiently addressed or even deliberately violated by a business, may lead to behavioural responses by those affected by the violation which pose risks for the very same business and its customers and suppliers. To address these risks requires therefore that managers become aware of the respective sources of risks. Social LCA can in principle furnish this kind of information aiming as it does on the whole supply chain. To illustrate the point, consider a supplier who denies to its staff the right to form an association or a union. If, as a consequence, staff calls for a strike to enforce its rights, then production may be interrupted or delayed and the enterprise which sources intermediate products from this supplier may also be affected by the strike. Here non-compliance with worker's rights increases the risk of industrial action and, as a consequence, the risk of interruptions to the supply chain.

2.1.4 Social impact in industries: a vertical versus horizontal view

We can look at social responsibility and impact in industries in a horizontal manner, where the focus is on the impacts of "one" organization. We can also look in a vertical manner, where the spotlight is on the impacts associated with a product life cycle. The term "product" refers to both goods and services. By definition, a product's life cycle includes "all stages of a product system, from raw material acquisition or natural resource production to the disposal of the product at the end of its life, including extracting and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling and final disposal (i.e., cradle-to-grave)". For example, we can assess the social responsibility performance of Unilever, as an organization, or we can assess the social responsibility of the supply chain or life cycle of Unilever Hellmann's Real Mayonnaise. The horizontal view of social responsibility (i.e. the organizational view) has been the main scope of most CSR initiatives, including the Global Reporting Initiative, ISO 26 000 and the Global Compact, and also for the field of responsible investing. In comparison, a vertical view assesses social responsibility across the entire life cycle of the products, looking at the social impact of the products produce by the brand or end producer. The focus is less on the end producer/brand owner and more on all the different nodes of their product supply chains (Benoit and Vickery-Niederman, 2010).

In Table 1, we present an overview of initiatives promoting social responsibility based on Benoit and Vickery-Niederman (2010).

2.1.5 Examples of introduction of Social Life Cycle Assessment in industry

Socially and economically expanded LCA: BASF (based on Nyrgen and Antikainen, 2010)

Traditional LCA primarily looks at environmental aspects. In order to comprehensively assess the sustainability of products, the costs and social impacts have to be integrated into analysis. In this way, the applicability of the analyses directly as a decision-making tool is higher. In a first stage, BASF has developed Eco-Efficiency Analysis for comparing products with respect to their in environmental impacts and economic costs. Later on, the company proposed the SEEBALANCE™ method. It goes further than the Eco-Efficiency Analysis by adding a third dimension and integrating social aspects into the analysis. Impacts on five stakeholder groups, employees, future generations, local community, international community and consumers, are considered in the assessment. At least 23 indicators are described for impacts on these stakeholders, ranging from employee safety to the amount of imports from developing countries. The task of quantifying all aspects of production is immense and maybe impossible, considering all the uncertainties, but it can ease value discussions in relation to production and help to identify key areas of improvement.

Table 1 Examples of Social responsibility schemes (based on Benoit and Vickery-Niederman, 2010)

Type	**Examples**	**Pertinent to**
International Policy Frameworks	The UN 'Protect, Respect, Remedy' framework Int. Labor Organization (ILO) Conventions Millenium Development Goals UN International Human Rights Treaties and Instruments	Corporations, Facilities, Governments
Principles and Codes of Conduct	UN Global Compact Own Codes of Conduct (e.g. Walmart, Ikea)	Corporations, Facilities, Governments
Sustainability Reporting Frameworks	Global Reporting Initiative UNCTAD Corporate Responsibility Indicators	Workers, Local Community, Society, Value Chain Actors
SR Implementation Guidelines	ISO 26000 OECD Guidelines for Multinational Enterprises	Corporations, Facilities, Governments
Auditing and Monitoring Framework	AIM-PROGRESS (facility level) Global Social Compliance Programme SAI/IFC PS2 (Social Accountability Int. Standard) SAI SA8000 BSCI (Business Social Compliance Init.)	Workers, Value Chain Actors
Financial Indices	FTSE4 Good Index Series (corporations and 1st tier suppliers) The Vigeo Group Sustainable Rating Indices Dow Jones Sustainability Indexes	Workers, Local Community, Society, Value Chain Actors
Methods	UNEP/SETAC methodological sheets for S-LCA of Products (relevant at Corp., Facility, Unit Process) Oxfam Poverty Footprint BASF Seebalance	Workers, Consumers, Local (and national) Community, Society, Value Chain Actors

Roundtable for Product Social Metrics

A group of experts from large companies decided to join forces, initiating the Roundtable for Product Social Metrics. Starting in early 2013, this working group, including Ahold, BASF, BMW Group, DSM, Goodyear, Philips, RB, AkzoNobel, L'Oréal, Marks & Spencer and Steelcase, aimed to i) consolidate principles for product social sustainability assessment and harmonise approaches, ii) align with other global initiatives and share with other companies and iii) develop solutions for cross-cutting implementation issues. They developed a handbook (Fontes, 2016), which proposes a practical methodology for organisations to assess the social impacts of products, building on existing standards at global level. In addition, given the Roundtable's wish to achieve broader consensus and credibility, this document reflects the development process as well as the end results. The methodology allows reasoned assessment of overall performance by including social topics and performance indicators that reflect positive and negative impacts of the product on three stakeholder groups: workers, consumers and local communities. 19 social topics are proposed, together with their individual performance indicators, including detailed definitions. Application examples and recommendations for the communication of results are also included in the handbook. The methodology can be applied in numerous scenarios, from understanding improvement opportunities and steering product development in different stages, to providing support for decision making and external communications. Ultimately, by supporting the assessment of social performance, this handbook aims to enable organizations to achieve greater transparency on the social impacts of their products.

2.2 Policy

Sustainability with its three pillars – the environmental, the economic and the social – has become one of the guiding principles of policy development in the European Union. Conceptually, the environmental and social dimensions of sustainability can be conceived as either positive or negative externalities of economic activity (Pelletier et al., 2013). Accordingly, market prices do not properly reflect the properties and impacts of a product or a service with respect to the social and the environmental domain. In the case of a negative externality, the market price is too low while in the case of a positive externality the market price is too high implying either under or over-production and consumption.

While this conceptualisation may not do full justice to all aspects of the social and the environmental pillar, it certainly allows for an easy and relatively seamless integration of the tree pillars of sustainability into a market based policy framework whose hallmark is to influence economic decisions on consumption and production through price signals. This being said, the implementation requires that information about such externalities is available to policy makers and the public at large. That is, policy makers need to know where (social) externalities (are likely to) occur and how significant they are and the same is true for citizens. It is for precisely this reason that S-LCA has the potential to contribute significantly to the policy making process. Both cases will be discussed in more detail in the subsequent paragraphs.

2.2.1 Information for policy makers

As for policy makers, it is usually information at macro level that is required and sought for. Thus policy makers need to know which type of product from which sector or country is associated with certain social externalities and how important these externalities are. The reason is that, typically, policy measures will also be taken at macro level targeting as they do classes or types of products rather than a particular product from a particular firm in a particular country. Thus taxes that seek to internalise externalities are imposed on a type or category of product and the same is true for regulations which have the same purpose.

It should be noted though that there is a caveat to this general principle. The principle assumes that products or services vary only little with respect to the externalities that

are associated with them.[5] While this condition cannot always be taken for granted in environmental LCA where externalities may differ widely depending on design, production technologies and production processes, the condition is even more problematic in social LCA where working conditions and other social impacts are only very loosely connected, if at all, to design and production technologies (Lehmann et al., 2013). Thus whether agricultural production involves child-labour or not has arguably nothing to do with the agricultural product in question but depends on the institutional and legal framework of the country together with the capital intensity of the sector (to name just two possible factors).

2.2.2 Citizens' responsibility and awareness

While it is obvious that policy makers need to be informed about social externalities and concomitant risks, a case can also be made for informing citizens about possible social externalities. This case rests on four arguments:

- In a democratic society, people can only exercise their voting rights in a meaningful sense if they have at their disposal sufficient information to assess the policy platforms policy makers have proposed with respect to the problems that are to be addressed and the solutions that are proposed.
- There is arguably not only corporate social responsibility but also citizen's social responsibility as citizens cannot put the blame for all social evils and problems on policymakers. In fact, the freedom to act in a liberal society goes hand in hand with the obligation to act responsibly. However, citizens need to be informed about the consequences of their choices and actions to be able to exercise fully their responsibility. Moreover, citizens need to be informed proactively about at least some of these consequences since gathering sufficient information is much more costly for citizens than for say enterprises or policymakers themselves and not all consequences may be immediately visible.
- Some social externalities may be idiosyncratic in the sense that they depend by and large on people's individual values, norms and cultural configurations. As a consequence, it is largely up to consumers to decide via their consumption decisions which signals they intend to send to enterprises as no political consensus is likely to come forth easily.
- Last but not least, whether some social impacts are positive or negative may also be context specific and thus depend on available alternatives. While for instance child labour is generally condemned if the alternative is going to school and receiving an education, the issue is less straightforward if the alternative to some form of child labour would be malnutrition. Moreover, there is also the possibility of certain trade-offs between what stakeholders consider to be acceptable (Kruse et al., 2009).

While some of the above cases require the same macro level information that policy makers also need, individual consumption decisions cannot be based on generic information in probabilistic form. It does not help consumers to know that a certain type of product involves with a certain probability child labour. For making adequate choices, consumers need to know more:

> "For substituting supply chain actors in order to improve stakeholders' social conditions, the buyer (whether a consumer buying consumer goods or a producer buying production inputs) needs adequate information such that his/her purchasing (or absence of) will send the adequate signal to the market. The same principle, but the other way around, has to be followed for marketing, reporting and labelling; responsible enterprises should adequately inform consumers so their purchases comply with desirable social norms that are expected to enhance stakeholders' social conditions." (Parent et al., 2013)

[5] The assumption of broadly uniform externalities is less relevant if the tax with which the externalities are supposed to be internalized is tied directly to the cause of the externality, e.g. to the emissions associated with a product.

It is for precisely this reason that empirical field work and involvement of stakeholders are often identified as important requirements for social LCA, even though field investigation can be very costly and time demanding, especially for the assessment of complex supply chains. Moreover, a balanced involvement of stakeholders is necessary to ensure that all groups the same chances and technical possibilities to participate in the assessment.

2.3 NGOs and social impacts: the example of fair trade indicators

"Doing ethical trade is much harder than it sounds. Modern supply chains are vast, complex and span the globe. Labour issues are themselves challenging. For example, what exactly is 'a living wage'? What should a company do if it finds children working in a supplier's worksite? Evicting children from the workplace can, paradoxically, make their lives worse" (Ethical Trade Initiative)

2.3.1 NGOs' approach

Within the context of social impact in supply chains, non-governmental organizations (NGOs) hold a different role and have a different approach when compared to other actors. This stems from the inherently different nature of their work, their raison d'être and ethical statute as are not driven by profits. NGOs are organizations originally born to tackle specific issues in local contexts. Nonetheless, through time, some have also grown to join together to form associations or become international in scope (Oxfam, Greenpeace, Save the children). They strive for improving the current status, in this context, to improve sustainability throughout the supply chain. Together with conscious consumers, NGOs put pressure on producers, typically multinational companies (MNCs), to improve the sustainability in their supply chain. Furthermore they conduct research and divulge critical information of the impacts, positive and/or negative, of the various phases (extraction, production, waste, etc.) and can act as third party independent verifiers of the social conditions throughout the supply chain. In the last years Oxfam has been publishing a series of reports called "behind the brands", where they rank top food and beverage companies based on chosen sustainability themes (Oxfam, 2014). This has been a great research and marketing campaign to publicly promote positive competition towards sustainability between these companies. As in the case of Fairtrade, some NGOs have also become catalysers of new alternative sustainable supply chains and promote new ethical standards.

When looking at a supply chain (for instance of an agricultural commodity), "**producers"**, such as MNCs, can be seen as actors that, through their activities and their position in the chain, can spur potential negative/positive social impacts. Government actors, both in the production and in the consumption side can be seen as "**regulators**", creating the legal framework and the playing field where activities are performed. NGOs can be seen as actors that perform duties of "**verifiers**" (e.g. Oxfam, Fairtrade, UTZ).

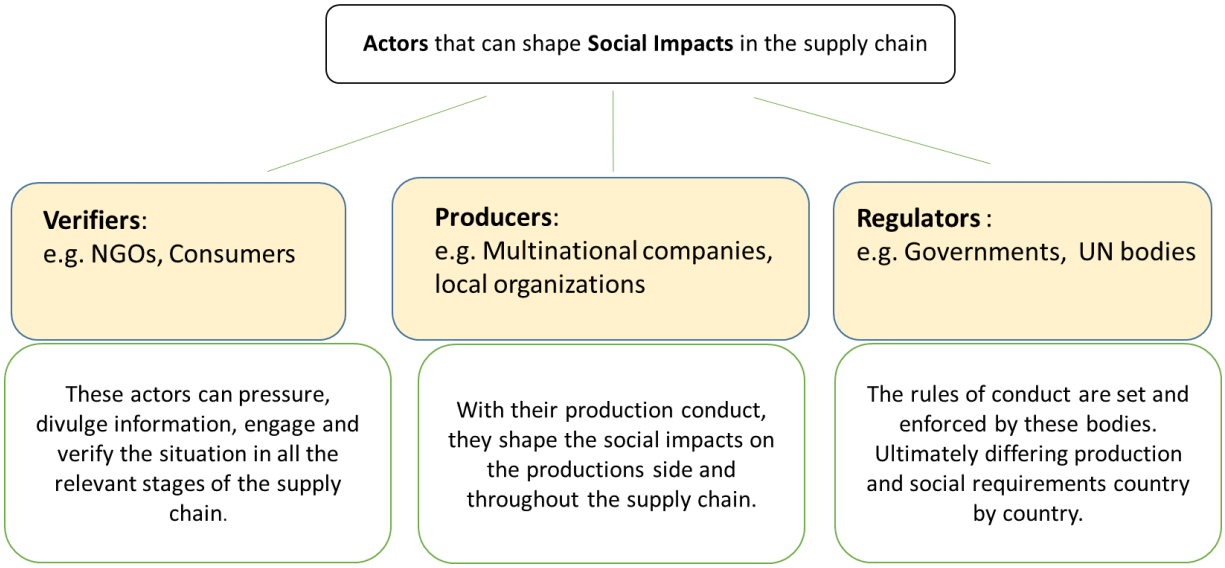

Figure 4 Main actors in supply chains sustainability

When looking at sustainability in supply chains, and more specific on social impacts, some NGOs play a major role. Some organizations have focused their work on raising awareness, others on developing standards in order to overcome the negative effects of the free market and make trade fair and beneficial and in some cases even initiated multi-stakeholder round-tables in order to engage and collaborate with the private sector and government authorities. These positive interactions can become good opportunities to divulge fair and sustainable practices worldwide and fill the regulatory vacuum that growing international liberalization of trade has left behind (Vermeulen and Seuring, 2009; Vermeulen, 2010). Such coalitions, often called roundtables, could have influence where the role of governments and intergovernmental agencies had declined or were unable to intervene in the markets (Molenaar, 2013). This is where NGOs can play a crucial role in the shift towards sustainability in supply chains. NGOs working towards sustainability in supply chains started to develop standards and systems to improve, assess and monitor impacts. These standards and systems have been developed to assure players in the supply chain that specific products have been grown, produced, traded and processed in a way that lessens the negative impacts on sustainable development and boosts the positive ones. Certification is the process by which compliance with the requirements of the standards are confirmed and guaranteed (Molenaar, 2013). Lemeilleur (2010) did a review of a coffee supply chain to try and identify consistent indicators of social sustainability by comparing recognized sustainability standards currently used, such as Fairtrade, UTZ, Rainforest Alliance, ETI. The study concludes that as standards are fairly diverse in their scope and objective, where some focus on environmental issues, some more on social and economic and some on a mixture of all, there is no ultimate consensus on indicators that represent a minimum social requirement. Although it concluded that there are certain areas of agreement such as Health and safety, Employment practices and Social benefits to name a few. Furthermore, each local social context and supply chain sector have different starting conditions, cultural structures and priorities. Therefore the same social indicators might not make sense in different contexts, making broader general impact areas easier to agree upon rather than specific indicators. In order to try and give a detailed example of what's currently in use, focus will be placed on Fairtrade standards and indicators as regarded as the most relevant and recognized within the context of social sustainability in supply chains.

2.3.2 The case of Fairtrade

If we think that more than ninety per cent of the world's 1.1 billion poor are small family farmers (Lipton, 2005), we can see the urgency to better understand how to overcome the market's inefficiencies and lift smallholders out of poverty through beneficial trade relations. Fairtrade is a non-profit association that aims to support small-scale farmers and workers who are marginalized from the benefits of trade (Fairtrade MELP report, 2014). Fairtrade is widely known for developing and reviewing the Fairtrade certification standards, demanding better working conditions, assisting small-scale producers gain and maintain the certification. It assists small scale farmers to organize, reach and capitalize on markets by reducing supply chain actors, linking producers and consumers and applying a minimum price for the produce in order to at least cover production costs, something not so straight forward in today's competitive global commodity markets. To achieve its goals, Fairtrade aims to achieve simultaneous changes in the following four areas: small producer and worker organizations, supply chain business practices (including labour practices), promoting sustainable consumer behaviour and divulging information for civil society's action. In order to achieve these changes, Fairtrade developed **standards** which establish the 'rules' to be accepted for fair trading practices and engagement in Fairtrade, and **strategies and policies** which enable engagement in Fairtrade by small producers, workers, employers, supply chain businesses, consumers and civil society organizations (Fairtrade MELP report, 2014).

The Fairtrade standards cover 2 categories, one focused on small-holder farmers (**Small producers' organizations**) and one focussed on workers (**Hired labour**). These standards are generally product specific (tea, coffee, bananas etc.), although there are also some general standards that apply as well such as prohibited chemicals, payment of Fairtrade prices, Premiums etc. Some of the aims of the standards for small scale farmers include*: Increase bargaining power, tackling power imbalances in supply chains, environmental management training, Fairtrade minimum price, Premiums mostly used for community projects.* Aims of the standards for workers include*: protection of worker's rights, health and safety, unions, no child labour, and fair wage* (Fairtrade standards, 2014). Through the Fairtrade label, consumers are able to support a sustainable production of the produce they consume, improving the sustainability aspects of production.

2.3.3 Indicators

Data collection is very resource intensive and due to the complexity and diversity of supply chains there is a lack of data to monitor the social impacts, especially for NGOs with limited budgets. Economic data is easier to obtain and quantify and is more widely available compared to its social equivalent. Although each supply chain has different problems specific to local contexts and products, a general set of areas important to evaluate social impact for Fairtrade can be gathered. The most important indicators that Fairtrade uses to monitor social impacts evolve around the following seven vital areas: (Aidenvironment 2008; Klier et al., 2012; Fairtrade, 2013; Fairtrade theory of change, 2013)

1) Health, 2) Education, 3) Gender, 4) Employment and economic situation, 5) Working conditions, 6) Power relations, 7) Development of services (social community projects)

In order to monitor the impact on these areas Fairtrade developed and reviews the following main indicators (Fairtrade, 2011; Fairtrade, 2012; Fairtrade, 2013) which aim to cover the necessities of the **Small Producers' Organization**:

- Number of community development projects (community infrastructure, community credit schemes, community disaster relief, support for community institutions such as children's homes or social charities.)

- Number of educational school infrastructure (schools, supplies, scholarships and bursaries, payment of school fees, teacher training, adult education, percentage of farmers with children that advanced schooling beyond primary school)
- Number of health clinics, health insurance, medical supplies, health training, sanitation.
- Number of gender equity programmes and projects focusing on women's needs (women's income generation projects, training and development, women's health, land ownership titles)
- Number of organic certification, trainings on good agricultural practices, environmental and waste management, environmental development projects

The following aim to cover the necessities of the **Hired labour**:

- Number of community development projects (community infrastructure, community credit schemes, community disaster relief, support for community institutions such as children's homes or social charities.)
- Number of educational school infrastructure (schools, supplies, scholarships and bursaries, payment of school fees, teacher training, adult education, percentage of farmers with children that advanced schooling beyond primary school)
- Number of working hours per day/week
- Number of environmental development projects outside of core business activities
- Number of health clinics, check-ups, vaccines, health insurance, medical supplies, health training, sanitation
- Number of gender equity programmes and projects focusing on women's needs (women's income generation projects, training and development; women's health)
- Investment in worker capacity building and career development (Capacity building and organizational development and support for worker organizations. Workers' exchange visits. Training and development for workers, including training on workers' rights, literacy, business skills, computer skills)

The following, more economic focused, indicators are also relevant to monitor the social well-being:

- Number and type of Fairtrade certified producer organizations
- Number of members and number of workers in Fairtrade certified producer organizations
- Gender breakdown of membership or workforce
- Land area used for cultivation of the Fairtrade certified crop or crops
- Total Fairtrade certifiable crop volume produced
- Total crop volumes sold by the producer organization
- Total sales revenues of the producer organization
- Total volumes sold as Fairtrade by the producer organization
- Total Fairtrade sales revenues of the producer organization
- Total Fairtrade Premium received by the producer organization
- Details of the how the Fairtrade Premium has been used by the producer organization
- Number of credits and loans accessible

Data for each indicator can be aggregated and analysed by country, by region, by product, or by producer type (Fairtrade, 2013). The other category of indicators that is very important, but more subjective and harder to measure, are indicators of a more qualitative nature. Some include:

- Farmer's sense of ownership
- Perception of community feeling
- Perception of empowerment
- Trust

- Increase in bargaining power
- Perception of improvement in relationships between workers and management

These indicators try to monitor improvements in the seven common areas that should be focused in order to achieve a positive impact on social issues in supply chains. Most of these indicators can be seen as a bottom- up approach, which identifies indicators at the micro-level in an attempt to take into account local realities. A bottom up approach can have drawbacks such as high data requirements, heavy reliance on ad hoc indicators and high site specificity (Lemeilleur et al., 2010). The above section focussed on Fairtrade as it is seen as the most representative. Nevertheless, other certifications and standards, such as Rainforest Alliance, which predominantly focuses on environmental issues have started to integrate social aspects towards a more complete sustainability goal. This can be seen as both a positive determination towards better supply chain systems but also as a negative issue as the increasing amount of standards can confuse both consumers and producers (Aidenvironment, 2008). Furthermore, commercial implications may arise due to the increasing competition between these certifications' market share and may cause fragmentation of efforts.

2.3.4 Fair trade and supply chain analysis: the way ahead

These certifications and standards, especially Fairtrade, can be seen as important tools to improve the social impacts of supply chains. MNCs could analyze their supply chain with relevant methods (Social LCA?) in order to pin point where harmful social impacts are and attempt to improve through adopting Fairtrade directly, or pressuring actors in the supply chain in doing so. Moreover, Molenaar et al. (2013) calls for synergies between LCA and certifications in order to improve the provision of assurance and traceability in supply chains. He also states that a combinations of these tools could provide a greater scale and greater impact in a way that is more effective than their functioning in isolation (Molenaar et al., 2013). Furthermore, academics in the field of Life Cycle Attribute Assessment (LCAA) underline the need to emphasize the connection with indicators in the field of certifications (Lemeilleur et al., 2010). This leaves plenty of possibilities for further research especially as certifications and standards are still limited to only specific sectors (tea, coffee, textiles etc.).

Certification schemes are frequently being adopted in order to improve corporate social responsibility (CSR). An increasing number of companies recognize that sustainability can build brand value and that sourcing certified produce can be a strategy in order to accomplish this goal (Molenaar et al., 2013). On the other hand, public policy and regulations are often crucial in creating the enabling environment for certification schemes to uptake (Molenaar et al., 2013). Governments could support certification schemes by providing direct financial or technical input, as well as providing a strong legal foundation for standards. Furthermore, Governments could also give a positive example by incorporating certified products in their own procurement policies.

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3. State of the art on social LCA

3.1 Historical development of social LCA

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Social life cycle assessment, S-LCA, is a rather novel approach to address the social impacts of goods and services along their life cycle. The starting point for this approach is the established methodology of E-LCA, aimed at assessing environmental interventions from product life cycles. The history of S-LCA dates back to the 90's, when O'Brien et al., (1996) first raised the idea of complementing E-LCA with social life cycle assessment. In the early 2000s, further input to the discussion was made by Klöpffer (2003) and Weidema (2006) on the topic of how S-LCA should be integrated or aligned with E-LCA methodology (Klöpffer 2003; Weidema 2006). Different social 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 argued for, as the impacts relate to company conduct and should therefore be assessed on-site (Dreyer et al., 2006).

An important achievement in the on-going development of S-LCA was the issuing of the UNEP/SETAC S-LCA Guidelines (Benoit and Mazijn 2009; Benoit et al., 2010), hereafter called the Guidelines. 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 are the outcome of a broad, global, transparent and open process involving many relevant stakeholders from the public, academic and business sectors. However, it only mirrors a vision on S-LCA methodology at the time. A lot of further development is needed to get a really usable tool. Further, S-LCA is limited to being an assessment technique of social impacts of products and services along their life cycle. S-LCA does not provide information on whether a product should be made or not, nor does it say anything on how to address identified social impacts. It can only provide elements of thought for a decision on the production of a product.

3.1.1 The methodological build-up in the Guidelines

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 predominantly addresses environmental impacts, whereas S-LCA addresses social impacts, i.e. impacts on human beings and the society.

In the UNEP Guidelines, social impacts are assessed in relation to an area of protection (AoP), which 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.

There are two different, or consecutive, approaches described 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 is 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 with proposals for data collection in S-LCA have been prepared in connection with the Guidelines (Benoît Norris et al., 2013). 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.

So far, only one database has been made available for social data: The Social Hotspot Database (SHDB) (Benoit-Norris et al., 2011). It contains social data for S-LCA hotspot assessments on country level, and in most cases also on sector level. The sector-level data are collected for 57 pre-defined sectors. The presence of sector level data in the SHDB depends on the availability and relevance of such data for each sector. Thus, it is only possible to obtain data on product group level, not for specific products. No data on specific production plants or sites are available either. The database has a pre-defined structure consisting of five social categories and a number of related social themes. For each theme, there are varying numbers of related indicators for which data are collected.

When it comes to impact assessment and aggregation, there is not one specified impact assessment method proposed 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 publication, a few more methods have been presented for assessing the results in an S-LCA related to the Guidelines (Franze and Ciroth 2011; Norris et al., 2012; Hsu et al., 2013; Ekener-Petersen and Finnveden 2013). In general, proposal of using so called performance reference points, such as internationally set thresholds, seems to be proposed by many.

3.1.2 Present state of the art

Different S-LCA methodologies have been tested in a number of case studies and are the subject of a lively discussion in the research community. As can be expected for a new development, some criticism of S-LCA has been voiced. Some line of critics are presented here, where one is the questioning the relevance of attributing social impacts to specific products instead of working with them on the base on the suppliers list. In response to this, it is argued that for the case one would like to use this methodology as a basis for product labelling schemes; it is then needed to attribute the impacts to specific product. Others again argue that it is a useful exercise as a means for facilitating the consideration of these issues already in the design phase of a product. Some people are also doubtful whether it is reasonable to devote the amount of resources needed, related to the value of the outcome. While being a completely legitimate question, it is likely that as more databases on social data develop, in alignment with what has been

seen in the field of E-LCA, the relation between effort and outcome will probable change in favour of its worthwhileness. Another criticisms, put forward by for instance by Andreas Jørgensen (Jørgensen et al., 2012; Jørgensen 2013), is whether the tool really contribute to improving social conditions. As stated above, maybe this actually is not the aim of the tool as such and thus the responsibility of the tool to do. Other approaches might be needed to handle the outcome in an S-LCA in an appropriate way.

The research community working on S-LCA has gathered at four key occasions; in Copenhagen, Denmark in 2010; in Montpellier, France in 2011; in Montreal, Canada in 2013 and finally in November this year, returning to Montpellier, France. The purpose has been to present and discuss work done in the field, such as conducted case studies or more theoretical methodology developments. The outcome of the Montpellier conference in 2011 was published in a scientific paper (Macombe et al., 2011). The latest conference in November 2014 focused on topics such as agreeing on the purpose of S-LCA; its relation to E-LCA and other similar and related approaches; the role of local stakeholders to define important social issues to asses; the handling of positive social impacts; the (lack of) social theory in which S-LCA is based; the benefits and limitation with the SHDB, among many others.

All in all, it seems that many scholars find the S-LCA methodology an interesting approach to further examine and develop. (Parent et al., 2012) underlines the importance of using a life cycle perspective, in contrast to many supply chain management approaches, 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 sub-optimisation when improving life cycles, which is an obvious risk when using the methodologies in three separate assessments. It has however been questioned whether this combined tool will be used in practise in the business community. It is argued that companies tend to put different priorities to the different sustainability aspects, and therefore make stepwise assessment, firstly assessing their highest priorities, typically economic viability and thereafter environmental and perhaps social aspects (Oral, Macombe, 4th S-LCA conference, Montpellier). Different approaches have been proposed for integration, among them Life Cycle Sustainability Assessment (LCSA) as proposed by Klöpffer (2008), where LCSA = LCA+LCC[6]+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). 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.

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

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3.2 Application of S-LCA at micro and macro scale: an overview

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Different application of S-LCA have been undertaken in the last years, at the micro as well at the macro scale. Regarding products, Table 2 present some examples of studies which encompass very different sectors (from food to biofuels, from materials to technology and service). The following sections report a summary of selected studies which present specific features in the application of S-LCA.

Table 2 Selection of case studies and products on which S-LCA has been applied

Products	**References**
Salmon	Kruse et al., 2009
Orange juice	Norris et al., 2011
Cheese	Paragahawewa et al., 2009
Fruit and vegetables	Feschet et al., 2010
Banana	Feschet et al., 2013
Coffee	Lemeilleur and Vagneron 2010
Roses	Franze and Ciroth 2011
Packaging	Oki and Sasaki, 2000
Biofuels	Kløverpris and Wenzel, 2007 , Blom and Solmar, 2009 Macombe et al., 2013
PET bottles	Foolmaun Ramjeeawon 2013
Recycling systems	Aparcana end Salhofer 2013
Construction sector	CEN standard for S-LCA (CEN 2012, 2014) Chang et al., 2011 Hosseinijou et al., 2013
Tourism	Arcese et al., 2012
Mineral sector	Lacey and Moffat 2012
Charcoal	Weldegiorgis and Franks 2012
Sanitary products	Musaaazi et al., 2013
Laptop	Ekener-Petersen and Finnveden, 2013

ICT	Moberg et al., 2009

3.2.1 Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems (Kruse et al., 2009)

Kruse et al., 2008 proposes a set of socio-economic indicators with a combined bottom-up and top-down approach. Top-down approach identifies indicators focus on internationally recognized societal values (ILO, Human rights) whereas bottom-up approach identifies indicators on (but should not be limited) industry or stakeholder interests and/or data availability.

The authors categorize the indicators in: **additive indicators**, measured quantitatively and related to the functional unit (i.e., they are additive through the chain- example, production cost per 1kg of salmon); **descriptive indicators** that do not meet the additive requirements and that can be either quantitatively or qualitatively described and/or measured at each point in the chain and but they cannot be related to the functional unit (e.g., fair wage and contribution to personal income). Descriptive indicators can be further split in to **General** (describe broad societal values, international standards top-down approach- ex. Living wage) and **Specific** (not widely applicable but focuses on relevant impacts in a specific process or product). Specific indicators may have limitations in the comparability across different LCAs. (Table 3)

Table 3 List of additive and descriptive indicators as presented in Kruse et al., 2009

Additive Indicators	**Descriptive Indicators – General**	**Descriptive Indicators - Specific**
Production costs Labor costs Gendered labor costs Migrant labor costs Value-added Person hours of production Gendered person hours Migrant person hours Deaths/accidents	Fair wage Employment benefits Hours worked per week Forced labor Discrimination/gender Right to organize Age distribution of workers Minimum age of workers (A proxy for child labour) Access to bathroom/potable water (A proxy for working conditions) Industry concentration Distance travelled within the supply chain	Contribution to income - *Contribution of product/process to personal* Fair price - *Price paid to fishermen is fair* Access - *Ability of a worker to enter the production process* Latent quota- *Level of unused fishing permits* Owner-Operator - *Level of permit owners who also fish* Adjacency - *Worker adjacency to point of primary production* Compliance - *Compliance with regulations by industry*

The main point under discussion in the paper are:

- **Data collection**: there are some sustainability standards for data collection which is likely to be extremely difficult (e.g., forced labor), and the use of proxy indicators should be considered as an alternative.
- **Site-specific data**: when performing studies on specific products and processes, the need for site-specific data may be a crucial issue, especially if the geographic or social context is more important than the activity itself.
- **System boundaries**: whether it is really feasible to have the same system boundaries for a biophysical LCA and a socioeconomic LCA is raised. If identical boundaries are not feasible between the 2 LCAs, then the possibilities are two: 1)

conduct separate analysis or 2) differentiate between the primary stage of production; in this case, the fishery or aquaculture farm, and the rest of the production chain, i.e., dock to consumer in order to get a comprehensive picture of both the environmental and socioeconomic impacts.

- **Trade-offs**: how to assess trade-offs between 1) stakeholder groups (benefit for employee vs employer) and 2) the pillars of sustainability.

3.2.2 Social Hotspot Database for Acquiring Greater Visibility in Product Supply Chains: Overview and Application to Orange Juice (Norris et al., 2011)

Norris et al., 2011 focuses on a pilot study on orange juice produced in the U.S.A. using the Social Hotspot Database (SHDB). Data for three criteria are used to inform prioritisation of Country-Specific Sectors (CSS): (1) labour intensity in worker hours per country specific sector, (2) risk for, or opportunity to affect, relevant social themes related to human rights, labour rights and decent work, governance, and access to community services, and (3) gravity of the social theme.

Hours per Dollar output is the basis of the ranking and analysis of the CSS. The social hotspot assessment, performed for US$1M of vegetables and fruits produced in the U.S., found that the largest share of worker hours is concentrated in the production activities occurring in the U.S.

The assessment of social hotspots range from health and safety of workers to excessive working time during the harvest season; low wage rates, particularly for unauthorised workers; potential of forced labour in the U.S. and child labour in other producing countries; and violations of the right to organise, collective bargaining and the right to strike.

3.3.3 Social Life Cycle Analysis (S-LCA): Some Methodological Issues and Potential Application to Cheese Production in New Zealand (Paragahawewa et al., 2009)

Paragahawewa et al., 2009 reviewed the methodological issue in S-LCA and gives an overview of the type of indicators –quantitative, semi-quantitative and qualitative- that are relevant for a S-LCA. S-LCA studies focus on direct impacts to workers and society, but no on consumers and use stage.

Endpoint indicators have the advantage that they can reflect the potential damage or benefits to the area of protection (AOP). However, midpoint indicators are considered preferable to endpoint indicators because they are closer to the stressors and more understandable for decision makers.

Regarding scale of the data, different authors debate on whether and how to either focus to use specific data (site specific) or general data (statistics). Paragahawewa et al., 2009 consider using site specific data as priority and where not able, complement with general data.

Functional unit has been selected in order to compare/ integrate results of LCA of 1kg of cheese

Impacts in the S-LCA context are due to the conduct of the company rather than due to the nature of the industrial processes.

Chosen area of protection (AOP) were **human dignity and well being.** Indicators are split in to **employees, company**, the **national** and **international community**, **future generations** and the **consumer** (Table 4).

Table 4 List of indicators as used by Paragahawewa et al., 2009

Indicators	
Employee	
Employment Practices	**Capacity Development**
Work place security	R & D
Employee contracts	Career Development
Equity Issues	Training
Labour source	**Health & Safety**

Strikes and lockouts	Practices and policy
Employment Stability	Accidents and incidents
Employment opportunities	Toxicity potential & transport
Remuneration	Occupational diseases
Influence on company practices	
Employee influence on company	
National Community	
Employment	**Governance systems**
No. jobs related to the functional unit	Monitoring, Legislation, Enforcement, Industry compliance
Tax allocation to social infra-structure	**Influence on company practice**
Housing	Influence of local community
Health	
Infrastructure	
Regulatory and public services	
Future generations	
Resource use	**Environmental impacts**
Non renewable materials	Air
	Water and Biodiversity
Consumer	
Safety	**Health**
Benefits & harms	Benefits & harms
Choice	
Accessibility	Pleasure & satisfaction
Affordability	GM food choices
Palatability	Labelling
Traceability	
Stakeholder influence on company practices	
Consumer influence	
Company	
Company Characteristics	**Research and development**
Stability	Engagement in R&D
Transparency	
Long term viability	
Ethics	
Stability	
Transparency	

3.3.4 Fruits and vegetables supply chains specificities and stakes as element of discussion on Social-LCA (Feschet et al., 2010)

The paper has an in-depth conceptual and theoretical discussion and suggest placing LCA in the perspective of development theory. The proposition is to endow LCA with an approach "by capitals", which seems particularly adapted to express sustainable development and well-being. The paper highlights the importance of an international recognized approach covering the covers the four types of "societal" capital: **social**, **human**, **produced**/**physical** and **natural capital**. The authors also propose a fifth form, the **institutional capital** (norms, rules).

S-LCA paid attention to characterize and organize social indicators, next step is to articulate them thanks the multiple capital model, in order to reflect social impact and damage or benefit to the AoPs.

3.3.5 Social impact assessment in LCA using the Preston pathway. The case of banana industry in Cameroon (Feschet et al., 2013)

In this paper the authors design a pathway for S-LCA using the relationship of the Preston Curve, which suggests that an increase in economic activity through growth in income will lead to improvement in health of the population where that activity takes place.

- The assumption is that growing economic activity has an effect on population health, and if one economic sector plays a dominant role in this economic activity, then we hypothesize that the sector contributes to improving the health of the population.
- They applied this pathway to a case study of a company in the banana industry in Cameroon, looking at 2010-2030, ultimately explaining/predicting a change in potential life expectancy generated by the change of economic activity.

The assessment is only valid when used for a comparative analysis and only if 4 conditions are met:(**1)** the activity is set within countries where the GDP per capita in purchasing power parity is less than $10,000 at the start of the period, (**2**) the assessed activity accounts for a significant part of the annual GDP and/or demonstrates obvious signs that it represents a huge stake in the country's economy, (3) the duration of the assessed activity is regular and long enough, and (4) the added value created by the activity is shared within the country

Preston pathway is designed to assess one part of one social impact (changes in health) of a given life cycle. This means considering "Life expectancy" as a proxy for Health and GDP as a proxy for real income. Main limits and further research: 1) Uncertainty in the data sources, 2)Even using real income and health, the link between both variables is not direct 3) The results must be compared with other scenarios 4) A multi criteria analysis must be developed to include other social impact categories and stakeholders 5) Downscaling from Macro to Micro (National scale to sector or company scale) is complex.

3.3.6 Looking for the (missing) indicators of social sustainability – Evidence from sustainability standards in the coffee sector (Lemeilleur and Vagneron 2010)

The authors try to identify consistent indicators of social sustainability, based on the study and comparison of well-known sustainability standards currently used in the coffee sector (FLO, ESR, IMO, ETI, UTZ, Rainforest Alliance and Globalgap). The outcome of the study was a list of where there are areas of agreement that we identify as minor **consensual indicators**:

- Health, Safety and Hygiene : "safety equipments" "risk management policy" and "access to drinking water"
- Prohibited labour Employment Practices: "no child labour" "prohibition of forced labour" "no corporal punishment" "no retain legal document by the employer" and "young workers"
- Conditions of Employment: compliance with the national legislation on minimum legal salary"
- Working hours : number of extra hours
- Discrimination: no discrimination on salary level
- Right to Association and Social Benefits: No consensus

3.3.7 A comparison of cut roses from Ecuador and the Netherlands (Franze and Ciroth 2011)

Franze and Ciroth 2011 perform a study using the Guidelines for S-LCA of UNEP/SETAC on cut roses from Ecuador and the Netherlands. The functional unit is a bouquet of roses with 20 caulis per spray, packaged and transported to the flower auction in Aalsmeeer, the Netherlands.

Finding suitable indicators to measure the status of the subcategories may be challenging. Moreover, the case study shows that results can be completely different for the environmental and for the social dimension, so that it often will be needed to perform both assessments if a complete picture is required.

Considered impact categories are: 1. Health and safety, 2. Socio-economic repercussions, 3. Human rights, 4. Indigenous rights (including cultural heritage); 5. Development of the country. Sub categories indicators are reported in table 5.

Table 5 Sub-categories indicators are reported by Franze and Ciroth, 2011

Sub-categories indicators	
Stakeholder group: Workers	
Freedom of association	Discrimination
Child Labour	Working hours
Forced labour	Health and safety
Social benefits	
Stakeholder group: Supply chain actors	
Promoting social responsibility	Fair competition
Stakeholder group: Local community	
Indigenous rights	Safe and healthy living conditions
Local employment	
Stakeholder group: Society	
Contribution to economic development	Corruption
Technology development	Prevention of armed conflicts
Stakeholder group: Consumers	
Health and safety	Transparency

3.3.8 Social life cycle assessment of biodiesel production at three levels: a literature review and development needs. (Macombe et al., 2013)

Also S-LCA in the context of biofuels is developing, see e.g. at the Biofuel Assessment Conference in Copenhagen in 2007 (Kløverpris and Henrik Wenzel, 2007). Two specific studies can be mentioned in this context. First, Macombe et al., (2013) reviewed social life cycle assessment of biodiesel production. Their paper reviews the field in general and take a closer look at the empirical case of biodiesel production, which is a timely topic globally in view of the climate change mitigation objectives. The analysis is carried out at three levels: company, regional, and state level. Despite active development in the field of S-LCA, they conclude that in many cases it is not yet possible to carry out a comprehensive S-LCA.

3.3.9 How to socially assess biofuels: a case study of the UNEP/SETAC Code of Practice for social-economical LCA. (Blom and Solmar 2009).

In a second study, Blom and Solmar (2009) focused on how to socially assess biofuels as a Case Study of the UNEP/SETAC Code of Practice for social- economical LCA. The starting point of their work are the concerns about the effects that the production of biofuels might have, both on the environment and on social issues. There are for example reports of slave-like working conditions in the Brazilian sugarcane fields and the link between biofuel production and increasing world food prices are given much space in the media. The purpose of their master's thesis was to describe the UNEP/SETAC Code of Practice for social and socio-economical LCA and to investigate how to use the Code of Practice when assessing ethanol, biodiesel and biogas. It was concluded that the biofuel with the least social impact is biogas. During the social life cycle assessment it was clear that even though there was a successful assessment with an evident result, the Code of Practice needs more fine tuning in order to be successful when comparing different products. The work also provides suggestions on how to enhance the usefulness of the Code of Practice. Means must be found to circumvent the large influence of the practitioners' subjectivity. Suggestions for achieving this are, for example, developing a universal set of indicators, databases for social aspects, and well-functioning characterization models.

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4. Databases and indicators for social LCA

Data sources for implementing social impact assessment are crucial and in many case very difficult to be built and maintained. The present section aim at illustrating two relevant databased developed in recent years, describing their main objectives and features

4.1 Social Hotspots Database Method

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It was with the ambition to make comprehensive and detailed information on supply chain human rights and working conditions available to everyone that the Social Hotspot Database (SHDB) project was launched in 2009. The goal of the SHDB is to provide access to best available social risk and opportunity information at the most granular level possible as well as to provide methods and tools to calculate and summarize this information into a social footprint for instance. The ultimate objective of the SHDB project is to foster greater collaboration in improving social conditions worldwide by providing transparent information about social risks and opportunities in the global economy. The information provided can help supply chain stakeholders to improve their management of social responsibility issues and create incentives to collaborate and drive progress.
The SHDB is a project centred at New Earth, a U.S. based not-for-profit focused on information systems for sustainability. In 2009, New Earth received seed funding from Walmart Private Brands to develop the Social Hotspots database. The Sustainability Consortium and private companies later contributed funding for further development. The Sustainability Consortium also funded the application of the SHDB to seven case studies, and then applied the SHDB to the assessment of 100 product categories. The development of the SHDB benefitted from the advice and support from the New Earth advisory board chaired by Raymond Robertson (Better Work Programme, Macalester college). The advisory board was composed of a group of 24 distinguished individuals from the academia, industry, intergovernmental organizations, government and non-governmental organizations. In 2013, New Earth made the SHDB publicly available through the SHDB website (www.socialhotspot.org) and through licenses that work in professional LCA software such as Open LCA and SimaPro. Since 2013, New Earth has been working on updates and further development of the database and making it available with different product system models. New Earth is currently working with the Center for Health and the Global Environment at the Harvard T.H. Chan School of Public Health, to grow the SHDB project and establish partnerships with relevant organizations and initiatives. Working jointly with Harvard, it will be possible to enrich the database with information on root causes and improvement opportunities (a Social Handprint library). This collaboration will also enable the launch new partnerships on data collection.

4.1.1 Structure of the SHDB

The Social Hotspots Database is meant to be a modular system, and includes three main components:

1. A Global Input Output Model
2. A Worker Hours Model
3. Data on social risks and opportunities

A key aspect of the project has been to ensure that users have full transparent access to information about working conditions and impacts in global supply chains, and also about the hundreds of sources drawn upon as well as the methods used to characterize risks within the SHDB. The SHDB development can be considered a follow-up initiative to the 2006 - 2009 development of the Social LCA Guidelines (UNEP-SETAC, 2009).
Technically, the SHDB is an input/output Life Cycle Inventory database providing a solution to enable (1) the modeling of product systems and (2) the initial assessment of potential social impacts. The main epistemological and methodological choice made was

to model the SHDB database on the pre-existing structure of E-LCA databases integrated into LCA software. The SHDB is different from GaBi or Ecoinvent but it works harmoniously in the same software systems, once integrated.
The SHDB system current Global IO model is based on the Global Trade Analysis Project Version 7, a global economic equilibrium model (GTAP, 2008). The total database contains data for 57 different sectors, in each of 113 different regions; most of these regions correspond to individual countries while others are regions containing multiple countries. Thus, there are 6441 unit processes in the database. However, the SHDB system can be used with other supply chain models including Eora, WIOD and process based models such as Ecoinvent. This part of the SHDB system is thus changeable depending on needs and preferences. V3 of the SHDB will use Eora as its Global IO model component. Even though the GTAP Global IO model aggregates some countries in regions, the SHDB project collects data on 225 countries and territories made available on the web portal.
The labor intensity data were developed by converting GTAP data on wage payments into estimates of worker hours, skilled and unskilled, for each sector in each GTAP country/region. This was made possible by compiling and using wage rate data, for skilled and unskilled labor, by sector and region. These labor hour intensity factors are used together with the social risk level characterizations, in order to express social risks and opportunities in terms of work hours, by sector and country, at a given level of risk relative to each of over 22 social impact subcategories and nearly 150 different indicators. The risk data addresses five main impact categories: labor rights and decent work, human rights, health and safety, governance and community.
The SHDB project draws upon hundreds of data sources ranging from the International Labor Organization, the World Health Organization, the U.S. Department of Labor and State, the World Bank, and more. Quantitative statistics and qualitative information by country and sector are used to develop characterization models. These models assign a risk (or opportunity) level to the data so that users can identify target areas in their supply chains to verify or improve social conditions.

Figure 5 Categories and themes available in V2 of the SHDB

The SHDB is based upon life cycle attribute assessment (LCAA), a methodology developed by Norris (2006). Each unit process (that we define as country specific sector when using global IO models) has a number of different attributes, or characteristics, relative to a large set of social issues. The activity variable used in the SHDB is worker-hours. Thus, the SHDB can be used to identify how many worker-hours are involved for each unit process in the supply chain, for a given final demand (final product or service output from the system). The sociosphere flows are expressed as worker-hours at a specified level of risk on a given risk indicator, per US $ of process output.
A social life cycle impact assessment method based on New Earth's Social Hotspots Index makes it possible to get results on 5 impact categories in addition to

disaggregated results by theme and indicator. Users also have the possibility to create and implement their own impact assessment method.
Some questions that users can answer by conducting assessments with the Social Hotspots Database in LCA software are, e.g.:
- How do I model a product system by country-specific sector?
- What are the key social issues & opportunities in a supply chain?
- How do these relate to the company's operations?
- Which inputs matter most?
- What and where are the hot spots?

The SHDB can move markets by helping the economy to know itself better. By constantly improving the flow of information available from supply chains back to purchasers, the SHDB can help decision makers take informed decisions on material sourcing that goes beyond reducing risk. Designers and managers will be able to make sourcing decisions based on the positive impacts they can make in the life of workers, communities and the greater society.

4.2 PSILCA: A new, comprehensive, interactive Product Social Impact Life Cycle Assessment database

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4.2.1 Background

Assessing the social impacts of products is gaining more and more importance; the guide-lines for S-LCA of products, from a UNEP/SETAC working group, have probably laid the ground (Andrews et al., 2009, Social Alliance 2015, Benoît-Norris et al., 2011). Now, more and more companies are considering to extend Footprint or Life Cycle Assessment approaches that have been established to consider impacts on the environment to cover also social impacts in order to address sustainability more completely. Another purpose might be to investigate social impacts "as such", independently, in order to detect potential social risks in product life cycles, and maybe also for revealing positive social impacts hidden in product supply chains.

A Life Cycle Assessment (LCA) study typically contains some core processes where specific information is collected, and many generic processes that are taken from databases such as ecoinvent, GaBi, and others. The same applies for studies about social impacts of products over their life cycle; at present, though, a S-LCA database which contains non-valuated, transparent information about social impacts of products along their life cycles does not exist.

4.2.2 Goal

The objective, therefore, is to create a consistent database that contains generic inventory in-formation for social impacts of products along their life cycles. More in detail, the database should satisfy the following requirements:

- Be comprehensive. Since product life cycles nowadays are global, also the database needs to capture the global economy in a reasonable, not too coarse resolution.
- Be up-to-date. The world, especially in emerging economies, is changing fast; also social conditions can change quickly. A dataset that is based on a 10 years old model seems not tolerable.
- Be transparent. Social assessment always involves some sort of subjectivity and cannot be completely based on natural science alone; yet still, the database must be as transparent as possible, and should especially provide a transparent basis for any assessment.
- Be flexible and "reasonably complete" concerning the social indicators that are covered. Many projects about social impacts of products start with yet another compilation and synopsis of social indicators which is an indication that a final, agreed list of indicators does not exist yet. The database should therefore, to a reasonable extent, be able to cope with a rather broad set of social indicators that are nowadays in discussion.

- Be sustainable. With this we mean 'technically and organisationally'. Simply put, this means that sufficient resources and also a suitable approach should be available from the beginning to ensure a long-term maintenance of the database. This is especially important in a quickly changing economy and in even faster changing social conditions.

4.2.3 Approach

To achieve these points, the following approach is taken:

- The Eora database, initially developed and maintained by Manfred Lenzen and colleagues (Worldmrio 2015, Lenzen et al., 2012, Lenzen et al., 2013, Wiedmann et al., 2013, Moran et al., 2013), is selected as a basis. Eora gives a very complete picture of the world economy, even in time series:
  - 187 individual countries represented by a total of 15,909 sectors
  - continuous coverage for the period 1970-2012 (satellite accounts to 2010)
  - various environmental indicators covering air pollution, energy use, greenhouse gas emissions, water use, Ecological Footprint, and Human Appropriation of Net Primary Productivity
  - high-resolution heterogeneous classification, or 25-sector harmonized classification
  - raw data drawn from the UN's System of National Accounts and COMTRADE data-bases, Eurostat, IDE/JETRO, and numerous national agencies
  - distinction between basic prices and purchasers' prices through 5 mark-ups, and
  - reliability statistics (estimates of standard deviation) for all results
- A broad set of quantitative and qualitative social indicators are addressed, using the subcategories proposed in the UNEP/SETAC guidance book (Andrews et al., 2009) as a starting point. A complete list of the indicators is provided in table 6.
- In order to populate PSILCA with up-to-date, reliable data a broad variety of sources is examined and analysed. In a first step, data is collected from reputable statistical agencies such as World Bank and the International Labour Organization. Also private or governmental databases on special issues are used. Further, big data analyses are carried out in collaboration with experts on that field. Data from own case studies as well as primary data collection for specific indicators complete the database.
- The current social assessment results are provided from recent S-LCA case studies with GreenDelta involvement, and from partners. In an extension, machine reading & rapporteurs will be used to keep the database up to date.
- The assessment will use performance reference points, PRPs (Social LC Alliance, 2015); they transparently describe evaluation ranges for the indicators. It is planned to allow even to change the assessment "scale" in the database, based on the requirements of a specific case study. One initial, coordinated set of PRPs will be applied, new sets can be developed based on the transparent description of the indicator values.

The database is developed starting from an initial, seed database, looking also for external input. Database development is closely linked to LCA software to avoid that a "finalized" database cannot really be used in LCA software by practitioners.

4.2.4 Outcome

PSILCA is a new database showing how social data can be organized, assessed and finally used for S-LCA or Life Cycle Sustainability Assessment. It will be available originally as open LCA and SimaPro database, ready to run in both software systems. Versions for other LCA software systems will be prepared upon demand. The database is planned to contain the indicators shown in Table 6, for 187 countries and overall for 15,909 sectors. Initially, the most current data will be provided for each indicator. Different versions of the database will have various levels of detail, both related to indicators and to the applied cut-off criterion for the database. The Developer model and database will be really comprehensive, with typically 15,000 process data sets in one system model, and it will yet be possible to use it on reasonably modern computers. But

the idea goes beyond creating a database. In a second phase, after the initial release of the first version of PSILCA, the authors are planning to build up a network of collaborators for data collection and also for providing local customer support. This, of course, depends to some extent on the success and usefulness of the initial version of PSILCA, and will therefore be detailed later.

Table 6 List of indicators in PSILCA

STAKEHOLDER	SUBCATEGORY	INDICATOR	Unit of measurement
WORKERS	CHILD LABOUR	Children in employment, male (% of male children ages 7-14)	%
		Children in employment, female (% of female children ages 7-14)	%
		Children in employment, total (% of all children agess 7-14)	%
	FORCED LABOUR	Evidence of forced labour	Text
		Frequency of forced labour	%
	FAIR SALARY	Living wage, per month	local currency
		Minimum wage, per month	local currency
		Sector average wage, per month	local currency
	WORKING TIME	Hours of work per employee, per day	h
		Hours of work per employee, per week	h
		Standard weekly hours	h
		Standard daily hours	h
	DISCRIMINATION	Occurrence of discrimination	Text
		Women in the labour force (% of economically active female population)	%
		Men in the labour force (% of economically active male population)	%
		Ratio of salary of women wages to men	%
	HEALTH AND SAFETY	Accident rate at workplace	#/100,000 workers
		Fatal accidents at workplace	#/100,000 workers
		Occupational risks	Text
		DALY due to indoor and outdoor air and water pollution	DALY/1,000 persons
		Presence of sufficient safety measures	# of security incidents
	SOCIAL BENEFITS, LEGAL ISSUES	Social security expenditures out of the total GDP	%
		Evidence of violations of laws and employment regulations	#/yr h
		% of workers with a contract	%
	FREEDOM OF ASSOCIATION, COLLECTIVE BARGAINING, RIGHT TO STRIKE	Trade union density (% of employees organised in trade unions)	%
		Right of association	index value
		Rigth of collective bargaining	index value
		Right to strike	index value
		Existence of standard rates	Y/N
LOCAL COMMUNITY	ACCESS TO MATERIAL RESOURCES	Level of industrial water use (% of total withdrawal)	%
		Level of industrial water use (% of total actual renewable)	%
		Extraction of material resources (fossil fuels, biomass, ores, minerals)	t/capita
		Presence of certified environmental management systems	#
		Description of (potential) material resource conflicts	Text
	RESPECT OF INDIGENOUS RIGHTS	Presence of indigenous population	Y/N
		Human rights issues faced by indigenous people	Text
		Respect of indigenous rights	Text
	SAFE AND HEALTHY LIVING CONDITIONS	Pollution level of the country	Index value
		Contribution of the sector to environmental load	Text
		Drinking water coverage (% of the population)	%
		Sanitation coverage (% of the population)	%
	LOCAL EMPLOYMENT	Unemployment rate in the country	%
		Work force hired locally	%
		Percentage of spending on locally based suppliers	%
	MIGRATION	Migrant workers in the sector	%
SOCIETY	CONTRIBUTION TO ECONOMIC DEVELOPMENT	Economic situation of the country	index value
		Contribution of the sector to economic development (in % of total GDP)	%
		Public expenditure on education (% of GDP)	%
	EDUCATION	Illiteracy rate, male (% of male population)	%
		Illiteracy rate, female (% of female population)	%
		Illiteracy rate, total (% of total population)	%
	HEALTH AND SAFETY	Health expenditure out of the total GDP of the country	%
		People affected by natural disasters (as % of population)	%
		Life expectancy at birth	Years
	PREVENTION AND MITIGATION OF CONFLICTS	Risk of conflicts with regard to the sector	Text
VALUE CHAIN ACTORS	FAIR COMPETITION	Presence of anti-competitive behaviour or violation of anti-trust and monopoly legislation	Text
		Presence of policies to prevent anti-competitive behaviour	Y/N
	CORRUPTION	Corruption index of country	index value
		Evidence of an active involvement of the enterprises in corruption and bribery	%
	PROMOTING SOCIAL RESPONSIBILITY	Presence of codes of conduct that protect human rights of workers among suppliers	index value
		Membership in an initiative that promotes social responsibility along the supply chain (number of enterprises)	#
	SUPPLIER RELATIONSHIPS	Interaction of the companies with suppliers (payment on time, sufficient lead time, reasonable volume fluctuations, appropriate communication...)	Text
CONSUMERS	HEALTH AND SAFETY	Presence of management measures to assess consumer health and safety	Y/N
	TRANSPARENCY	Presence of certifications or labels for the product/sites sector	Y/N
	END OF LIFE RESPONSIBILITY	Strength of national legislation covering product disposal and recycling	Text

4.2.5 Application

The basic purpose of PSILCA is to enable practitioners to conduct extensive social LCA. Social risks along product life cycles can be investigated and localized in the affected countries. Complemented by product or company specific data social hotspots in the supply chain can also be detected in order to enable firms to change specific suppliers or improve production and working conditions on a micro scale. In contrast to E-LCA, also positive social impacts hidden in product supply chains can be revealed by applying PSILCA. Hence, companies are shown possibilities to contribute to a positive social development in special regions or countries or to improve specific social issues.

Since PSILCA provides comprehensive data for a broad range of industry sectors worldwide it is also relevant for the application in the field of sustainability policies (Pelletier et al., 2013). Governments can reveal potential social risks in specific sectors of their trading partners or identify high-risk contributing sectorial flows to production in individual countries.

Based on these findings they might adapt their import regulations or even replace the trading partners not keeping to social regulations in order to cope with laws and agreements on sustainability, human rights and labour standards and to avoid socially unsustainable imports. Furthermore, governments or trade unions can also seek to change the legislative environment in the affected sectors or countries or adapt their own trading policies or customs regulations to mitigate social risks and impacts. In addition to this, PSILCA can be applied to extend traditional Product Footprint or Life Cycle Assessment approaches to cover also social impacts. By a combination of the PSILCA approach of S-LCA with E-LCA sustainability aspects of products can be addressed much more completely. In this way, consumers will get a comprehensive picture of sustainability aspects of the products they purchase.

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5. Positive impacts and Indicator Categories in Social Life Cycle. Assessment. Results from a systematic review.

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5.1 Introduction

The goal of this chapter is to take into account the Social Life Cycle Assessment (S-LCA) methodology, after six years from the publication of the UNEP/SETAC Guidelines in 2009, through the analysis of case studies published between 2006[7] and December 2014, in order to detect whether positive impacts have been underlined along with negative ones, and the indicators used[8]. In order to better understand this goal, it is useful to define what a social impact and an indicator are. As reported in the Guidelines and Principles for Social Impact Assessment (1994, 107), Social impacts are: "the consequences on human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize themselves so as to meet their needs and generally cope as members of society." From this definition it is possible to better understand what a social positive impact is, and to delve deeper into the purpose of the present study.

The concept of positive impacts arises within the field of Social Impact Assessment (SIA). Vanclay (2003), introduces concepts that stimulate a new vision of Impact Assessment (IA). This is not only seen as a mere methodology aiming at calculating negative impacts, but it also assumes a positive connotation for a proactive and better development of outcomes. As far as indicators are concerned, a clear definition was given by Paragahawewa et al., 2009: "Indicators are 'pointers' to the state of the impact categories (and/or subcategories) being evaluated by the S-LCA". Indicators can be quantitative, semi-quantitative or qualitative.

5.2 Method

A preliminary review of S-LCA case studies was carried by taking into account various papers on theoretical basis of positive impacts: Collaboration for Environmental Evidence 2013, Kitchenham et al., 2007, Chiu & Chu 2012, Chung et al., 2014, Clancy et al., 2013, and Roy et al., 2009. An extended review is reported in Di Cesare et al (2016).

The search engines used were: Google Scholar, Scopus and the inter-database Discovery Service (powered by EBSCO Host) accessed by the University "G. d'Annunzio". The keywords used to conduct the research were as follows: "Social Life Cycle Assessment" AND/OR case study, S-LCA AND/OR case study, "Social LCA" AND/OR case study, Social LCA AND/OR case study, Societal AND/OR LCA case study, "Societal LCA" AND/OR case study, "Societal Life Cycle Assessment" AND/OR case study, Societal Life Cycle Assessment AND/OR case study, Social Life Cycle Assessment AND/OR case study.

The search was performed in both the "title" and the "abstract" fields for the case of the Discovery Service, in the fields of "title" and "topic" for the case of Scopus and in all fields in the case of Google Scholar, for the period from 2006 to December 2014. Papers not pertinent to the topic and those that were not S-LCA case studies[9] were excluded. At the end of this phase, 40 case studies were considered as relevant.

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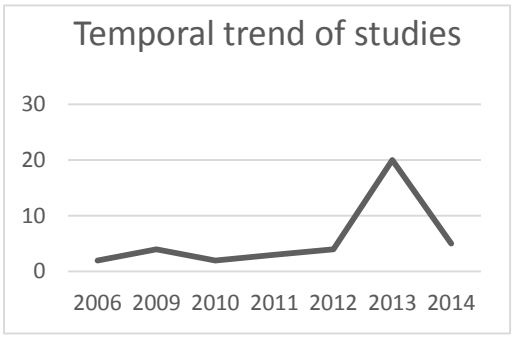
[7] Case studies developed through the S-LCA methodology and published before 2009, when this methodology had not yet its official recognition, are available, and are taken into consideration in this paper.
[8] This paper represents an update and extension of two previous works: the first presented during the 4th International Seminar on S-LCA by Petti et al.,(2014) and the second one presented by Di Cesare et al.,(2014) at Ecomondo, Rimini 2014.
[9] Including case studies in which social impacts are assessed, but not with the S-LCA methodology.

To better analyse the role of positive impacts in S-LCA, a questionnaire was edited and submitted to the authors of the case studies and to a number of experts in the S-LCA field.

5.3 Results and Discussion

Critical review. The use of the keyword "case study" to perform the research proved to be insufficient since most case studies are integrated in theoretical papers as an application or appendix.

Within the 40 case studies considered, the following were identified: 4 papers on energy sources (3 on bio-fuels and 1 on diesel and petrol), 8 on Information and Communication Technologies, 9 on the agri-food sector and 5 on waste management. The remaining 14 papers can be classified as "Others" because of the diversity of the topics covered.



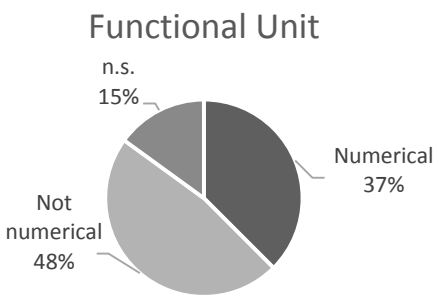


Figure 6 Temporal trend of studies on positive impacts

The temporal trend (Figure 6) shows that during the first years (2006-2008) there was a low number of studies on S-LCA. During this period, the methodology was still in its infancy and no consensus had been reached concerning the performance of a case study. This trend was temporarily interrupted in 2009, when there was a slight increase in the number of studies due to the publication of the UNEP/SETAC Guidelines (2009), which have indeed contributed to the identification of two main characterisation categories: Type1 and Type 2. In 2013, a substantial increase occurred in the number of studies carried out, a sign of growing interest in social issues. In 2014, a dramatic decrease of published studies is registered, perhaps a sign of the methodology still being incomplete and requiring further development. However, there have been two international conferences within 2014, the SETAC Europe 24th Annual Meeting (Basel, 11th-15th May 2014) and the 4th International Seminar on S-LCA (Montpellier, 19th-21st November), where a number of case studies were presented, some of whom were not yet published on scientific journals.

The analysis of the 40 identified papers showed that approximately 72% (29 of 40) of these were conducted in accordance with the UNEP/SETAC Guidelines. This confirms that these have had an essential leverage on the S-LCA research field.

Main methodological issues. Here some of the methodological issues described in ISO 14040 are analysed: Functional Unit (FU), System Boundary and Impact Assessment (IA) methods.

Only 37% of the papers analysed took into consideration a numerical FU, whereas 48% considered a non-numerical FU. The remaining 15% did not state any FU (Figure 6).

Regarding the System Boundary, 35% of the analysed studies (Figure 7) considered the entire life cycle from "cradle to grave". 25% assessed the life cycle of the product from "cradle to gate" while 28% assessed it from "gate to gate" (e.g. from banana plantations to the port, in Feschet et al., 2013). 7% of the authors did not specify the System Boundary considered in their work. Two papers were categorised as "Other" because of the particularity of the System Boundary considered: Macombe et al., 2013 considered "the national economy" and Paragahawewa et al., 2009 affirmed that "it is appropriate

to focus on all socially significant impacts from both company and production specific activities as per ISO 14044 requirements for E-LCA".

Regarding the IA phase, 65% of the analysed papers used an IA method in the field of the so-called Taskforce approach, 5% used DALY (Disability-Adjusted Life Year), 5% the Pathways approach, two papers (5% of the total) did not implement any IA. Other two did not specify the IA method used. 15% of the studies analysed were included in the category "Other" in virtue of the peculiarities of the method used (Figure 7).

A weakness in the methodology is pointed out by the tendency of many authors to propose different IA methods. As it is also explained in the UNEP/SETAC Guidelines (2009), the IA methodologies are considered as an open field and further developments of IA methods are greatly needed. To fill this gap an attempt was made by publishing a Handbook on Product Social Impact Assessment by Prè Sustainability in September 2014 (Roundtable for Product Social Metrics 2014).

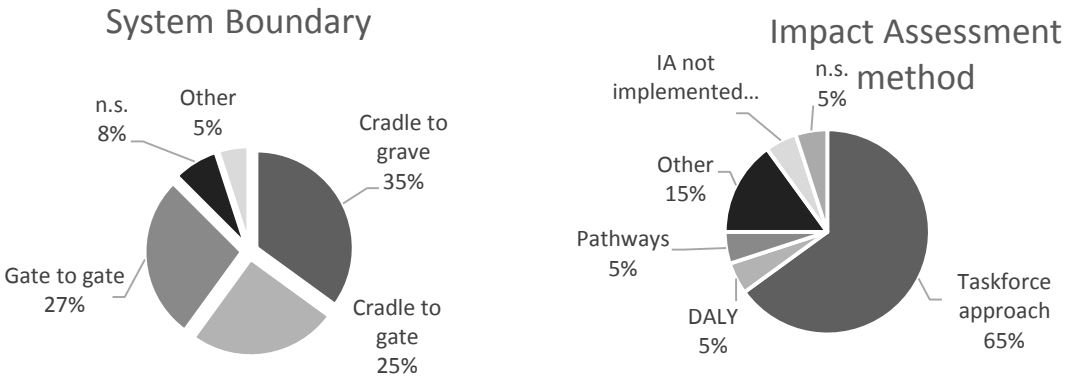


Figure 7 Percentage breakdown of the analysed papers according to the Functional Unit, System Boundary Impact Assessment method considered.

Impact indicators. With regard to the impact indicators, crucial to assess the various social issues of concern (subcategories), they are not specified in about 30% of the total of case studies.

Regarding the need, or not, to set new Subcategories, some disagreement also emerges from the survey conducted among the authors and the experts: i) a part of them claiming new Subcategories to set; ii) another could not say if this is necessary or deemed necessary only in cases where it applies a specific IA method; iii) most believe that the existing Subcategories are sufficient. The definition of new Subcategories would not be, indeed, the best way to identify social impacts, but it would be more interesting to find social impacts on social science literature. It will, therefore, not be necessary to set new subcategories if the relationship (pathway) to assess social impacts is not identified. However, if site-specific assessments are made, more specific categories or indicators may be necessary. For this reason, a specific definition (of what aspects are included) is needed. At the same time, simplification can help in broadening, deepening and implementing of the S-LCA methodology.

Within the analysed papers, the most considered stakeholder category is "Workers". This could mean that workers are considered by the authors, as the most impacted stakeholder category from a social point of view. The analysis of the papers has shown that some authors use indicators that help to better characterise the context in which a company operates. These are however not present in the Guidelines. These elements are the characteristic indicators of a given sector which would have little meaning if considered within a different context. Other indicators, present in the methodological sheets, are considered less apt to the specific case study developed and are therefore not taken into account.

About 483 indicators were detected (Figure 8): 17% of them are quantitative indicators, 56% are semi-quantitative, and 27% are qualitative (descriptive). This breakdown

should highlight the effort of the authors to express the indicators as quantitative variables.

The UNEP/SETAC Taskforce indicators assess the social context surrounding the unit processes. Some "generic" indicators focus on the average social conditions of sector, country, and region as it is proposed in the Guidelines. Without specifying the social agents responsible for the social conditions observable at the regional and sector-based level, it is clear that the sources of the stressors are not of a technical nature. These are, instead, of an organisational nature and therefore belong to the socio-sphere. Other indicators clearly assess the enterprises, as some are explicitly related to the management practices (Parent et al., 2010).

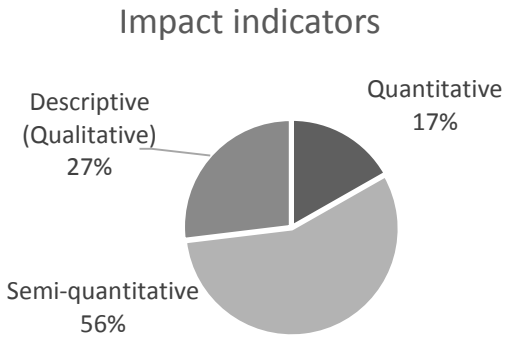


Figure 8 Percentages breakdown of the typologies of indicators considered in the analysed papers.

Almost all indicators are tailored for specific purposes by researchers. Indicators are chosen from a list based on their author's experience, resulting in heterogeneous lists that differ from one approach to another (Grießhammer et al., 2006).

Regarding positive social indicators, Ekvall (2011) states that the concept of a positive indicator (and of the impacts that it assesses) is related to the concept of freedom. He affirms that it is necessary "to focus on the issue of democracy and distinguish between countries that are free, partly free, or not free" (Ekvall 2011, p. 2). In fact, if a positive indicator is used, it can be measured in terms of "value added" in free countries. "Value added" in partly free countries can then be included in the calculation at half value. If a negative freedom indicator is used, the calculation includes the "value added" in countries that are not free with the addition of the half of the half the "value added" in partly free countries. This approach will describe to what extent the product contributes to economies in countries that are politically free (or not free).

Positive social impacts. One of the problems in dealing with positive impacts is found in the definitional phase. Indeed, the authors interviewed demonstrated low consensus in providing a definition of positive social impact. These definitions are almost perfectly divided between: "The net positive effect of an activity on a community and the well-being of individuals and families" and "An improvement related to the previous situation", owing to the subjectivity of the issue itself. In any case, saying that a positive impact is not the absence of a negative one was largely agreed upon.

Defining a positive impact as an improvement appears to be vague, because the beneficiary and the duration time are not specified. On the other hand, it is important to underline who the subject of improvement is and who acknowledges it. If it is a top-down improvement, it can concern several Stakeholder Categories, but it may fail to record important changes that occur at a local level (Lahtinen et al., 2014).

In past years, the theme of positive social impacts has been dealt with, for example, by: Norris (2006), UNEP/SETAC (2009), Ekener-Petersen (2013) and Sanchez Ramirez et al., (2014). In particular, the first author refers to "health impacts" (both positive and negative), introducing the concept of positive social impacts. Norris (n.d.) also developed a new approach (called "Handprint accounting"), in which, positive impacts can be directly compared with (and subtracted from) the negative ones.

The analysis of the review shows that 37% of the case studies (13 of 35) do not explicitly identify any positive impact. The remaining 63% was divided per industrial sectors, as shown in Figure 9.

The analysis pointed out that the utility of goods is identified as a positive impact in two papers (Baumann et al., 2013, Ekener-Petersen and Moberg 2013). The utility, in the economic language, is defined as the well-being that a given good or service is able to provide to a person as it is suitable to satisfy a desire or fulfil a need (Treccani 2012). It appears, therefore, somehow significant to consider the utility performed by the good during its use phase as a positive impact. The concept of positive impacts, however, does not refer merely to the utility (benefit from its use), but in a broader sense, to the so called "win-win" situations10. These solutions improve the condition of the various parties involved.

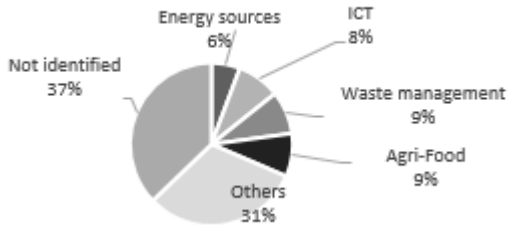


Figure 9 Percentage breakdown of the analysed papers according to the consideration of positive social impacts.

Another interesting consideration regarding positive impacts is made in the paper of Vinyes et al., (2013). The authors claimed that "[n]egative indicators are those whose high values have a negative contribution to sustainability (economic and environmental indicators) and positive indicators are those that have a positive contribution to sustainability (social indicators)".

A noteworthy feature of social impacts is that they produce their effect as soon as there are changes in social conditions. Moreover, it is not only the stakeholders who are subject to these impacts, but they also provoke an active response, implying a certain degree of dynamism. For this reason, they are difficult to identify and are situation/site-specific (Slootweg et al., 2001), triggering a virtuous chain. They refer, in addition, to both quantitative variables (demographic and economic) and to changes in values, belief system and in the perception of the context in which they are produced (Lahtinen et al., 2014). An example of context-related positive impacts is given in the paper of Jørgensen et al., (2010), in which the authors highlight that child labour can be regarded as a positive impact in some situations. These could include: helping children to develop discipline, responsibility, self-confidence and independence, teaching them how to manage money, and providing them with working skills.

5.4 Conclusions

The concept of positive impacts has arisen in the field of Social Impact Assessment (SIA). Indeed, after having performed a literature review and analysed a set of papers, no shared definition of positive social impacts as part of the S-LCA methodology could be deducted. It will be therefore necessary in the future to create a debate about it amongst researchers. As a result of the questionnaires, it should be noted that the unanimity of the authors believe that research in the context of positive impacts is useful for the general advancement on social impacts.

In the framework of social positive impacts (meant as "win-win" situations), helping communities (and other stakeholders) to identify development objectives and ensuring that positive results are maximised. This might be more important than minimising the

[10] A win-win situation is defined as a situation in which all parties involved in the initiative have a benefit in terms of value created in their favour (Molteni 2007).

damage originating from negative impacts. Positive social impacts, in the opinion of the authors, can be regarded as a subjective, context-related issue and have to be assessed as in the case of negative ones (the same category of indicator can display a positive or a negative impact, depending on the previous situation that is set as the reference).

As far as indicators are concerned, it is evident that positive impacts are among the main driving forces towards sustainable development.

There is wide agreement that indicator-sets for the purpose of S-LCA are needed. The Taskforce did not develop a universal indicator-set as a basis for all further S-LCA applications. A universal set of indicators that covers the social aspects in all social, economic and political contexts is considered to be still a challenge.

Future research developments may concern identifying social evaluation criteria to establish what is to be considered as "positive" and deeply understanding the context, for instance: in what way may the context evolve after a change which has led to an improvement occurred?

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6. Social issues in classical and social LCA: from identification of overlaps to an integrated framework

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In order to come to an overall Life Cycle Sustainability Assessment (LCSA), it has been stated many times that classical (environmental) Life Cycle Assessment (LCA) should be extended with economic and social impact assessment like Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA). This methodological framework reflects the concept of sustainable development as defined in the Johannesburg World Summit on Sustainable Development (UN, 2002). Indeed, according to this definition the sustainability principle should integrate the three pillars of economy, environment and society, also referred as 3P approach: people, planet and prosperity. LCA has first emerged as a tool for environmental management, based on the compilation of physical exchanges in between the natural environment and the human/industrial environment (energy and materials) and the assessment of the environmental impacts directly attributable to a system throughout its life cycle.

The importance of understanding social aspects of supply chains and their cost and benefits for human societies have been increasingly recognized. S-LCA and LCC methodologies are aimed at addressing these aspects, complementing the information provided by LCA on the environmental aspects. However, it is questionable whether LCA assesses the environmental impacts only, as stated in the ISO definition (ISO 14044, 2006), or if it already includes socio-economic aspects. This is particularly evident in the impact assessment of natural resources, based on the assumption that decreased availability of resources will damage human systems. Beyond scarcity, the security of supply of mineral raw materials has become a high-priority theme in the political agenda of many countries, especially those highly dependent on imports. The need of taking into account in LCA economic and geopolitical aspects that can reduce resource availability has been acknowledged (Schneider et al., 2011, Mancini et al., 2015), and is debated if they should be accounted in LCA or in S-LCA (Mancini et al., 2013).

Establishing clear domains between LCA and S-LCA implies the definition of what we want to protect or promote using one methodology or the other. Traditionally, the three Areas of Protection (AoP) in environmental LCA are Human Health, Natural environment and Natural resources (EC - European Commission, 2011), but the inclusion of the AoP "Human Dignity and well-being" was proposed by Dreyer et al., (2006) to supplement the existing ones through S-LCA. The Prosuite[11] proposal for an integrated sustainability assessment framework to be used in LCA includes five impact categories: Human Health, Social Well-being, Prosperity, Natural Environment and Exhaustible Resources, broadening the scope of LCA to the three pillars of sustainability.

Impacts on human health due to physical exchanges in between the ecosphere and technosphere are typically accounted for in environmental LCA, in terms of Disability-adjusted life year (DALY) or quality-adjusted life-year (QALY). Human health is also accounted for in S-LCA, but typically taking into account impacts on different stakeholders, often caused by socio-economic conditions, e.g. labor conditions. This suggests that there may be an overlap between Social and Environmental LCA: both target to quantify impacts on humans caused by a production and consumption cycle. At a second glance, the identification of this 'overlap' might be a source of rethinking social impacts; indeed, both environmental LCA and S-LCA envisage the same AoP "Humans"

[11] Prospective Sustainability Assessment of Technologies (Prosuite, EC 7th Framework Project)

(health, dignity, well-being) but starting from other causes. In this sense, further analysis might result in recognizing some complementarity instead of overlap.

Given the above picture, this chapter aims at contributing to the scientific discussion on the scope and field of domain of LCA, in relation with the S-LCA and LCC. This is done through: i) an analysis of the overlaps of contents among existing areas of protection ii) the proposal of a framework for the AoP 'Humans' based on the application of cause-effect mechanisms and the integration of bio-physical accounting with economic accounting in the assessment of production and consumption systems.

6.1 Analysis of the Areas of Protection and proposal of an integrated framework

While the AoP natural environment (also defined as "ecosystem quality" in the UNEP classification (UNEP/SETAC Life Cycle Initiative, 2011)) has a pure environmental focus, the inclusion of natural resources and human health in the environmental assessment is less straightforward. Natural resources, in particular, are at the edge of natural and anthropogenic systems, as they are extracted from the natural environment to feed the economic production systems. The impacts due to resource extraction and use are very different and depend on the life-cycle stage. At the cradle (i.e. before the resource use), resources extraction can negatively affect the functioning of ecosystems, therefore negatively impacting the natural environment. Moreover, availability issues can rise, especially for the non-renewable resources. The risk of resource depletion, and its future consequences on human wellbeing, is currently accounted in LCA through the resource depletion impact category. Even though this issue is commonly included within the environmental assessment, the consequences of limited resource availability are likely to affect the human societies primarily. Resource scarcity can also result as a consequence of temporary disruptions in the supply chain. This aspect is closely related to the concept of "resource criticality", and regards the risk of supply of raw materials due to geo-political reasons. In the criticality assessment socio-economic aspects like, e.g. governance of the producing countries, market concentration and import dependency are taken into account (EC - European Commission, 2014; Graedel et al., 2012). Resource criticality, even though not included in the mainstream practice, is starting to be considered in the (environmental) LC impact assessment methods. Despite of its socio-economic nature, the integration of this aspect in LCA appears to be much more feasible than in S-LCA, due to the accounting in physical units and the compilation of mass flows inventory that is commonly practiced in LCA (Mancini et al., 2014). Other social aspects linked to resource supply chain can be captured in S-LCA and they refer to, e.g., labor conditions, human rights violations and sharing benefits from resources extraction with local populations. These aspects are considered in this methodology also because they need the involvement of different stakeholder categories and the magnitude of the impact is expressed in terms of risk and working hours.

Human health is accounted in environmental LCA with the aim of quantifying the changes in both mortality and morbidity that are associated with goods or services and caused by various types of environmental stressors induced by 'elementary flows' at the ecosphere/technosphere interphase. According to Dreyer et al., (2006) S-LCA should embrace a broader understanding of the human life, and not be limited to the life expectancy. Health is one of the three prerequisites for protecting human life, together with dignity (i.e. to live a decent life and enjoy respect and social membership) and basic needs fulfilment (i.e. the access to food, water, clothes, medical care, etc). Therefore, the AoP human health in LCA can be considered a sub-set of the wider area AoP 'Humans', including Human Health, Human Dignity and Well-being, the latter two more addressed in S-LCA.

This brief analysis highlights that, in spite of the formal definition of environmental LCA, the methodology does not account environmental impacts only; the metrics used in the assessment (physical, economic, etc), seems to be the main criteria for the inclusion of an aspect in a methodology or in the other, rather than the nature of the impact itself. Some aspects like natural resources, however, are multifaceted and need a more holistic assessment.

6.2 Proposal for an integrated framework to cover social issues in (S)LCA

Classical environmental LCA is based on a life cycle inventory, i.e. listing all resources extracted from and emissions released into the environment. This physical exchange between the environment and the human-industrial sphere is the starting point of so-called cause-and-effect chains that impact AoPs: the natural environment, natural resources and human health. However, human health and other impacts on humans are not only affected by this cause-and-effect chain that is initiated at the ecosphere/technosphere interphase. Indeed, Humans as a broadly defined AoP can be threatened by other causes within the human-industrial environment or technosphere.

So if one aims at a holistic analysis of impacts on Humans as AoP due to the life cycle of a product (including resource extraction, processing, design, manufacturing, retail, distribution, use, collection and re-use/recycling/energy recovery/disposal), we may propose two types of cause-and-effect chains that impact the AoP Humans.

Indeed, Figure 10 illustrate and integrated framework to assess impacts on Humans in (S)LCA as AoP next to other AoPs as a result of a production and consumption system (top), through effects as a result of two types of causes: (1) elementary flows as in classical environmental LCA (elementary flows in between ecosphere and technosphere) (left hand side); (2) economic flows within the technosphere (right hand side). Arrows represent negative impacts but positive ones (effect of income for necessities and fulfilling needs) as well.

Firstly, there is the cause-and-effect chain typically considered in environmental LCA, see Figure 10 at left hand side: it starts from flows in between the ecosphere and technosphere. After their inventory, they are translated into impacts on the classical AoPs. With respect to Humans, the considered health effects can be local, short term, global and/or long term.

Secondly, the aforementioned set of life cycle stages of a product does not only result in physical ecosphere/technosphere exchanges, but also in a number of economic exchanges within the human-industrial sphere that impact humans as well, see Figure 10 right hand side. Over the life cycle, we identify two basic economic exchanges that can be identified as a starting point of a cause-and-effect chain and that are situated within the technosphere. First, there is the exchange "labor for income", to be situated in the production phases: humans receive money in turn for their labor. This first exchange can be the starting point of a first set of cause-and-effect chains that impact humans. On one hand the labor conditions can cause several effects on humans as typically recognized in social LCA (child labor, excessive working hours …). On the other hand this exchange provides income so that the employee or employer receives income he can spend to meet his needs. This latter impact is a positive impact; positive impacts are rarely considered in a cause-and-effect context in LCA.

A second economic exchange is "expenditure for products and services": humans spend money to acquire products and services. This exchange is clearly at the use phase in the life cycle. Again, the exchange can be seen as the starting point of two kinds of cause-and-effect chains. First it results in exposure to products and services that may impact health or even safety of humans when they are not properly manufactured. Second and maybe more importantly: the acquisition of products and services helps in meeting needs of people, hence in a positive impact.

In summary, the life cycle of a product results into both physical exchanges in between the ecosphere and the technosphere, and in economic exchanges within the technosphere. These exchanges result in four types of negative effects on the AoP Humans (health, dignity, well-being):

- Local/short term impacts on humans caused by emissions (impacts mainly on health)

- Global/long term impact on humans caused by emissions (impacts mainly on health)

- Impacts on humans caused by exposure to labor conditions (impacts mainly on health, safety, well-being)

- Impacts on humans caused by exposure to products (impacts mainly on health and safety)

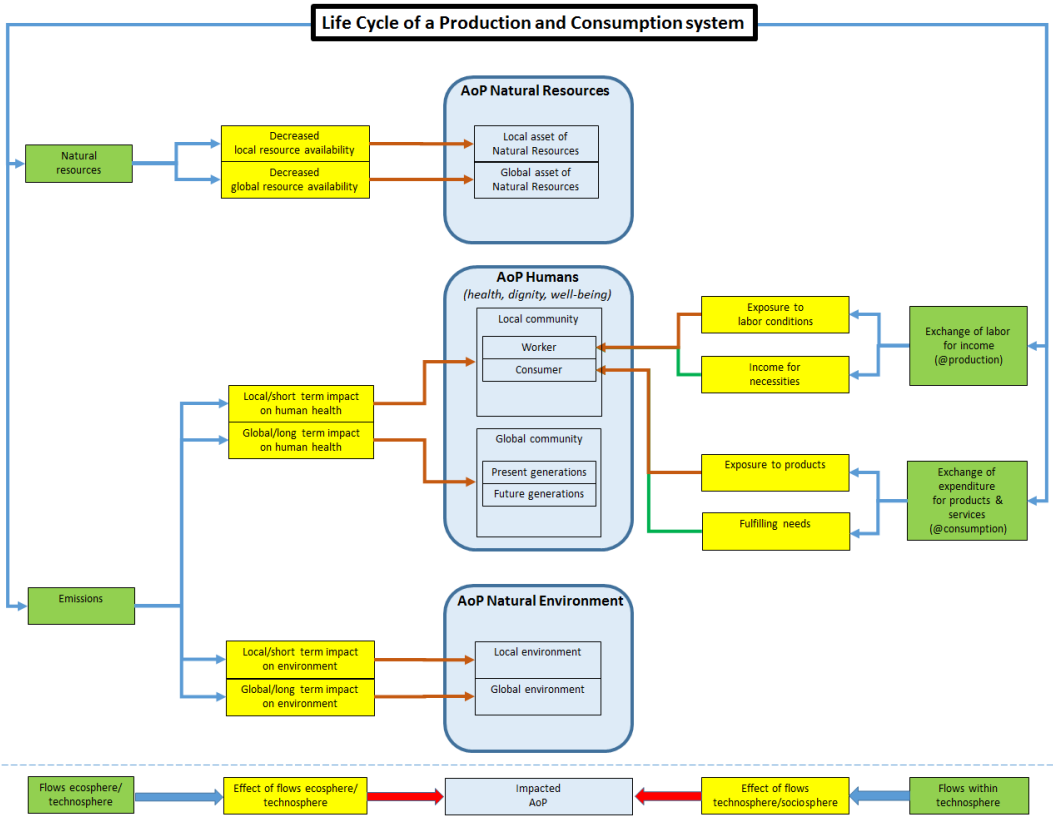

Figure 10 Proposal for an integrated framework for impact assessment

Secondly, there are also positive impacts as a result of a product's life cycle to be recognized:

- Income for necessities for humans as a result of the labor offered into the product's life cycle (at production)

- Meeting of needs for humans as a result of the consumption of the product's use phase (at use)

6.3 Conclusions and perspectives

Social issues are part of both classical (environmental) LCA and S-LCA. The aforementioned sections revealed that both aim at quantification of impacts on Humans as AoP, but typically as a result of other causes, ending in the conclusion that both frameworks are rather complementary, although with some overlapping. A holistic analysis of cause and effects chains that impact Humans as AoP have been proposed. This may be ground to a better integration of social and environmental LCA. A next step may be a quantification of impacts of both physical and economic nature in a similar way, ideally on the basis of a same unit. In a first phase, at least negative impacts may be considered. Basically, there is the possibility of the quantification of labor conditions in terms of QALYs (instead of risk hour equivalents) (Weidema, 2006). Even positive impacts have been approached in a similar way, e.g. the QALY concept is typically used in health economics to assess the benefit of the intake of medicines as product (Whitehead and Ali, 2010).

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7. Social Sustainability in Trade and Development Policy

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7.1 Trade policy in EU

Sustainability is a guiding principle and objective for policy development in the European Commission (EC) (EC 2001a). The EU Sustainable Development Strategy (SDS) requires an impact assessment of all major policy proposals vis-à-vis sustainability objectives (EC 2009) Sustainability is based on four fundamental pillars: environmental, economic, social and institutional sustainability. Socio-economic aspects are fundamental both as drivers of potential impacts as well as possible elements of the system that are subject to impacts along product supply chains. These aspects are of particular relevance to the sustainability dimensions of trade and development policies.

The founding Treaty of the European Union specifically includes the objective of 'fostering sustainable economic, social and environmental development of developing countries, with the primary goal of eradicating poverty' (Article 21(3)). Following the Lisbon Treaty (Article 21(3) TEU and Articles 205 and 208(1) TFEU), the EU's external policies must respect the 'principles of democracy, the rule of law, the universality and indivisibility of human rights and fundamental freedoms, respect for human dignity, the principles of equality and solidarity, and respect for the principles of the United Nations Charter and international law' (EC 2008).

With respect to trade policy, since the early 1990's all EU trade agreements have been required to incorporate a clause defining 'human rights' as a basic element. This clause encompasses the core labour standards as defined in the International Labour Organisation (ILO) Conventions. More specifically, the Council conclusions of October 1999 outline the EU's position on trade and labour in social development (EC, 2001b). Here, the Council agreed that the EU should strongly support the protection and respect for core labour standards; provide support for the work of the ILO as well as its co-operation with the World Trade Organisation (WTO); and oppose any sanctions-based approaches (EC 2001b). The Commission's subsequent *Communication on 'Corporate Social Responsibility: A Business Contribution to Sustainable Development'* encourages the adoption of 'codes of conduct, management standards, instruments for measuring performance, labels on products, and standards for Socially Responsible Investment (SRI), in order to direct investors towards enterprises in light of their corporate social responsibility results' (EC 2002).

In this context, life cycle thinking and life cycle-based methodologies are considered, due to their systemic nature, to contribute the core feature of robust sustainability science (Sala et al., 2013 a and b). Life Cycle Assessment, Life Cycle Costing and Social Life Cycle Assessment (S-LCA) may, hence, play a central role in helping to define better policy options towards sustainable development.

In order to assess the efficacy of S-LCA applications in policy contexts, there is the need to evaluate its added value based on case studies at different scales (i.e. at micro (product) as well as meso (regional) and macro (country/ global) scales). To date, application at meso and macro scales are very limited (see. e.g. Rugani et al., 2012 on Luxembourg and EU 27; Ekvall, 2011), whereas examples of application of S-LCA at product level are more common and already cover a number of key products and services (some of them even with complex international supply chains) such as biofuels

(e.g. Macombe et al., 2013), bananas (Feschet et al., 2013), laptop computers (e.g. Ekener-Petersen and Finnveden, 2013), and tourism (Arcese et al., 2012).

The present study focuses on application of S-LCA at the macro scale, with the aim of assessing its potential relevance and use in trade and development policy contexts.

A case study has been carried out for EU 27 Member States, considering the origin, magnitude and distribution of social risk associated with traded commodities. The analysis employs two approaches in order to assess the added value of life cycle thinking and tools in this context. The first is a non-life cycle based "country of origin" approach, and the second is a life cycle based cradle-to-country of consumption approach.

7.2 Methodology

The primary objective of this study is to evaluate the social risks attributable to imports of traded commodities into EU-27 Member States in 2010 from both intra and extra-territorial trading partners. This is achieved by combining Eurostat ComEx import data at the HS06 level (Eurostat, 2013), mapped to GTAP sector codes, with the country/sector-specific social risk indicator data currently available in the Social Hotspots Database (SHDB) (Benoit et al., 2010).

In order to map Eurostat HS06 trade data (7395 unique classifications) from ComEx to the GTAP sectors employed by the SHDB, the study used a concordance table from the World Bank (2013). Since Eurostat trade data does not include services, this reduced the number of GTAP sectors considered in the analysis from 54 to 43. Where full, six-digit HS06 data were not available for specific trade flows for confidentiality or other reasons, these were excluded from the analysis. This accounted for 1,116 of the 7395 unique HS06 codes reported by Eurostat for imports to EU-27 Member States in 2010. Such exclusions generally represented minor fractions of overall trade flows. In some cases, however, exclusions were non-trivial for certain trading partners. Overall, however, only 2.5% of import flows by value were excluded from the analysis on this basis.

Data for a total of 78 extra-territorial trading partners, along with the (at the time of the study) 27 Member States of the EU-27, were considered. Although EU-27 Member States actually traded with a total of 202 extra-territorial trading partners in 2010, this nonetheless effectively encompassed 88.4% of imports by value from extra-territorial trading partners, 95.5% of imports by value from intra-territorial trading partners, and 92.8% of overall imports by value into EU-27 Member States in 2010. GTAP-mapped Eurostat ComEx trade data and SHDB social risk indicator data were then combined in two ways: a country of origin (A) approach and a life cycle based (B) one.

First, in the country of origin approach (A) – Figure 11, we undertook to assess the comparative social risks attributable to products imported into the EU-27 from extra-territorial trading partners compared to similar products produced and traded within the EU-27, taking into account the social risk scores for country- and sector-of-origin only (i.e. not using a life cycle approach). Here, we used Excel spreadsheets to multiply the social risk scores of imports for each country/sector combination by the % by value that imports from the country/sector combination contributed to total (intra- or extra-territorial) import values for that sector. This resulted in a value-weighted average indicator score per euro of imports for each sector and for each of the 117 sub-indicators, which were subsequently also multiplied by total trade value by sector to obtain overall risk scores for each sub-indicator.

We applied the same set of sub-indicators and the same weighting scheme used in the life cycle-based social risk assessment method in order to re-express the sub-indicator results per indicator (characterization), social theme (damage assessment) and as a single score. This allowed us to rank sectors in terms of apparent social risk per euro

spent on imports from a sector as well as based on the total value of sectorial imports for both intra- and extra-territorial imports. We also computed "externalization ratios," which are intended to convey the ratio of risk associated with the production of traded products outside of territorial boundaries to that which occurs within the EU-27, per euro spent on traded goods in each sector.

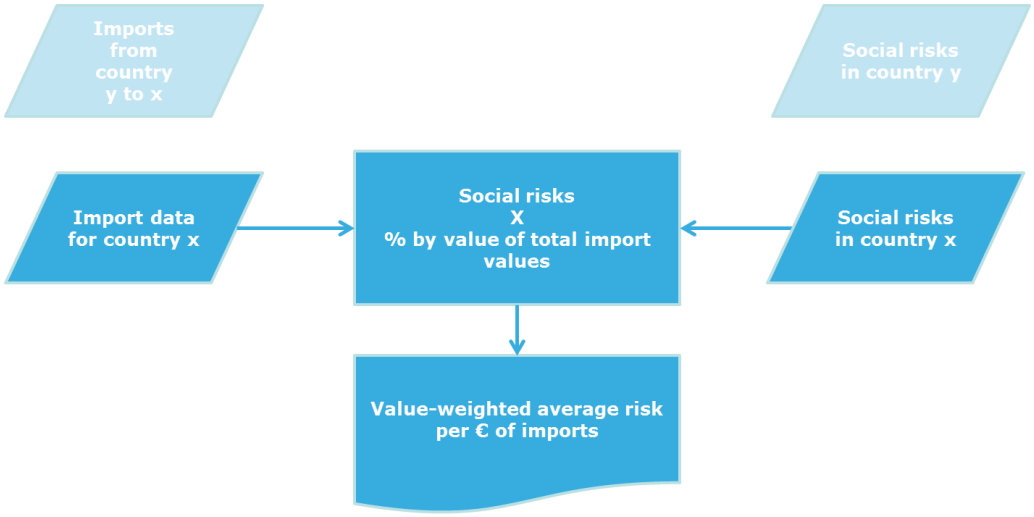

Figure 11 Schematic representation of Country of origin approach

Second, applying a life cycle –based (B) approach (Figure 12), we performed a life cycle-based evaluation of the social risk profile of EU-27 imports in 2010 using the version of the SHDB currently available in the SimaPro 8.0 software package. Here, we entered all GTAP-mapped trade data for imports by sector from intra- and extra-territorial trading partners into a SimaPro model and used the Social Life Cycle Impact Assessment Method Version 01.1 to assess the magnitude and distribution of social risks attributable to EU-27 trade by sector and in aggregate. Characterization results by social theme, damage assessment results by thematic area, and aggregated, single scores for life cycle social risks were generated. As before, we computed externalization ratios per euro spent on trade in each sector. In order to directly compare the country-of-origin versus life cycle-based social risk assessments, we transformed both into % contributions to total risk for each measure. We subsequently compared results between the country-of-origin and life cycle-based assessments in order to determine if these two approaches provide different 'signals', and to evaluate the relevance of a life cycle approach to understanding and managing social risk.

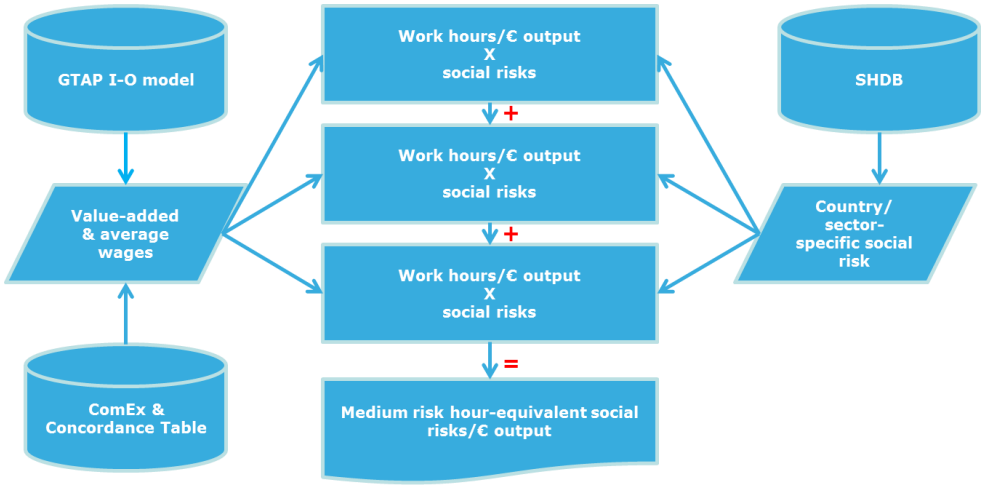

Figure 12 Schematic representation of Life cycle based approach

The two methods allows for calculating results as presented in Table 7, where top ten sectors for single score social risk (by % contribution to overall social risk) attributable to EU-27 imports in 2010 from extra- and intra-territorial trading partners considering (A) country-of-origin or (B) cradle-to-producer gate life cycle social risk scores are reported. Further methodological details and results are reported in Pelletier et al., (2013).

Table 7 Example of results comparing country of origin and LCA results. Top ten sectors for single score social risk (by % contribution to overall social risk) attributable to EU-27 imports in 2010 from extra- and intra-territorial trading partners considering (A) country-of-origin or (B) cradle-to-producer gate life cycle social risk scores.

A	Country-of-Origin approach		
	Extra-	Intra-	Total
Motor vehicles and parts	2%	12%	15%
Machinery and equipment n.e.c.	8%	3%	11%
Chemical, rubber, plastic products	7%	4%	11%
Oil	9%	0%	9%
Ferrous metals	0%	4%	5%
Textiles	2%	2%	4%
Wearing apparel	2%	2%	4%
Paper products, publishing	1%	3%	4%
Metals n.e.c.	3%	1%	4%
Electronic equipment	2%	1%	3%
SUM	**36%**	**33%**	**69%**
B	**Life Cycle-Based approach**		
	Extra-	Intra-	Total
Oil	17%	0%	17%
Crops n.e.c.	8%	0%	8%
Machinery and equipment n.e.c.	5%	2%	7%
Metals n.e.c.	6%	1%	7%
Chemical, rubber, plastic products	4%	2%	6%
Textiles	5%	1%	6%
Electronic equipment	4%	1%	5%
Wearing apparel	4%	1%	4%
Food products n.e.c.	3%	1%	4%
Minerals n.e.c.	3%	0%	3%
SUM	**58%**	**9%**	**67%**

7.3 Key findings from the application of the two approaches

Applying the two approaches (as described in methodology A and B), the following key observations emerged:

- There is a disproportionately large contribution to overall social risk attributable to the Injuries and Fatalities indicator in both analyses (A and B). This is strongly influenced by the high weighting for risk of fatalities relative to the weightings for the other social risks considered.

- The Injuries and Fatalities risk indicator is proportionately more important relative to the other risk indicators in the country-of-origin analysis (90% compared to 72% in the life cycle-based analysis).
- There is a much larger degree of social risk attributable to extra-territorial imports compared to intra-territorial imports, again for both analyses (almost 100% for the country-of-origin analysis and 83% for the life cycle-based analysis).
- Considering individual social themes, contributions from intra-territorial trading partners are negligible across indicators in the country-of-origin analysis for overall trade, but range from 9% for risk of Child Labour to 20% for risk of Injuries and Fatalities in the life cycle-based analysis.
- Turning to single scores results at the sectorial level for total EU-27 imports in 2010, the results of the country-of-origin versus life cycle-based evaluations of social risks are even more divergent. Both the distribution of risks between sectors and the relative importance of extra- versus intra-territorial imports vary widely.
- Considering single score results per euro spent on trade in each sector also presents highly divergent results between the country-of-origin and life cycle-based evaluations, as the influence of magnitude of trade flow is not a factor here.

7.4 Discussion and conclusion

Our analysis underscores the importance of a life cycle-based approach to understanding and managing social risk in support of policies for socially sustainable development. Both approaches (A and B) that we evaluated provide the same high-level insights that (1) the majority of social risks associated with imports to EU-27 countries are attributable to extra-territorial rather than intra-territorial imports, and (2) the risks of Injuries and Fatalities make the largest proportionate contribution to an overall, single-score measure of risk. However, these two approaches provide otherwise dissimilar "signals" as to the magnitude and distribution of social risk. The approach (A) would invariably prioritize interventions targeting only those direct trading partners known to have high levels of social risk in the sectors providing exports to EU-27 Member States. In contrast, the approach (B) provides insight as to the distribution of risk along supply chains, which may be low in the sector of a given country exporting products to Europe, but high overall for those products due to the social risks associated with the activities that support production in that sector. Although we observe that the majority of social risk associated with total trade flows is attributable to extra-territorial imports, this is nonetheless also relevant for intra-territorial trade. If considering only country/sector-of-origin social risk, intra-territorial imports may appear to have low associated social risk. Consideration of the distribution of social risk along upstream supply chains, however, may provide a very different picture if inputs to production within specific sectors in EU-27 Member States come from extra-territorial trading partners with higher social risk profiles. Hence, targeted policy initiatives to mitigate social risk in the interest of leveraging improved social sustainability based on either of these approaches would prioritize different countries and sectors. The case study also highlighted the need for better considering certain methodological issues: i) as the methodology implies a weighting scheme, this weighting should be carefully considered and possibly subject to sensitivity analysis; ii) even if the source of data are considered trustworthy, reliability of data and comprehensiveness could be questioned, in particular for those countries under critical political conditions ; iii) the scale of the assessment (country) is the best trade-off for ensuring data availability ; nonetheless, sub-country (regional) differences

may imply huge variability for the results; iv) the use of human labour as an indicator is questioned in the literature and could be also subject to sensitivity analysis adopting other reference indicators (e.g. Iribarren and Vázquez-Rowe, 2013).

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8. Including socio-economic considerations in supporting resource policy: a proposal of including Resource Security of Supply in LCA

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The security of supply of mineral raw materials has become a high-priority theme in the political agenda of many countries, especially those highly dependent on imports. At EU level, resource security is claimed as a policy objective both in the Raw Materials Initiative of the European Commission (EC, 2008) and within the resource efficiency policy (EC , 2011a; EC, 2011b). "Criticality" has also emerged as a research subject and different methodologies for assessing critical raw materials (CRM) have been developed. Most of them are based on supply risk and vulnerability of a system to a potential supply disruption (Erdmann and Graedel, 2011). Security of supply is also one of the conditions for ensuring a sustainable supply of raw materials. It is debated if environmental Life Cycle Assessment (LCA) (ISO 14044, 2006) should take into account resource security, as well as other socio-economic issues related to resources or if these aspects should be included in a social LCA (Klinglmair et al., 2014; Mancini et al., 2013; Mancini et al., 2015).

Nevertheless, resource security is a recurrent issue over history, mainly determined by the uneven geographical distribution of mineral reserves around the globe and the consequent import dependency in resource-poor countries (Buijs et al., 2012). This concern has recently regained importance. Global population growth, new consumption habits, technological change and economic development of some countries have enlarged the demand for raw materials both in terms of amount and variety of materials used. Some metals are increasingly relevant for emerging technologies, including those that are supposed to contribute to more sustainable societies, e.g. low carbon energy supply and transportation technologies.

Supply of raw materials can be threatened by different factors: geological, technological, geo-political, economic, environmental and social. In the criticality assessments the aspects that are commonly included are related to the raw materials markets and economy (e.g. market concentration, consumption and demand); technology (e.g. recycling potential, substitutability, by-products, etc.) and geo-political (governance and political stability of producing countries). Biophysical availability of raw materials is also included in some assessments (Morley and Eatherley 2008; Erdmann et al., 2011; Graedel et al., 2012) while in others this aspect is not addressed due to the short time frame of the study, e.g. in the assessment of CRMs for the European economy by the European Commission (EC, 2010; EC, 2014). In this methodology the identification of CRMs is based on two main variables: economic importance and supply risk.

Resource availability for present and future generations is a central issue in the sustainability science. In LCA natural resources represent one of the areas of protection (next to natural environment and human health). The impact related to resource use is assessed through different methods, in which limitations to the accessibility due to geopolitical reasons are usually not taken into account. The need of taking into account in LCA the economic and geopolitical aspects that can reduce resource availability has been acknowledged (Schneider et al., 2011; Mancini et al., 2015). It is, however, also debated if the aspect of resource security of supply, or even socio-economic issues in general, should be accounted in so-called (environmental) e-LCA or in a (social) s-LCA (Mancini et al., 2013). An example proposal for including this concept in e-LCA is reported in Schneider (2014), where the Economic Scarcity Potential (ESP) is proposed as an aggregate indicator. It gathers eight different aspects related to the resource security (including governance, concentration of supply, application of trade barriers, demand growth, etc.) and setting thresholds of risk. EPS was calculated for 17 metals.

8.1 Inclusion of criticality in supply chain analysis

Having information on the use of critical resources in supply chains is very useful in eco-design contexts and policy making. This information can support and guide the minimization of CRM use, or maximization of benefits from them, their recovery in waste management and substitution. As security of supply is a socio-economic aspect, it is questionable if it should be accounted in the e-LCA (which includes a dedicated area of protection on natural resources) or in the s-LCA (where social impacts are addressed). We argue that even if the use of critical raw materials does not constitute an environmental issue per se, the current framework of e-LCA, accounting inputs and outputs in the supply chain, is most suitable for assessing the impacts linked to the use of physical resources. Indeed, the inventoried flows are measured in mass unit in e-LCA, while in the s-LCA the inventory data are accounted in dollars or working hours.

LC inventories could be readily used to analyse the use of CRM along the life cycle, relying on the outcomes of governmental critical raw material assessments. At impact assessment level indicators used for the assessment of criticality can be applied to develop characterization factors for the impact category "resource security". As outlined in Mancini et al., (2013), the main methodological hurdles and inconsistencies that have to be faced in this operation consist of: (i) the "relativity" of the criticality assessment (generally referred to a subject, a geographical region, a timeframe); (ii) the presence of elements of subjectivity (i.e. thresholds are set to establish which materials are critical); (iii) the temporary nature of the assessments (the condition of criticality can quickly change over time, even in the short run).

8.2 Proposal for the inclusion of criticality in LCA

The methodology for the identification of CRMs for the European Union combines two main variables: economic importance (EI) and supply risk due to poor governance (SR_{WGI}). The latter encompasses four sub-components: (1) level of concentration of worldwide production of raw materials (using the *Herfindahl-Hirschman Index* (HHI)); (2) political and economic stability of the producing countries (using the *Worldwide Governance Indicator*); (3) potential of substitution of the raw materials (estimated through experts' opinion); (4) recycling rate (considering the shares of EU consumption of raw materials addressed through secondary materials). A group of experts set criticality thresholds for SR_{WGI} and EI values that define an area of criticality; the materials located in this area are defined as CRMs. (EC, 2014).

We argue that SR_{WGI} data provided in the EC study on CRMs could be used in LCA for evaluating resources consumed in a product's life cycle in terms of resource security. In the impact assessment phase, the amounts of resources used in the supply chain (composing the inventory) can be multiplied for the SR_{WGI} factor, providing an indicator of the total resource security impact. This information could complement the existing indicator on resource depletion that does not take into account the access to resources.

The choice of supply risk as indicator allows overcoming the methodological hurdles listed above: (i) the indicators that compose SR_{WGI} (e.g. WGI and HHI) are calculated at global level (while the EI is assessed at EU level), or are based on expert judgment; recycling rate is assessed through shares of EU consumption, but these values could be substituted with global estimates on recycling rates provided by UNEP (Unep 2011) (ii) no thresholds or other subjective elements are included in this indicator (iii) frequent updates of the CFs could provide consistent assessments.

8.3 Implementation options and testing example

In LC impact assessment the input/output flows compiled in the inventory of materials consumed and emissions are quantified in terms of indicators through characterization factors (CFs). An emission or resource flow is multiplied by a factor to give an indicator. The nature of the indicators varies, some reflecting contributions to impacts, risks, or pressures; some reflecting environment, health, and/or socio-economic considerations.

SR_{WGI} data provided in the CRM study for EU could be used as CFs in a new impact category called "resource security". However, the SR_{WGI} dataset has a low variability, and the relative difference between materials in terms of security would be not well represented if these values are applied as linear weighting factors.

In order to obtain factors that could better represent the supply risk, two different options could be envisaged:

- raising the values with an exponent, that could spread the resulting values in a wider range
- dividing the values of supply risk by a measure of the size of the market, e.g. the world mine production in a given year, in order to assign more importance to specialty materials having small markets.

Three methodological options have been tested using an example dataset:

- baseline option: SR_{WGI} values as such
- option 1: $(SR_{WGI})^6$
- option 2: SR_{WGI}/world mine production in 2011[12]

A further option is to use the list of CRM published by the EC and apply a binary variable as CF, that assign the value 1 for the materials included in the list as critical and 0 to the non-critical ones. An extended presentation of options for calculating characterisation factors for CRM's is reported in Mancini et al., 2016.

The product used for testing the different options is a multi-crystalline silicon photovoltaic (PV) panel of one square metre and weight of 26 kg. The inventory includes the following raw materials: silicon, silver, aluminium, chromium, cast iron, copper, manganese, magnesium, zinc (Jungbluth et al., 2009).

Table 8 presents the results of applying the different options of CF based on SR_{WGI}. It also includes information on the CFs resulting from the three methodological options and the amount of raw materials included in the inventory.

In terms of mass, aluminium and silicon are the most important raw materials. CFs have the same ranks in the baseline and option 1, with magnesium and silicon having the highest CF; in option 2, where mine production is taken into account, the ranking is different and silver has the highest CF.

In terms of impact result, Figure 13 presents a contribution analysis of the total impact calculated with different CF sets, next to the contribution of the different metals in terms of mass and the "binary approach". In the baseline case, the contribution of silicon is the most relevant, followed by aluminium. This reflects the contribution of the raw materials in terms of mass, even though in this case the order is inverted. Using the CF from the option 1, i.e. applying the exponent 6 to the SR_{WGI} values, the materials with the higher supply risk factor pop up, while the amount of material used has less importance; indeed magnesium is the most relevant contributor to the total impact. It is noted that the choice of the exponent is arbitrary, and the variability of the results increases as higher exponents are applied, as well as the distance between the minimum and the maximum value. In this exercise the exponent 6 is chosen as an example. But, this choice is not underpinned by a biophysical law or scientific evidence. The choice rather depends on the importance one wants to assign to the risk (instead of the mass). In option 2 the supply risk relates to the size of the market, using data on mine production in 2011. This allows highlighting the materials that are used in small amounts over the bulk materials. Therefore, silver has a more relevant contribution (in spite of its low mass in the inventory), together with silicon and magnesium. Due to the incomplete statistics on magnesium production (that do not include US mine production), the figure on magnesium production is underestimated and therefore the CF2 and the related impact are overestimated. In the binary approach all the impact is due to silicon and magnesium; using this approach all the materials that are not critical in the EU list are

[12] Data on mine production are from USGS (US Geological Survey 2011)

cut off, even if they have high risk values and are very close to the criticality threshold. From the other side, this method accurately reflects the policy priorities on raw materials.

Table 8 Resource security impact assessment results of a PV panel (1m²)

	Input flow	**resource security impact**			**characterization factors**		
Material	mass (kg)	Baseline	SR1	SR2	CF baseline	CF1	CF2
Silicon	1.545	2.52	28.98	3.15E-07	1.63	1.88E+01	1.40E-11
Silver	0.009	0.01	0.23	2.73E-07	0.73	1.51E-01	8.42E+00
Aluminum	2.537	1.09	0.01	2.47E-08	0.43	6.32E-03	2.53E-05
Chromium	0.008	0.01	1.64	3.37E-10	1.01	1.06E+00	4.43E-04
Cast iron	0.011	0.01	0.02	1.91E-12	0.5	1.56E-02	1.66E-06
Copper	0.115	0.03	0.00	1.58E-09	0.22	1.13E-04	2.50E-03
Manganese	0.013	0.01	0.01	4.10E-10	0.43	6.32E-03	2.35E-05
Magnesium[13]	0.080	0.20	405.27	2.60E-07	2.53	2.62E+02	2.48E-06
Zinc	0.005	0.00	0.01	1.94E-10	0.45	8.30E-03	3.65E-03

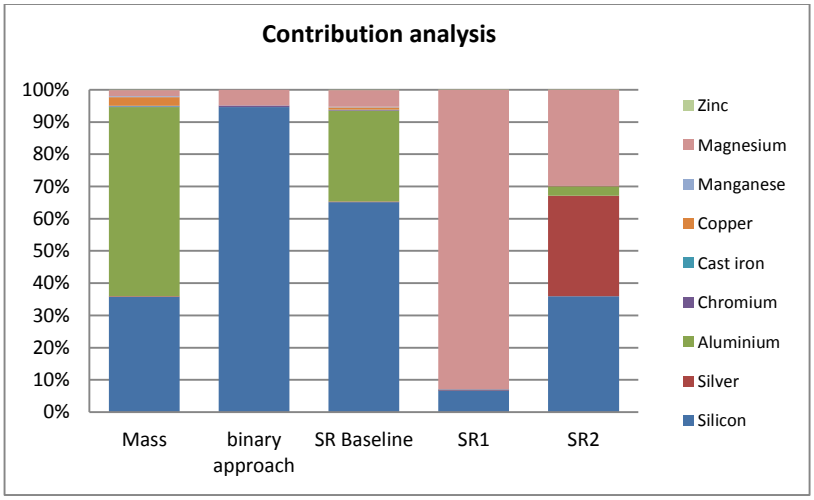

Figure 13 Contribution analysis from different options for characterization

8.4 Conclusions

This chapter suggests that so-called environmental-LCA is well positioned to include resource criticality considerations; essentially a socio-economic indicator. Separate

[13] USGS statistics for magnesium production do not include US production; hence, the CF2 is overestimated

consideration in social LCA, in relation to human flows related to product life cycles, is not needed for this particular calculation.
Different options for the calculation of resource security impact have been shown, and the outcomes of the different choices are illustrated through an example on a PV panel. Data on supply risk due to low governance used as characterization factors (baseline) does not well represent the relative difference in raw materials security, and the impact depends mainly on the masses. Applying an exponent to the supply risk dataset the values are spread on a wider range and the impact depends more on the risk factor. The choice of an exponent is arbitrary and arguable; therefore it could be established in a stakeholder consultation.
In the third option the supply risk is related to the annual mine production, which indicates the market size; this method gives more importance to specialty metals. Using a 0/1 variable for calculating the impact leads to the consideration of the materials that are defined as critical in the list published by the European Commission and the exclusion of the non-critical ones, even if their value of risk is very close to the thresholds.
Even though the choice of an option over the others is not possible at this stage and more implementation examples are needed, this exercise is expected to contribute to the discussion on the inclusion of criticality in LCA. Further analysis could be conducted including also the economic importance of materials, and comparing results with other LCIA methods and indicators.

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9. Social sustainability of mining sector

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9.1 Introduction

Metals and minerals play a fundamental role in meeting societies' needs and fostering the economic development. Through the centuries, the demand of raw materials has evolved quantitatively and qualitatively: population growth, economic and technological development and new consumption styles have required increasing amounts and a wider variety of raw materials.

By the late 19th century, the role of mining in Europe declined and in the 20th century mining location shifted from developed to developing countries. Nowadays six resource rich countries (Chile, Brazil, Peru, South Africa, Zambia, Democratic Republic of Congo) produce almost 25% of the global supply, and Australia, Canada, China and Russia are also major supplier (ICMM 2012). There are several reasons why Europe became more and more dependent on imports of metals and minerals. First of all, colonial relationships and the expansion of higher valued added sectors (i.e. manufacture and services) made the provision of raw materials from extra EU countries relatively convenient from an economic point of view. Moreover, heavy environmental and social impacts (including severe labour security issues) associated to the mining activity induced most of the European governments to disincentivize this sector and rely more and more on imports. Consequently, impacts have been shifted to the producing countries (that barely can be assessed through the currently available sustainability assessment methods) and the importing countries are more vulnerable to commodity price volatility.

Concerns on the security of supply of raw materials have been rising periodically over the history, especially in import dependent countries. In European Union, the risk of supply disruption due to, e.g., the application of protectionist measures, and the potential repercussions on the competitiveness of downstream industries has intensified in the last years. In 2008, the European Commission launched the Raw Materials Initiative (RMI), based on three main pillars: to ensure the access to raw materials on world market at undistorted conditions; to foster sustainable supply of raw materials from European sources and to reduce the EU's consumption of primary raw materials (EC - European Commission, 2008). The EC also identified the materials facing the highest supply risk with respect to the whole economy, called Critical Raw Materials and deserving better monitoring and further potential policy actions (EC - European Commission, 2014a, 2011).

Due to the renewed interest on raw materials and the need of fostering a sustainable European supply of raw materials, the assessment of environmental and social impacts linked to the mining sector has gained increasing attention.

9.2 Mining and sustainability

The mining industry has a fundamental role in the creation of economic value, providing raw materials to the downstream industries, and in achieving human well-being by meeting its materials need and creating employment. On the other hand, extractive operations lead to a variety of environmental impacts (including disturbance of the landscape, air and water pollution) and a variety of social impacts (e.g. above average threats for health and safety of workers and citizens: for instance, underground metalliferous mines have the highest incidence of fatalities, and gold industry the highest average fatality rate) (IIED and WBCSD, 2002). In order to improve its performance and gain social trust and acceptance the mining industry has engaged since the years 2000-2002 in the sustainability debate, e.g. through the Mining, Minerals and Sustainable Development (MMSD) project and other international initiatives aimed at improving the sustainability performance, e.g., strengthening reporting of economic, environmental, and social performance (Global Reporting Initiative) or improving accountable and transparent governance in resource-rich countries (Extractive Industries

Transparency Initiative). Moreover, the International Council on Mining & Metals, as a global industry representative body, established a set of 10 principles for sustainable development, which company members are required to implement (Buxton, 2012).

In this chapter, we present a literature review of the main social impacts related to this sector, and we point out to what extent these are covered by e.g. the Social Hotspot Database, and would therefore be captured in a related Social Life Cycle Assessment study. The contribution is not intended to be a complete review on the topic, but aims at highlighting the main social issues of concern for the mining sector, which have been treated in the scientific literature and in reports from NGOs, international organizations and industries organizations.

9.3 Literature review of social impacts of the mining and minerals sector

This analysis of the literature took into account twelve studies, eight scientific papers and four reports from international organizations. The list of reviewed studies is reported in Table 9. From the review, social impacts associated with the mining industry can be clustered into six main macro areas:

1. Economy and income: economic impacts can be both positive and negative; while the mine opening can give stimulus to the local economy and increase the population income, conflict over the distribution of the benefits coming from the resource extractions and corruption due to the bad management of mineral wealth are also described in the literature.
2. Employment and education: the creation of jobs is a relevant positive consequence of the mining activity, but many negative impacts related to the quality of job, dangerous working conditions and high frequency of accidents, child labour and lack of freedom to organize in trade unions are also reported.
3. Land use and territory: land competition can arise when mining projects are developed and a consequent negative impact on population is the displacement and resettlement of communities. A limited access to land for the rural population implies a consequent negative impact on livelihood and therefore food insecurity. The presence of a mine in the territory can also have a positive effect in terms of infrastructure provision and therefore improved access to health and education.
4. Demography: the mining activity is likely to attract workers also from other regions and cause migration flows and a change of the demographic structure in the mining town. A gender imbalance can emerge due to the prevalence of male workers, undermining social cohesion and the spread of problems of a psychological or behavioural nature. The inflation and the rising cost for accommodation can also negatively affect the local population.
5. Environment and health: environmental and health impacts are well documented in the literature, even though the analysis of the ecological consequences of the extractive activity is out of the scope of this chapter. Many environmental impacts, however, can severely affect human health of the local communities, having, e.g. toxic or carcinogenic effects.
6. Human rights: violation of human rights can have different forms and include discrimination of vulnerable groups as well as lack of stakeholder inclusions especially with regard to the indigenous populations.

Table 9 List of reviewed studies

N°	Reference	Typology
1	Azapagic, 2004, Developing a framework for sustainable development indicators for the mining and minerals industry.	scientific paper
2	Kitula, 2006. The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District.	scientific paper
3	Solomon et al., 2008. Social dimensions of mining: Research, policy and practice challenges for the minerals industry in Australia.	scientific paper
4	Petkova-Timmer et al., 2009. Mining developments and social impacts on communities: Bowen Basin case studies.	scientific paper
5	Kotey and Rolfe, 2014. Demographic and economic impact of mining on remote communities in Australia.	scientific paper
6	Parsons et al., 2014. Maintaining legitimacy of a contested practice: How the minerals industry understands its "social licence to operate."	scientific paper
7	Owen and Kemp, 2015. Mining-induced displacement and resettlement: a critical appraisal.	scientific paper
8	IIED and WBCSD, 2002. Breaking new ground: Mining, minerals and sustainable development.	report
9	Environmental Law Alliance Worldwide, 2010. Guidebook for evaluating mining projects EIAs.	report
10	Switzer, 2001. Armed Conflict and Natural Resources: The Case of the Minerals Sector.	report
11	Franks, 2012. Social impact assessment of resource projects.	report
12	Hajkowicz et al., 2011. The relationship between mining and socio-economic well-being in Australia's regions.	scientific paper

The Social Hotspot Database (SHDB)[14] was created for facilitating the Social Life Cycle Assessments at a macro scale, ensuring the access to information about working conditions and impacts and global supply chains. It provides social risk data on a sector and country level, and is integrated with a global input-output model derived from the GTAP database. It allows modelling of social impacts and risks and covers 22 social themes (e.g. child and forced labour, wage assessment, freedom of association, human health issues, gender equality, etc.) for numerous countries and sectors (figure 14).

In Table 10, describing the social impacts emerged from the literature review and the related source, it is pointed out if the aspect is accounted in the SHDB.

[14] http://socialhotspot.org/

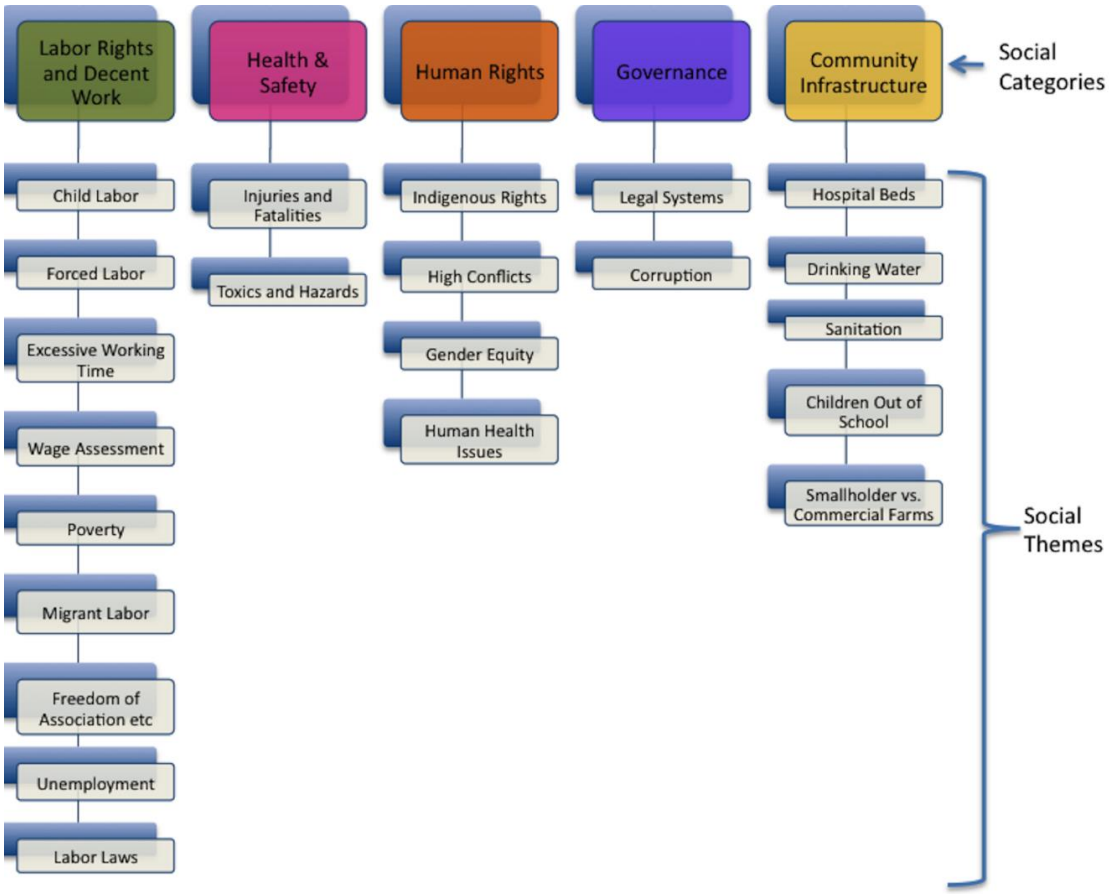

Figure 14 Social categories and social themes included in the Social Hotspot Database

Table 10 Social impacts in the mining sector documented in the literature

POSITIVE IMPACTS	source	SHDB?	NEGATIVE IMPACTS	source	SHDB?
Economy and income					
Contribution to local income and poverty alleviation	2,8, 11, 12		Bribery (to obtain licences and permits or to sway judicial decision) and corruption (due to bad management of mineral wealth)	1,8, 11	x
Business & employment opportunities in other sectors due to revitalized economy	2,4		Thefts and accidents	2	
			Low level of economic stimulus from mining due to the prevalence of non-resident workers	4	
			Conflicts[15] and social tensions due to the inequitable distribution of benefits and	8, 10	x

[15] conflict minerals are also addressed in "additional issues"

			costs with communities		
POSITIVE IMPACTS	**source**	**SHDB?**	**NEGATIVE IMPACTS**	**source**	**SHDB?**
Employment and education					
Employment (direct and indirect to community and national economy)	1, 4, 11, 12		Child labour, forced and compulsory labour	1, 2	x
Employee skill development and further education	1, 12		Dangerous working conditions (fatalities at work, work related accidents)	1, 8, 11	x
			Lack of freedom to organize in Trade Unions and non-conformity with the requirements of the International Labour Organization convention	1	x
			Creation of mostly temporary jobs in relation to permanent, low stability of jobs and the workforce	1	
Land use and territorial aspects					
Improved infrastructure, telecommunications, road network, power and water supplies, improved access to health and education	2, 11, 12	x	Population displacement and resettlement (and consequent unemployment, landlessness, homelessness, loss of common resources, impoverishment of living standards)	1, 2, 7**,** 8, 9, 11	
			Limited access to land and consequent impact on livelihood, food insecurity, and loss of protected areas	2, 8, 9, 11	
Demography					
Positive impacts due to demographic change and population growth	5		Population growth and gender imbalance in mining communities (and consequential alcoholism, drug and prostitution, domestic violence, sexual violence, change in social norms, culture and customs, migration, high school turnover)	2, 4, 9, 11	
			Inflation, rising cost and access of accommodation for workers other than mining	4, 11	
Environment and health					
			Negative health impacts and safety on workers	1,2,9, 11	x
			Negative health impacts and safety local population	1	x

			costumer health and safety		
POSITIVE IMPACTS	**source**	**SHDB?**	**NEGATIVE IMPACTS**	**source**	**SHDB?**
			Environmental impacts affecting social conditions and health (e.g. reduced water supplies or water contamination)	2,8, 9, 11	x
Human rights					
			Human rights abuses	1, 8, 11	x
			Impact on cultural and aesthetic resources	9, 11	
			Lack of stakeholder inclusion and non- involvement of indigenous communities	11, 7, 1	x
			Unequal opportunities and discrimination (gender based, marginalization vulnerable groups, i.e. disabled, aged, ethnic minorities, indigenous, young)	11, 7, 1	x
			Respect of the rights of indigenous people	1	x

9.4 Additional issues related to social sustainability of the mining sector

In addition to the social impacts summarized in the previous section, there are some other aspects related to the social sustainability of the mining sector that have drawn more and more attention in the last years. They relate to the societal acceptance of the extractive activity, the artisanal and small-scale mining, the consequences of mine closure and the conflicts rising around the exploitation of mineral resources.

9.4.1 Social licence to operate

The concept of "social licence to operate" (SLO) has emerged in the mid 1990s in response to a perceived threat to the industry's legitimacy due to the occurrence of environmental disasters (Boutilier and Thomson, 2011). This concept stems from the discourse of corporate responsibility and refers to a local community's acceptance or approval of a project or a company's ongoing presence, beyond formal regulatory processes. SLO derives from the acknowledgement that stakeholders may threaten a company's legitimacy and ability to operate through boycotts, picketing or legal actions.

The term SLO has been adopted by a wide range of actors in the resources sector, including mining companies, civil society and non-governmental organisations, research institutions, governments, and consultants. Social licence to operate has also been adapted by a range of other industries, including pulp and paper manufacturing (Gunningham et al., 2004), alternative energy generation (Hall et al., 2013) and agriculture (Williams et al., 2011). Different aspects can influence the social licence, i.e. demands and expectations, legitimacy, credibility and trust, and consent (Parsons et al., 2014).

Many studies highlight that in order to obtain a SLO, mining companies have to develop good relations with all the stakeholders. In Thomson and Boutilier (2011) legitimacy, credibility and trust are identified as the main components necessary to achieve a SLO, while (Moffat and Zhang, 2014) highlight that the community trust in a mining company is the central element. Such trust is affected by the extent to which a mining company manages and mitigates operational impacts. Moreover, the way companies engage with communities and treat community members will influence community trust and therefore their acceptance to mining operations. Other aspects, i.e., the importance of the social and environmental context, establishing good relationships with the community, transparency and information disclosure, good and open communication, public participation and stakeholders involvement are seen as crucial for achieving SLO in other studies (Browne et al., 2011, Prno, 2013).

Mining companies should also be sensitive to cultural norms, create realistic expectations, develop fair conflict resolution mechanisms, be consistent and predictable regarding their ethical behaviour and try to accommodate the needs of the community. From a company perspective, obtaining a SLO is essential for reducing the risk of public criticism, social conflict, and damage to the company reputation and at consequently reduce its profitability. A content and discourse analysis of sustainability reports presented in (Bice, 2014) reveals that Australia-based mining companies define sustainable development and their social licence to operate through three broad areas of interest: environment, social and community issues (including health and education) and employment practices (including occupational health and safety and employee relations).

9.4.2 Artisanal and small-scale mining

Artisanal and small-scale mining (ASM) refers to mining by individuals, groups, families or cooperatives with minimal or no mechanisation, often in the informal (and illegal) sector of the market (Hentschel et al., 2002). Despite many attempts, a common definition of ASM has yet to be established. In some countries a distinction is made between 'artisanal mining' that is purely manual and on a very small scale, and 'small-scale mining' that is more mechanised and on a larger scale. In some West African countries (Mali, Niger and Burkina Faso), small-scale mining is differentiated from artisanal mining by the presence of permanent, fixed installations established once the existence of an ore body is confirmed (ibidem).

According to the World Bank, ASM employs 100 million people globally, with artisanal and small-scale gold mining employing 15 million people alone. It is believed to provide a livelihood for over 100 million, almost all of whom live in developing countries. In general, this activity is labour intense, and mechanization, capital and technologies are poorly employed (ICMM, 2011). According to a study within the Mining, Minerals and Sustainable Development Project (Hentschel et al., 2002) the following features characterize the ASM:

- lack or very reduced degree of mechanization, great amount of physically demanding work
- low level of occupational safety and health care
- deficient qualification of the personnel on all level of the operation
- inefficiency in the exploitation and processing of the mineral production (low recovery of values)
- exploitation of marginal and/or very small deposits, which are not economically exploitable by mechanized mining
- low level of productivity, salaries and income
- periodical operation by local peasants or according to the market price development
- lack of social security
- insufficient consideration of environmental issues
- chronically lack of working and investment capital
- mostly working without legal mining titles

ASM can operate within formal and informal sector (including illegal mining) and is associated with significant environmental and health impacts. However, it is also acknowledged that ASM plays a crucial role in alleviating poverty, increasing community capital and diversifying the local economy in many rural regions of the developing world, because it can be practices in remote areas with minimal infrastructure where large scale industries could not function. Women are highly involved in the activities associated with ASM in developing countries, representing a third of the total workers (ICMM, 2011). ASM can be practiced as a main source of income and therefore be a key component of traditional livelihoods, or can be a secondary mean of livelihood and be practiced seasonally in combination with the agricultural activity. ASM can also be driven by shocks, i.e. drought, economic collapse, commodity price fluctuations, conflict, etc.

9.4.3 Mine closure

The mining sector can be a very important contributor to the national and local economies, especially in resource rich countries. For this reason, mine closure can have significant impacts on the local community. Indeed, mining is a temporary activity, with the operating life of a mine that depends on the size and quality of the mineral deposit being extracted, lasting from a few years to several decades. Mine closure occurs once the mineral resource at a working mine is exhausted, or operations are no longer profitable. Laurence (2006) identifies seven reasons that can lead to the premature closure of mines:

- Economic, e.g. when commodity prices decrease, making resource extraction no longer profitable;
- Geological, when reserves are overestimated a premature closure can occur;
- Geotechnical, when the rock mass has imperfection falls, inrush, filling, etc. can take place and produce accidents and lead to the closure of the mine;
- Equipment failure (causing also severe accident and injuries)
- Regulatory pressure, due to, e.g., environmental or safety breaches
- Government policy, e.g. in case of change of land use preferences and allocation to other uses;
- Community opposition.

The main social implications of premature mine closure include job losses, consequential negative impact on the local economy and decreased well-being. Unemployment can be a long-lasting problem after the mine closure, leading to the worsening of living standards, impoverishment, and the emergence of informal, insecure forms of employment at lower wages with fewer legal and social safeguards. Migration is also directly linked to the worsening of the global market. Mine closure has also a negative impact on services to the population that are provided locally and associated with the municipal budget. The loss of enterprises and personal income taxes reduce the municipal revenues, affecting the delivery of social services. Community cohesiveness can also be affected as a consequence of the previous impacts. The negative shocks of mine closure can indeed undermine social instability and cause problems of a psychological or behavioural nature, including various manifestations of socially undesirable or self-injurious behaviour such as substance abuse, prostitution and children abandonment (Haney and Shkaratan, 2003).

9.4.4 Conflict minerals

According to the political economist and geographer Philippe Le Billon, conflict minerals are those minerals "whose control, exploitation, trade, taxation, or protection contribute to, or benefit from the context of, armed conflict." (Le Billon, 2001). Actors involved in conflicts can be both a country's regular army and rebel groups or warlords. Usually the profits derived by the trade of minerals are used to purchase weapons and other finance the armed conflict. In the case of the Democratic Republic of Congo, different national army units have gained control over the mineral rich areas of Kivu regions and have been fighting for the resource rent (UNSC, 2010). Due to the complexity of the global

supply chain and the number of actors involved, however, is not always easy to establish who benefits from the situation.

Conflict minerals are part of a scholarly debate, emerged in the Nineties, on the link between a country endowment of natural resource and conflicts, the so called "resource curse" hypothesis (Ballard and Banks, 2003; Bleischwitz and Bringezu, 2007; Le Billon, 2001). The combination of open access to resources and weak governance and institutions are especially facilitating this phenomenon.

Minerals that are commonly involved in conflicts are casserite (tin), coltan (tantalum), diamonds, gold and wolframite (tungsten). In the case of diamonds, an international governmental certification scheme, the Kimberley process, was set up in 2003 to prevent the funding of conflict and ensure that diamond purchases are not financing violence by rebel movements (Kimberly process, http://www.kimberleyprocess.com/). In 2010, the OECD (Organization for Economic Cooperation and Development) published the "Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas", in order to provide recommendations to companies for avoiding human rights violations and contribution to conflicts and enable responsible mineral supply chains (OECD, 2013). In the US, the Dodd-Frank Act signed in July 2010 requires companies to ensure the raw materials they use to make their products are not tied to the conflict in Congo, by auditing the mineral supply chains. Therefore, supply chains have to be traced and audited. At EU level, recently the Commission proposed to set up a "Union system for supply chain due diligence self-certification of responsible importers of tin, tantalum and tungsten, their ores, and gold originating in conflict affected and high-risk areas"(EC - European Commission, 2014b).

9.5 Conclusions

Impacts linked to the mining activity are very diverse and largely differ depending on the geographic area where the activity is taking place. From the literature review emerged that studies documenting more positive impacts due to mining refer to case studies performed in Australia, suggesting that the development and governance status of the country is strictly related to the emergence of negative impacts. The brief analysis allowed checking the coverage of aspect in the Social Hotspot Database (SHDB), an emerging data provider available for performing a Social Life Cycle Assessment (S-LCA) at a macro scale. The database has coverage in the categories of labour conditions, health impacts and human right, while the aspects related to the access to land and in particular displacement and resettlement of the local communities are not included. Positive impacts derived from mining are also overlooked in the database, but there is still a lack of consensus on how positive impacts should be taken into account in a Social LCA. Further important issues related to the mining sector, not strictly defined as impacts, were briefly described separately. Even if these topics can be more difficult to quantitatively assess, they are important drivers for other impacts and can heavily influence the economic, social and environmental performance of mining companies.

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10. Discussion and conclusion

Social Life Cycle Assessment may represent a very valuable approach for accounting for social impacts associated to production and consumption along supply chains as well as to support decision makers in different contexts (e.g., business and policy). Indeed, S-LCA can be used to explore supply chains at different scales (Micro -products, Meso -sectors, Macro- countries) being used by different actors with different perspectives (Policy, Business, NGO's).
However, from this report, it is clear that the application at product level is still in a preliminary stage and relevant efforts are needed to improve reliability, robustness and applicability of current approaches.
Starting from the **theoretical foundations**, the inherent nature of S-LCA, stemming from its environmental counterpart, is currently questioned in the literature as if it should have the same methodological framework as LCA or if it should be based on different basis, using indicators and models that usually cannot be empirically verified. Theoretical basis and the nature of S-LCA are under discussion in the scientific community. In particular, it is questioned if S-LCA should be based on a post-positivist epistemological paradigm (as LCA) or on a constructivist paradigm, as for the post-normal science. Therefore, it was discussed if qualitative or quantitative assessment methods are more suitable for S-LCA. It was stressed that in S-LCA the evaluation is strictly context bounded and a certain level of subjectivity cannot be avoided, therefore the generalizability is limited. Furthermore, the question of what the Areas of Protection (AoP), what human well-being is and what is to be achieved should be furthered explored through a normative framework. The principles of the capabilities approach would be one of the conceptual frameworks that could further strengthen the multidisciplinary needs through philosophical perspectives to evaluate human lives and needs (Reitinger 2011).
It can be noted that if sustainable development lacks an agreed theory of development, S-LCA lacks a social theory. It is important to make clear that S-LCA should not be a copy of E-LCA, but has to have a different framework, even though the focus on supply chain should be maintained. The need for an interdisciplinary approach for the development of S-LCA and the need to bring together knowledge, concepts and methodologies from different frameworks and disciplines is becoming a clear path.
From a practical implementation point of view, our brief review (chapter 2) spotted several critical points (some of them already presented in Zamagni et al 2011) which are still not solved and harmonised. For example, the definition of the functional unit, the company vs the products perspectives, the geographical and cultural context in which the supply chain is taking place as well as the definition of what is included under the concept of "social impacts".

It is increasingly clear that there are overlapping and complementarity issues between S-LCA and LCA and the opportunity of an **integration/complementarity** of the two methodologies is existent (as discussed in chapter 6 and specifically for critical raw materials, in chapter 8); this may require the use (or not) of the same functional unit and the necessity to avoid double counting. However, this brings its own difficulties as, e.g., it has been questioned if the proper functional unit for S-LCA is the product, or if looking at the company is a more suitable way to make a social assessment. Furthermore, there are still some contradictory elements that emerge between S-LCA and other methodologies; there is the need of reconciling the S-LCA and the other dimensions. For instance, S-LCA assumes that high paid employment is a benefit, while in LCC this is the opposite. A comprehensive integration towards a sustainability assessment still needs considerable efforts.

There is a wide **variety of indicators** adopted for assessing social impacts and their selection depends on the method, data availability and specific contexts. The recently agreed UN's sustainable development goals with their horizon up to 2030 should be used as a model to shape society's path for the next 15 years. The SDG goals have been split into 17 initiatives and 169 targets, where 8 initiatives are directly linked to social aspects and which could help shape future indicators, coverage and aims of S-LCA. Furthermore, the process towards the achievement of these goals and targets should produce very

useful data that could improve the much needed current databases for S-LCA. Given the prominence of certain social aspects (such those recently reported amongst the SDG's) there is ultimately some general agreement on the importance of covering certain social themes. However, so far, most of the case studies showed the difficulty in conducting a comprehensive S-LCA especially in terms of data availability, quality, and reliability. This affects also those data retrieved from existing databases (as presented in chapter 4, for an overview). Besides, the perception of the severity of an impact is associated to cultural values and context-related elements, which should be identified and understood. Furthermore, for specific sectors, current database may miss important drivers of social impacts, therefore the completeness issue should be tackled (see chapter 9 and the discussion on the social impacts associated to e.g. mining sector).

Furthermore, not only impacts but also benefits could be the focus of the assessment. Assessing **positive impacts** broadens the horizons of social assessments and although it brings it a step closer to reality, it also complicates the assessment of social issues, as certain activities can lead to positive social outcomes that are hard to capture and/or quantify, an interesting issue to further investigate. The method to evaluate positive impacts in S-LCA is under debate (as presented in the review in chapter 5), as well as the need of proper indicators. Positive impacts give another interesting dimension to the reality assessed, but also bring along further difficulties.

Another issue that needs further exploration is the **interpretation of results** from S-LCA. It is still problematic and most of the studies have a gate to gate approach, and do not consider the whole life cycle. It is important to be able to complement data (that enable measurement) with information (allowing understanding and reducing uncertainty). In general, the need of trading off scientific foundations and of normative framework is still of high importance. Besides, uncertainties associated to results are barely discussed in literature, whereas they could be extremely high due to data quality and availability.

The **involvement of stakeholders and their underpinning values** are a crucial aspect that will need to be further taken in to account (as illustrated in chapter 2). In S-LCA the identification of the normative framework is very important as well as the involvement, where possible, of stakeholders that is possible only through field investigation. Indeed, empirical field work and involvement of the stakeholders are identified as important requirements for S-LCA, even though the field investigation could be very costly and time demanding, especially for the assessment of complex supply chains. Moreover, the involvement of stakeholders can be unfair, since certain groups have less chances and technical possibilities to participate in the assessment.

S-LCA should definitely **support decision making** by different actors. This could be done partnering on how to best reduce the hotspot of impacts identified in the supply chain. Here is where a company's CSR policies can influence the conduct of its suppliers and where sustainable certifications can play an important role. Optimally, and it is becoming more frequent, there should be joint collaborations between Companies, NGOs and public institutions to holistically tackle social impacts in supply chains. Besides, the role of economics in LCSA should be better and further explored (Hall, 2015), as in the example of the assessment of social impacts applied to economic sectors of trading (Chapter7). Overall, S-LCA is becoming an important approach for the assessment of supply chains and has a strong potential for improvements, but it requires further interdisciplinary and transdisciplinary effort before being ready to robustly support policies.

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List of abbreviations and definitions

LCT- Life Cycle Thinking	A perspective to include all stages of a product's life from cradle to grave
LCA –Life Cycle Assessment	A method for assessing environmental impacts associated with all the stages of a product's life from cradle to grave
S-LCA - Social Life Cycle Assessment	A method for assessing potential social and socio-economic impacts throughout all the stages of a product's life from cradle to grave
LCC- Life Cycle Costing	A method for assessing cost in a life cycle perspective
LCSA-Life Cycle Sustainability Assessment	LCSA is a method or a family of methods which aims at assessing environmental, social and economic impacts and benefits towards more sustainable products throughout their life cycle
CSR - Corporate Social Responsibility	CSR is a management concept whereby companies integrate social and environmental concerns in their business operations and interactions with their stakeholders
CRM - Critical Raw Material	CRMs are material which combine a high economic importance with risk associated with their supply

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