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SOCIAL LCA, SUSTAINABLE DEVELOPMENT, CSR: STATE OF RESEARCH? WHAT ARE THE METHODOLOGICAL NEEDS?

ACV SOCIALE, DEVELOPPEMENT DURABLE, RSE : QUELS BESOINS METHODOLOGIQUES ? OÙ EN EST LA RECHERCHE ?

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SCORE LCA is an association that has been created to financially support collaborative research on LCA and related topics. It aims to promote and organize cooperation between companies, institutional and scientists in order to support the evolution of LCA methods and its practical implementation at European and international level.

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RESUME

Cette étude vise à fournir un état de l'art de la recherche et des perspectives associées concernant l'analyse sociale du cycle de vie, tant d'un point de vue contextuel et méthodologique que des applications envisagées. Pour mener à bien cette analyse, il a été nécessaire de définir au préalable : le domaine d'application de l'ACV sociale, ainsi que les synergies existantes avec les standards RSE. Une revue de la bibliographie a été réalisée mettant en exergue les méthodes d'évaluation existantes, ainsi que les différents profils d'utilisateurs et les applications possibles. Grâce aux lignes directrices développées pour les analyses du cycle de vie sociales des produits, services et organisations, un cadre méthodologique, basé sur les normes ISO 14040 et 14044, a été établi. Grâce aux développements actuels (conférences, articles, séminaires et publications de groupe industriel), les méthodologies se diffusent, évoluent et gagnent en maturité. Cependant, l'analyse effectuée a clairement soulignée que l'ACV sociale est un sujet en perpétuelle évolution où des développements sont à prévoir ; tant au niveau de la méthodologie, des méthodes d'évaluation, de l'interprétation que de la communication associée ; afin d'assurer un avenir pérenne à cet outil en devenir.

MOTS CLES

Évaluation socio-économique et sociale, Analyse du Cycle de Vie, Responsabilité Sociétale des Entreprises, Catégorie de partie prenante, Sous-catégorie, Catégorie d'impact, Indicateur midpoint/endpoint.

SUMMARY

This study aims to provide a comprehensive overview of the current developments and its perspectives concerning Social Life Cycle Assessment (S-LCA), both from the methodology and applications points of view. This analysis started out by discussing and framing the definition of the scope of S-LCA and the synergies between S-LCA and the existing standards in terms of CSR. Then, to present the current state of the art of S-LCA, the differences existing between the Social Life Cycle Impact Assessment methods have been highlighted, and a systematic literature review has been carried out in terms of users and use. Through the existing guidelines for S-LCA of products, services and organisations, the field of S-LCA started establishing a framework building on the ISO 14040 and 14044 LCA standards. Through current development (conferences, articles, seminars and industry group publications), the method is spreading, evolving and gaining in maturity. However, the carried-out analysis clearly pointed out that it is an evolving field, and main developments to foresee, both at the level of methodology and results, interpretation and communication in order to find a path forward.

KEY WORDS

Social and Socio-Economic Assessment, Social Life Cycle Assessment, Life Cycle Assessment, Corporate Social Responsibility, Stakeholder categories, Subcategory, Impact category, Midpoint/endpoint category.

GLOSSARY

- AoP: Areas of Protection
- BR: Basic Requirement
- CBA: Cost Benefit Analysis
- CSR: Corporate Social Responsibility
- DALYs: Disability Adjusted Life Years
- E-LCA: Environmental LCA
- FU: Functional Unit
- GDP: Gross Domestic Product
- GRI: Global Reporting Initiative
- IA: Impact Assessment
- ILO: International Labour Organization
- LCA: Life Cycle Assessment
- LCC: Life Cycle Costing
- LCI: Life Cycle Inventory
- LCIA: Life Cycle Impact Assessment
- LCSA: Life Cycle Sustainability Assessment
- OLCA: Organisational Life Cycle Assessment
- PRP: Performance Reference Point
- QALYs: Quality Adjusted Life Years
- SAM: Subcategory Assessment Method
- SOLCA: Social Organisational Life Cycle Assessment
- SB: System Boundaries
- SDG: Sustainable Development Goal
- SETAC: Society of Environmental Toxicology and Chemistry
- S-LCA: Social Life Cycle Assessment
- UNEP: United Nations Environment Programme

SUMMARY

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1. Introduction

The aim of this report is to provide a comprehensive overview of the current developments in the field of Social Life Cycle Assessment (S-LCA) and its perspectives, both from the methodology and applications points of view.

The final objective of the study is to obtain a clear vision of the developments in S-LCA and to be able to argue on the means and interests to quantify today the social impact of a product, by adopting a life cycle approach. This vision will be reinforced by a roadmap of practical recommendations, which will identify the essential steps to be taken for further developing the methodology and its uptake, as a decision-support tool.

In addition, the findings could identify the methodological gaps and the complementary work needed to ensure the practical use and evolution of S-LCA in a broader global context, such as a framework for the Life Cycle Sustainability Assessment.

Reason-why for S-LCA

Traceability and control of the value chain are among the major challenges currently faced by companies in terms of environmental and socio-economic impacts. In this context, the S-LCA could be an effective methodology for measuring social impacts.

S-LCA is a multi-criteria, multi-stakeholder and multi-step analysis that provides useful, transparent and science-based information on social and socioeconomic performance of a product throughout its entire life cycle. The benefits of conducting such an analysis are many. S-LCA results enables an evidence-based decision-making process, which may be very useful in highlighting trade-offs between different alternatives (UNEP/SETAC). Indeed, S-LCA can be used to compare two or more products, services or organizations, by highlighting not only which one is better but how each performance outdo the other regarding the assessed criteria and the local context.

Furthermore, by identifying the social hotspots, S-LCA highlights the life cycle stages in which the potential improvements are critical.

As the international context becomes increasingly demanding on social issues, S-LCA may be a good way helping the companies to be compliant with ONU's Sustainable Development Goals. Thus, thanks to its complementarity with other CSR reporting tools and standards, S-LCA can be used in combination with other techniques or tools, to provide further information and help linking social impacts at the company level to the product's life cycle stages.

Finally, S-LCA may be an effective way to communicate with the company's stakeholders on social impacts providing that the results are tailored to the target audience.

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2. Definition and scope of Social Life Cycle Assessment

2.1. What does "social" mean?

In 1992 in Rio de Janeiro, the United Nations have declared "sustainability" as the guiding principle for the 21st century, and the term has then become popular thanks to the Bruntland report of the World Commission on Environment and Development (Klöpffer, 2002 - Klöpffer, 2008). In this report the definition of sustainable development ("the development that meets the needs of present without compromising the ability of future generation to meet their own needs") has been introduced, for the first time, and it has been emphasized the responsibility of humankind towards the future generation. (Klöpffer, 2002).

From a careful interpretation of the definition it has emerged that sustainability comprises (at least) three components, known as "pillars of sustainability", which have to be properly assessed and balanced if a new product has to be designed or an existing one has to be improved: environment, economy and social aspects (Klöpffer, 2002 - Klöpffer, 2008).

Furthermore, as a result of globalization and of the increasing complexity of modern economies, a new concept has become a focus of interest, passing from a narrow and often marginalized notion, to a complex and multifaceted concept: corporate social responsibility (CSR). (Fet, 2006 – Cochran, 2008). Corporate social responsibility has become an important component in the management of relationship between companies and community, public, employees and shareholders, since companies who successfully pursue a strategy of seeking profits while solving social needs may earn better reputation and gain a competitive advantage over companies esteemed socially irresponsible. (Fet, 2006 – Cochran, 2007).

Finally, the need to integrate the life cycle assessment (LCA) with the social aspects that led to the S-LCA dates to 15 years ago. Since then, there is certainly much increased interest around the social impacts of products, services, and organisations to promote sustainability. According to Jørgensen (2013), the S-LCA still needs to prove that « works » before it can be out of its infancy.

Concerning its definition[1], the main purpose of S-LCA is to provide decision support. This decision support may create an effect if decision makers follow the "advice" of the assessment and choose the alternative with the most favourable social consequences (Traverso et al. 2012b).

In order to increase the relevance of S-LCA for policy support, the development of indicators addressing both negative and positive impacts is fundamental. This may help assessing social aspects of global supply chains in a more comprehensive way and ensuring that life cycle-based methodologies are used to complement more traditionally monetary-based Cost Benefit Analysis (CBA).

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[1] SLCA is a social (real and potential) impact assessment method (Macombe et al. 2011) that aims to assess the social and socio-economic aspects of products and their positive and negative impacts along their life cycle encompassing extraction and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling, and final disposal (UNEP/SETAC, 2009).

2.2. What is the scope of Social Life Cycle Assessment?

The scope of a methodology refers to the extent of the subject matter that it deals with, which in this case means the depth and breadth of S-LCA. It is of paramount important to define and clarify it as it affects the consistency and robustness of the results.

More in detail, the scope is defined in terms of:

- Paradigm;
- Framework.

The paradigm represents a set of values, concepts, guiding principles (e.g. precautionary principle, dematerialization, decoupling) as well as perspectives used to define, assess and solve problems, and as such it provides the foundation for answering the "what" and the "how" of the question at hand:

- What is to be assessed and what questions are going to be asked;
- How the questions will be assessed;
- How the results should be interpreted.

According to the paradigm chosen, social values and ethical and ideological positions underlying the indicators of social impacts are considered differently (Baumann et al., 2013), which means that if different paradigms are adopted – or if it is not clear which one is referred to - a diversity of approaches for implementing a methodology could arise.

S-LCA has been developed taking the LCA perspective as a reference, without discussing which paradigm was considered. Only recently this discussion has been raised in the scientific community (Iofrida et al., 2016), mainly driven by the following considerations: even if this methodology is new, already many different approaches have been developed and are being developed for quantifying social aspects. However, their robustness and consistency cannot be properly judged, as is not explicitly stated what is guiding the assessment, i.e. which perspective and values. This is extremely relevant in any scientific discipline, but even more in social science, where values are at the core of the assessment, together with facts.

The investigation of the paradigm led to the identification of four main paradigms (Figure 1), which differ one another for the following aspects:

- The conception about the nature of reality;
- The nature of knowledge especially with reference to its limits and validity;
- The methodologies applied.

Positivism	Post-positivism	Constructivism	Interpretivism
Reality can be explained through its laws and cause-effect relationships	Full explanation of the reality not possible due to the influence of the context	Reality can be constructed Subject and object are dependent	Reality cannot be explained but can be understood and described Subject and object are dependent
Relevant methodologies are quantitative, experimental and detached from their context, and value free	Replicated findings are probably true. Methodologies most applied are quantitative and experimental but recognised role of scientific community in validating them	Mainly qualitative methods Stakeholders' experience Consensus reached through dialogue, conversation	Mainly qualitative methods Stakeholders' perceptions Consensus reached through dialogue, conversation

Figure 1: Typology of paradigms (adapted from Iofrida et al., 2016)

With reference to S-LCA, it was found out (Iofrida et al., 2016) that there is a variety of paradigms adopted (73%: Interpretivism paradigms, 24% post-positivism). This tells us that - without going into the detail of each of them - there is not one paradigm preferable over the others, but it is important to state clearly which one is adopted, taking into account that a key concept of any paradigm for S-LCA is the life cycle perspective.

The adoption of the life cycle concept has several implications, which makes S-LCA unique compared to other methodologies for assessing the social aspects and performances (4.1. Methods for Social Life Cycle Assessment), namely:

- Any (product, service, and organisation) system analysed (e.g., electricity production) is made of interconnected activities (e.g., extraction and processing of fossil fuel, fossil fuel transportation) affected by the behaviour of stakeholders (e.g., workers in the power plant but also in the upstream process of the fuel production and in the pipeline construction; local community at the different life cycle stages);
- All the actors along the value chain are responsible for the performance of the system at hand, at different levels that should be reflected also by the power of contractual relationship and by the remunerability;

By taking into account the whole life cycle, the burden shifting is avoided at different level, i.e. between the steps of the life cycle, the different social impacts and/or performances and/or risks, and the different actors.

According to this, the same concept as in LCA is adopted, but there is one important difference: how the life cycle is defined. In LCA, the environmental life cycle is defined by both processes (technical activities necessary to deliver the output of the system) and environmental mechanisms, which describe the cause –response pathway of each substance release to or extracted from the environment. In S-LCA; the social life cycle is still defined **by processes** (social impacts arise as a consequences of interaction among stakeholders driven by activities) **but also by socio-economic mechanisms**. The latter consists of relations among stakeholders involved in the life cycle, as a result of the activities carried out. According to this perspective, stakeholders are the key elements for defining the system under study, and its boundaries (as in LCA we define the system boundaries between the system and its environment) (Fig.2).
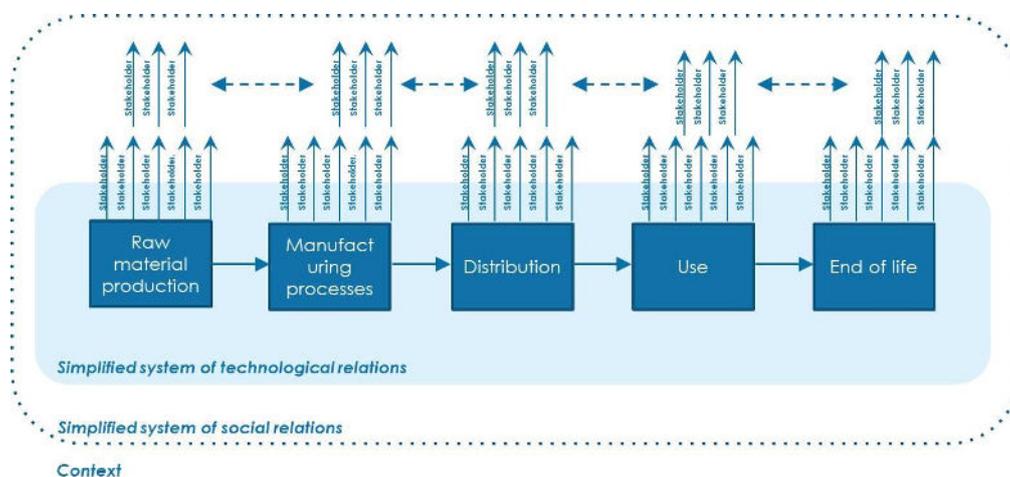
Figure 2: Theoretical system boundaries in S-LCA

As shown in Figure 2, system boundaries in S-LCA should take into account:

- The causal relationships that connect the level of two activities within the domain of technology, i.e., processes needed for delivering the output of the system;
- Social relations (second layer defined by dotted lines), driven by stakeholders: at each step of the system life cycle, there are different actors who might be potentially affected. These in turns have different kind of relationships (e.g., commercial, administrative) with other actors who might not be strictly connected with the technological life cycle, but this interaction gives rise to social effects that affect the system under study.

This multiple layer of relationships is caused by the interaction of the product system with the surrounding context, an aspect that clearly distinguishes S-LCA from LCA.

Together with the paradigm, another important aspect for the definition of the scope is the ***framework***. It is the skeleton that accommodates values and concepts of the paradigm in a consistent way, and it is made operational by means of several methodologies. A framework is defined in terms of:

- Modelling principles;
- Object of the assessment;
- Level of assessment;
- Temporal and geographic coverage

2.2.1. Modelling principles

Currently a framework for S-LCA has been developed by the UNEP/SETAC Life Cycle Initiative, and published in 2009 (UNEP/SETAC 2009), mirroring the LCA framework, as described in the ISO 14040 and 14044. This choice is due to the need, on the one side, to embrace the analytical aspects of the life cycle concept also in the social assessment, which means: quantification, and responsibility along the value chain; on the other side, to allow integrating and/or combining S-LCA together with other life cycle-based methodologies, such as LCA and life cycle costing (among others), towards a life cycle sustainability assessment (LCSA). From the practical point of view, this means that in principle the S-LCA methodology:

- is structured along four main phases, namely Goal and scope, Life Cycle Inventory, Life Cycle Impact Assessment, Interpretation;
- is based on the concept of functional unit, i.e. product, service, and organisation systems are defined based on the function they deliver. As a consequence, on the basis of the function it is possible to compare different systems, thus comparability is at stake;
- adopts the same modelling principles as LCA, namely: i) linearity (the double the quantity considered, the double the impact; ii) "ceteris paribus assumption", i.e., other things being equal or held constant. According to the latter, the product, service, or organisation system is considered to work under the hypothesis of isolation, without reacting to the effects of the surrounding context in which it is embedded;

- focuses on routine functioning, i.e., exceptional situations that might occur in the functioning of the product, service, or organisation system are not accounted for;
- facts and values are both present and part of the assessment.

However, in section 6 Limits of Social Life Cycle Assessment, it is discussed how some of these characteristics present limitations, which currently hamper the development of S-LCA.

With respect to LCA, in S-LCA a prominent role is played by the stakeholders of the product, service, or organisation system, and by their views and values. Stakeholders are defined as a cluster of actors who are expected to have shared interests, and they are grouped into five main categories: workers, local community, society, consumers, and value chain actors. These categories are not exhaustive per se, and other could be added when deemed relevant: as such, the current structure of the Guidelines, while keeping its applicability, is not static, but can be broadened and enriched, building upon the knowledge developed with the applications, according to an inductive approach. Stakeholders categories can be linked to different socially relevant themes or attributes (called "sub-categories"), such as Child labour, fair salary, fair competition and health & safety, to make just a few. The relation between stakeholders and sub-categories is one-to-many, i.e. one stakeholder category can be affected by more than one social theme, and usually one social theme can be of interest for one specific stakeholder category only.

Stakeholder categories	Subcategories
Stakeholder "worker"	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and Safety Social Benefits/Social Security
Stakeholder "consumer"	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility
Stakeholder "local community"	Access to material resources Access to immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions
Stakeholder "society"	Public commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption
Value chain actors* not including consumers	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights

Figure 3: Scheme on sub-cat and stakeholders [Source: UNEP-SETAC]

The stakeholders are the key characteristic of S-LCA, and they behave driven by the activities carried out in the life cycle of the product, service, or organisation system and according to their values, which in turn are affected by the context in which they live. So the theoretical system boundaries of S-LCA depicted in Figure 2 can be revised and simplified as represented in Figure 4: System boundaries in S-LCA according to the effect- and technology – oriented approach by the yellow line.
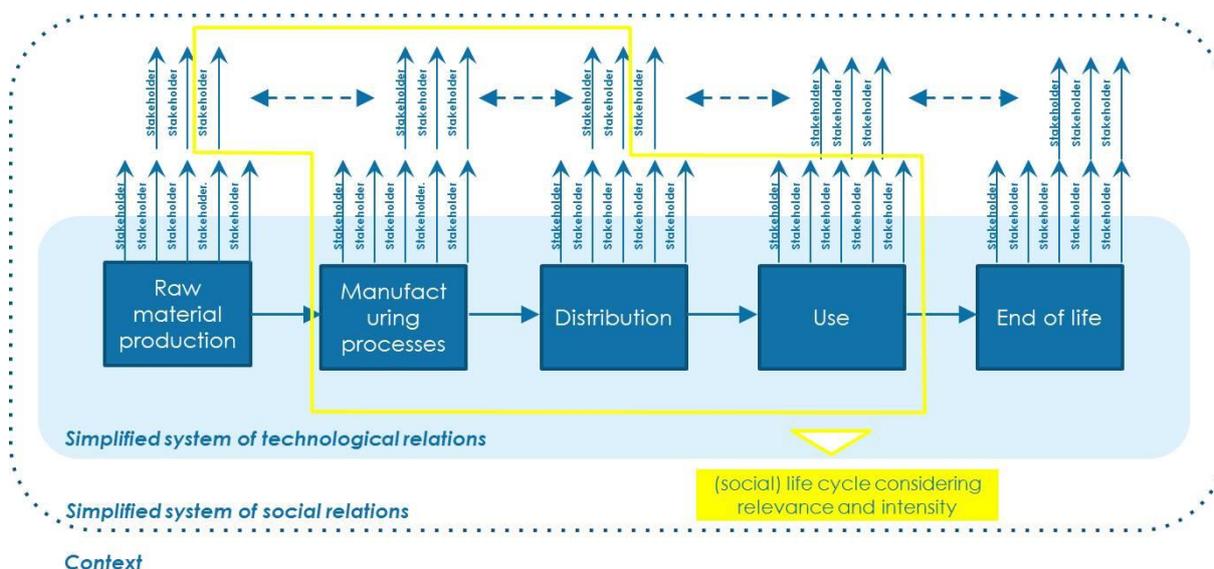
Figure 4: System boundaries in S-LCA according to the effect- and technology – oriented approach

According to the figure, the system boundaries are defined considering two main aspects (Zanchi et al., 2017):

- technological relations (effect-oriented approach), which are linked to the several physical units present in the product, service, or organisation system, and define the production cycle and the entire life cycle phases;
- social relations (technology-oriented approach), which are related to the level of interest and influence, and thus take into account the affected stakeholders and the related effects.

The principle of materiality[2] could support a first identification of the relevant stakeholders, for cutting the system boundaries as in Figure 4: System boundaries in S-LCA according to the effect- and technology – oriented approach, which however needs to be supported by a structured approach, internal to the organisation, for its implementation.

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[2] Material aspects are those that reflect the organization's significant economic, environmental and social impacts; or that substantively influence the assessments and decisions of stakeholders (Global Reporting Initiative 2015).

2.2.2. Object of the assessment

The object of the assessment is defined in terms of types of impacts accounted for and of targeted system.

As far as the impacts are concerned, S-LCA takes into account social and socio-economic impacts generated along the life cycle of the product, service, or organisation system under investigation. Social impacts are consequences of positive or negative pressures on social areas of protection (AoP) (i.e. well-being of stakeholders), due to: (i) a specific behaviour held by one or more stakeholders (e.g., social interactions in the context of an activity and/or stimulated by it and/or by preventive or reinforcing stakeholders' actions such as enforcing safety measures in a facility); (ii) downstream effect of socio-economic decisions; (iii) the original context (attributes possessed by an individual, a group, a society (e.g., education level.).

Social impact generates different kind of changes about: People's way of life (e.g. work, play, place they live), their culture, their community (e.g. stability, character, services), political systems (e.g. participation at political decisions), or environment (e.g. water used by people, quality of the air) (Vanclay et al., 2015) Thus, the impacts not only generate effects on environmental, economic and social spheres, but they produce consequences at the individual level. This increases the significance of social impacts, which are therefore important matters that companies must address (Vanclay et al., 2015).

In addition to impacts, whose quantification is acknowledged as a complex issue still under study, S-LCA assess also social performance, effects and risks. While social "**impacts**" are caused by changes in the context, which originate effects related to e.g., changes in life expectancy, health, social status, social "**effects**" measure the effect of an activity on stakeholders but an intermediate level, as the entire causal relationship is not identified. "Social "**performances"** are neither social effects nor social impacts of changes, but "[…] features of a situation in a relevant organization (or features of the value chain of organizations shaping the life cycle), referring more or less to social issues" (Macombe et al., 2013, p. 205). Finally, a social "**risk**", contrary to social performances, impacts and effects, measures the likelihood of negative effects only (damage, injury, loss) that may be avoided through pre-emptive action.

To assess social impacts, scholars and practitioners use social impacts indicators. They are "evidences, subjective or objective, qualitative, quantitative or semi-quantitative being collected in order to facilitate concise, comprehensive and balanced judgements about the condition of specific social aspects with respect to a set of values and goals" (UNEP/SETAC 2009: 101). Semi-quantitative indicators are defined as "a numerical description of qualitative information by using different scoring systems" (Aparcana and Salhofer, 2013). They show the presence/absence of something or the occurrence of specific situations (UNEP/SETAC 2009).

Qualitative indicators do not use numeric measures, but describe the status of a specific situation in qualitative terms, and thus may best track changes in organisational or institutional behaviours (World Bank 2012) and stakeholder perceptions.

Within S-LCA, social indicators are indicators of a social life cycle inventory result of a social impact category (UNEP/SETAC 2009:101). Inventory indicators are aggregated in subcategories, which can be aggregated in impact categories.

Positive impacts

As opposed to environmental life cycle assessment (E-LCA), S-LCA considers also positive impacts, which are the basis of any social-related policy and intervention, and their quantification can play a major role in S-LCA (Benoît et al., 2010). Moreover, positive impacts are meant to encourage performance beyond compliance (with laws, international agreements, certification standards, etc.) as, for example, in the sustainable development goals (UN 2015a, b). Initially, the theme of positive social impacts has been dealt with by Norris (2006) and Grießhammer et al. (2006), the "early movers" on emphasising positive impacts.

Norris (2006) questions the issue of how to measure, aggregate, compare and stimulate society wide improvement of context-dependent attributes within and across product, service, or organisation life cycles in life cycle assessment (LCA). With a case study, Norris shows that the health benefits of economic development impacts in product life cycles have the potential to be very significant, possibly even orders of magnitude greater than the health damages from the increased pollution.

Grießhammer et al. (2006) state that the quantification of negative impacts is more difficult than positive ones. For the authors, the social impacts may be assessed using indicators which allow aggregation across the entire life cycle according to the ISO 14040. Some of the positive impacts may be directly quantified but for the negative impacts, and in particular in the obligatory categories, a direct quantification is often not meaningful. For example, violations of labour rights can be hard to prove, and the lack of reported infringements or complaints could tell more about inefficient accounting than of the work environment quality. On the contrary, the risk that negative impacts occur may be gauged from the way that the company manages the relevant activities as proposed by.

In more recent years, Jørgensen et al. (2010a, 2010b), Ekvall (2011) and Neugebauer et al. (2014) examined in depth the positive impacts issue. Jørgensen et al. (2010b) consider the child labour indicator as generating a context-related 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. Furthermore, the distinction between positive "direct" effects and positive "indirect" effects has been proposed (Jørgensen et al., 2010a). Assuming that the main functionality of S-LCA is to provide decision support, this support can create an effect that depends on the choices of decision makers. By choosing alternatives, which have more favourable consequences than those that would have been chosen without a S-LCA study, the decision that may derive from S-LCA can be seen to have created a positive effect. This type of consequence is a "direct effect". Consequently, the results of a S-LCA study might point out situations that could led the decision makers to take decisions, which in turns might generate – in the short-medium or long term – positive effects. Ekvall (2011) suggests accounting for the social performance of governments and countries in

an S-LCA, by using a positive indicator related to the degree of civil liberties and political rights guaranteed in each country. Ekvall affirms that it is necessary "*to focus on the issue of democracy and distinguish between countries that are free, partly free, or not free. […] if a positive indicator is used, it can be measured in terms of value added in free countries*" (Ekvall 2011:2). This approach will describe to what extent the product contributes to economies in countries that are politically free (or not free).

Neugebauer et al. (2014) built two pathways to describe the cause-effect relation between the midpoints fair wage and level of education which may affect the area of protection of social well-being both positively and/or negatively. The authors included three endpoints to address social well-being: economic welfare, damage to human health and environmental stability. In particular, the midpoint "level of education" affected the economic welfare by the direct impacts of job and working situation via inventory categories like finished apprenticeships or literacy rate. All of this positively influenced social well-being. In addition, participation on sport or cultural events may have a direct impact on job security and working conditions and positively influence the level of education and finally well-being.

Only a few papers considered the issue of positive impact, likely due to the difficulty to evaluate them, in addition to the lack of a clear definition of what is a positive social impact. In this regard, Norris (2013) coined the term "Handprint", in opposition to the term "Footprint", to address "the beneficial environmental and social impacts that we can achieve". The Handprint is based on the principle that social impact could be reduced by consumption of product and service. It is possible to have a "net positive impact" such as compensation between Handprint and environmental footprint. This phenomenon occurs when positive changes in the conduct of people or companies (in relation to an impact category) are more than the estimated footprints for the same category (in a given year). Despite this, with the compensation we can hide negative social effects somewhere in the value chain, which could be relevant and on which measures to mitigate them can be undertaken. The reduction of environmental footprints and the increase of handprint entails a "beneficient" behaviour: a combination between efficient (minimise our footprint) and beneficial (generate positive impacts in the world) (Norris, 2015).

Finally, since the aim of a S-LCA is to contribute to improve current living conditions, it will probably, in most cases, be reasonable to include negative impacts rather than positive ones. As consequence, the motivation for improving positive impacts can be expected to be lower (Jørgensen et al., 2012) and the focus on positive impacts may be weaker. Conversely, focusing on positive indicators is interesting as it improves the completeness and the relevance of S-LCA. Indeed, most indicators mask the complexity of the individual topics. An illustrative example can be the topic of child labour. In contrast to what one might think, it is not easy to define child labour with one threshold-age globally. In fact looking at the ILO Minimum Age Convention (No. 138), one finds a whole set of possible threshold ages for different kinds of work and for different economic situations (Grießhammer et al. 2006). According to that, an example was given by Jørgensen et al. (2010b): in the study, the authors replace the assessment of child labour incidence with other indicators that evaluate positive impacts generated by child labour. These indicators are more precise than those more commonly used, for example to evaluate the presence of child labour

within the organisation under study, traceable in most case studies (e.g. presence of child labour, percentage of children working, risk of child labour, and percentage of children out of school).

Regarding the targeted system, S-LCA has been developed with a focus on products, services, and organisations, like E-LCA and other life cycle-based methodologies. However, the perspective adopted in S-LCA is different, because social impacts and/or performances are the results of actions undertaken by stakeholders, driven by production and consumption activities. As such, a product system is a "system of interacting organisations whose social behaviour depends on the existence of the product studies and causes social effects" (Macombe et al., 2013). The product, service, or organisation does not cause social impacts, but it is human action that creates them; moreover, human activities that produce goods are structured into organisations. Thus, organisations are the reference units for a social life cycle: social impacts/performances are not directly related to process flows and to the function(s) delivered by a given product, service, or organisation, but rather to the way a particular company interacts with its stakeholders. Currently, the attribution of the impact/performance to a product is only an allocation issue.

In line with this thinking, the Social Organisational LCA (SOLCA) has been proposed as a methodology, which is built upon the S-LCA and the OLCA (Organisational LCA) (ISO/TS 14072:2014). The organization and its portfolio are the reference unit of analysis (Martínez-Blanco et al. 2015): the social aspects relate to the organization, thus there is no need to express them per unit of process output.

This approach is new, and applications are not available yet, but experiences will be built upon the outcomes and lessons learnt by the current initiative on OLCA, promoted by the UNEP/SETAC LCI trough the road test initiative[3].

2.2.3. Level of the assessment and coverage

S-LCA can in principle be carried out at different *levels*, namely:

- Micro: products/services/technologies;
- Meso: it may include "groups of related products and technologies, baskets of commodities (e.g., the product folio of a company), a municipality, a household" (Guinée et al., 2011: 93), a territory;
- Macro: "refers both to economies of states or other geographical/political entities and eventually the world. An example for this level might be the assessment of options for emerging technology domains, like for example large scale introduction of wind energy or solar cells as strategy for phasing out fossil energy, nanotechnology, and new communication services" (Guinée et al., 2011: 93). Thus this level of assessment considers the life cycle stages in interaction with the society where they are embedded, including the background processes that are affected by large-scale consequences (Selke et al., 2011).

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[3] http://www.lifecycleinitiative.org/activities/phase-iii/lca-in-organisations/

It should be considered that these three levels are not separated one from the others, as e.g., large scale effects influence activities carried out at micro level, and – vice versa – the transition towards e.g., the sustainable development goals can be carried out also through various independent initiatives at micro and meso scale.

Currently the applications of S-LCA available in literature (§ 4 The state of the art of Social LCA) are mainly at micro level, while there is only one application – to our knowledge – at macro level, related to the assessment of trade and development policy in EU (Pelletier et al., 2013). Pelletier and colleagues have applied the S-LCA methodology, with the support of the Social Hotspot Database (SHDB), to understand how and to what extent current trade-based consumption in the EU-27 may be associated with socially unsustainable conditions, and to identify related mitigation and corrective actions. The results showed that the evaluation of social risk associated with production, consumption and trade may be used for policy support in different ways, pointing out e.g., the priority sectors to act on as those where risks are most acute, irrespective of the current magnitude of imports across sectors. "This consideration is particularly relevant in order to prevent burden shifting from one country to another or from one dimension of social risk to another that could occur as result of policy-influenced changes in trade" (Pelletier et al., 2013: 88).

Finally, it is necessary to point out that the level of assessment does not correspond to the level at which data are collected. In fact, in many cases S-LCA studies at micro level are carried out using data at company, regional, and state level (Martinez Blanco et al., 2014). Company level data are site-specific, and as such are the most representative of the product system at hand, despite being more difficult to collect, while the regional and country level data provide average information on a given territory or sector, which can be used to address the data gaps in S-LCA, at least for the most remote life cycle stages. The criterion for the choice of company vs other resolution-scale data should be guided by the identification of background or foreground (site and product specific) processes (Zanchi et al., 2017), whose distinction in turn is based on the relevance of the process(es) and the level of interest and influence (Martínez-Blanco et al. 2014). Given the different types of requirements just described, it is common that in a S-LCA study different types of data are used, as also mirrored in the structure of the methodological sheets of the UNEP/SETAC S-LCA Guidelines.

As far as the **geographical coverage** is concerned, contrary to E-LCA, S-LCA is context-driven, i.e. social impacts/performances are intrinsically related to the specific geographic and cultural context where they unfold, even if culture can cross geography. Culture in particular is of paramount importance, and by some authors is recognized as an additional pillar of sustainability (Pizzirani et al., 2016). Cultural indicators are also present in S-LCA subcategories (e.g., cultural heritage, respect of indigenous rights), however performing an S-LCA does not always guarantee the inclusion of cultural values because the supporting data are often associated only with the presence or absence of national and international policies, agreements, standards and reports. The importance of a good representation of culture within S-LCA is because "values are the building blocks of culture" (Pizzirani et al., 2016) and core elements of S-LCA too. Thus, for better representing in S-LCA the context in which a product system in embedded, cultural values should be further developed and included in the assessment.

Regarding the **temporal coverage**, current S-LCA is not prospective yet, but it captures current and past effects; in addition also the temporal horizon at which the impacts are assessed is not defined yet. Overall, the time issue is not well defined in S-LCA for three main reasons:

- The impact assessment is still poorly developed, when the causal relationships that describes social impacts are concerned;
- In S-LCA, more than in E-LCA, the urgencies of the issues evaluated is at stake, and the risks and social performances evaluated in the case studies available in literature are traced in current times, because the impacts – besides being potential – are also real, and as such already experienced by actors;
- Value changes over time and this can strongly affect the validity through time of S-LCA results, depending on the reference context for the study.

Any prospective evaluation should be carried out with caution, and, most importantly, shall specify the reference values considered, as a support to the interpretation of the robustness of the results.

2.3. What is the purpose of Social Life Cycle Assessment?

The ultimate objective for conducting a S-LCA is **to promote improvement of social conditions and of the overall socio-economic performance of a product throughout its life cycle for all of its stakeholders**. The main objective is to assess the social impact of the product to improve the social conditions of the stakeholders that are involved in the life cycle. S-LCA (as E-LCA) do not have the purpose to provide information on whether or not a product should be produced.

S-LCA is also identified as a decision support tool, therefore, its implementation should be an agile and scientifically valid assessment to answer to the following questions:

- What are the options for improvement of the product along its cycle life?
- What are the steps and processes of the life cycle responsible for the main social impact of the product?
- What would be the social consequences related to change a given production process in a certain way?
- What would be the social consequences related to the use of recycled material for this product, instead of using virgin raw materials as now?
- Which of the product A, B and C used in the application X is the preferable choice, from a social point of view?

3. The social dimension outside Life Cycle Assessment

The objective of this part is to provide a state of the art consideration of the social dimension in sustainability reporting. To do this, this task identifies existing standards and then evaluates the different methodologies, indicators and ways of working. These standards encourage companies to assess their supply chains risks and impacts. Many of them are deciding about which tools and processes can be used to meet the requirements.

As UNEP indicates, social aspects can be assessed through a variety of tools – analytical tools, procedural and management tools, monitoring, reporting and communication tools. SA 8000[4], and ISO 26000[5], for example, are procedural and management tools that provide a level of assessment at the facility and organization level (respectively), fair trade standards (Fair Trade International[6]) at the product level, while CSR reporting tools such as the Global Reporting Initiative (GRI) Standard[7] serves a reporting purpose (mainly) at the organizational level. Meanwhile, life cycle-based tools are analytical tools useful to undergo an analysis at the product, service or organisational level.

Although various tools cannot replace one another, they can be complementary. For example, reporting tools such as GRI and management tools such as SA8000, can feed into S-LCA as they also consider social and economic aspects. In addition to data provided by themes, the various tools provide information at various scopes (single sites, enterprises, part of the supply chain). This is important as S-LCA's focus is almost always product level, which therefore calls for site specific information that is related to facilities where the unit process is located. In other words, CSR information can be useful for assessments-LCAs.

The UNEP/SETAC Guidelines for S-LCA products categorize different social issues into social and socio-economic impact categories and subcategories, comparable to the GRI and other international schemes. The resulting list of subcategories can be classified in a table, where the first column represents the stakeholder groups and second column identifies the impact areas. As discussed earlier, the reason for this categorization by stakeholders is because Social impacts are defined as consequences, positive or negative, on 'social endpoints', being stakeholders.

However, one of the main issues in S-LCA is to standardize indicators from multiple sources and turn them into meaningful information. To do this, let us look more closely at how these CSR tools and methods categorize and report on social indicators.

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[4] *Social Accountability 8000 ®Standard, http://www.sa-intl.org/index.cfm?fuseaction=page.viewpage&pageid=1689*
[5] *International Organization for Standardization, "ISO 26000 – Social Responsibility" https://www.iso.org/iso-26000-social-responsibility.html*
[6] *Fair Trade International, "Standards" https://www.fairtrade.net/standards.html*
[7] *Global Reporting Initiative Standards: https://www.globalreporting.org*

CSR Tools and Methods analysed

The following section provides an overview of the CSR tools and methods that were analysed amongst the large number of social responsibility standards that were published in the recent years[8]:

- **GRI Standard**

  The Global Reporting Initiative provides a reporting framework for economic, environmental and social aspects including guidelines for performance indicators. As many enterprises use this reporting system, it can be used as a source of information for social and socio-economic assessment of companies. The GRI is the most widely used reporting standard in the world with over 10 000 organizations using it. Furthermore, 35 countries either 'recommend', 'mention' or 'require' GRI reporting in legislation. In October 2016, the GRI released the GRI Standard, which build upon the GRI4 reporting guidelines. The new GRI Standard allows indicators to have separate reporting guidelines so that updates are more easily integrated per indicator. The new GRI Standard revises, clarifies and deletes some of the GRI4 indicators, and reorganizes these indicators numerically.

- **ISO 26000**

  ISO 26000 is the international standard developed to help organizations to effectively assess and address social responsibilities that are relevant and significant to their mission and vision. ISO 26000 in of itself is not a requirement, but provides organisations with guidance; in other words, it is not certifiable. Nonetheless, it provides principles and actions that organizations should take into consideration in a qualitative manner.

- **SA 8000**

  The Social Accountability 8000 (SA8000) Standard is a worldwide accepted certification standard, focusing on enterprises and organizations addressing workers' rights. The standard presents a set of criteria and a specific monitoring system that an enterprise needs to comply with in order to be certified. The intent of SA8000 is to provide an auditable, voluntary standard based on the UN Declaration of Human Rights, ILO and other international human rights and labour norms and labour laws. The certification is only available at site level and outlines 9 social accountability requirements. The Standard is accompanied by a performance indicator annex that sets out performance expectations largely in a qualitative manner. In some cases, the criteria and the monitoring system could be used in a S-LCA.

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[8] Note: The report was prepared according to the state of the art in force in February 2017. All subsequent updates of the standards were not taken into consideration.

- **Fair Trade International (Max Havelaar)**

   Fair Trade International's purpose is to promote sustainable development and to reduce poverty through fairer trade. To do so, Fair Trade International has 6 audited standards for small producers, hired labour, contracted production, traders, and standards on climate and textiles. Each standard has different general requirements, core requirements and development requirements. These requirements are laid out in mainly qualitative manner. The analysis for this report comprised of an analysis of the standards on Small Producers and Hired Labour.

- **EcoCert**

   EcoCert if a certification body for sustainable development. Their audited ESR Standard[9] ("Equitable, Solidaire, Responsable", or, "Fair Trade, Solidarity Responsibility") is used to certify organic products. The seven topics included in the standard are inspired by the ISO 26000 standard guidelines. The certification scheme is based on social responsibility at a company/organizational level and also Fair Trade certification on a product/supply chain level. Each criterion is evaluated based on a scoring list from 0-4, with 2 being 'compliant'.

In addition to these tools and methods of sustainability reporting, the Sustainable Development Goals (SDGs) indicators were also evaluated. The SDGs, otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another. The SDGs provide clear guidelines, indicators and targets for all actors to adopt in accordance with their own priorities and the environmental challenges of the world at large. It is worth mentioning that the Gold Standard 3.0 (under development) will provide a methodology to quantify co-benefits (on health, clean water, clean air, etc.) of projects and products and their contribution to the SDGs.

After choosing the methods and tools to analyse, the second step was to do an analysis on the scope of the methods and tools, as seen in the table below:

	Integrates value chain		Scope			Data accessibility			Data sources		Type of data		Audit Required?	
	Yes	No	Products	Services	Organisations	Easy	Reasonable	Difficult	Internal	External	Database	Interviews	Yes	No
GRI Standard	X				X		X		X	X	X	X		X
Fair Trade International	X		X				X		X	X		X	X	
EcoCert	X		X				X		X	X		X	X	
SA 8000		X			X	X			X			X	X	
SDGs	X	X	-	-	-	-	-	-	X	X	-	-		X
ISO 26000		X			X	-	-	-	X		-	-		X

Figure 5 : Characteristics of various standards

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[9] EcoCert Group, "Fair Trade Certification Program" http://www.ecocert.com/en/fair-trade-certification-program

SOCIAL LCA, SUSTAINABLE DEVELOPMENT, CSR: STATE OF RESEARCH? WHAT ARE THE METHODOLOGICAL NEEDS?

The table above identifies specific characteristics of each standard: whether it integrates the value chain, what the scope is, how accessible the data is, what the sources are, what type of data is reported/used, and whether there is an audit. The GRI Standard stands out compared to the other methods and tools analysed with this table. The reasons are that the GRI Standard, although an audit is not technically required, integrates the value chain (products and suppliers), with a data accessibility that is reasonable. The same cannot be said for other standards. The Fair Trade International and EcoCert standards cover products, and are applicable to a limited number of agricultural products or products that are imported from developing countries. Meanwhile, SA 8000 provides very useful, audited information but that stays at a site level and is limited to employee stakeholders. Indeed, the ISO 26000 covers a large scope of stakeholders, and provides the guidelines for companies to implement social responsibility into their operations. However, the guidelines do not provide the means to report on them. Therefore, in a lens of an S-LCA, the GRI Standard provides the fertile ground for information that can be used in an analysis.

The Fair Trade International and EcoCert standard provide social indicators, both qualitative and quantitative, however the indicators are used mainly for agricultural producers and products, rather than providing information at an organizational level. As such, the indicators used in these standards are not easily transferrable to other products that are non-agricultural or that are produced in developed countries. As such, these standards were considered to have too limited of a scope.

The indicators published for the SDGs are not company specific, but are a mean for countries to track their progress on a national level. Nevertheless, these indicators are useful for generic analysis (hot spot analysis) when specific indicators are unavailable. In other words, these inventory indicators can be listed in an updated version of the UNEP/SETAC LCA methodological sheets.

Indeed, this exercise shed light on the most useful tools and methods in terms of S-LCA indicators. The GRI, although it does not cover all of the sub-categories listed in the UNEP/SETAC table, is the most widely-used reporting protocol in the world today. It means that organizations that report with the protocol have at their disposal a wealth of useful information to conduct a S-LCA analysis. For this reason, it is worth delving deeper into what the GRI can offer for a S-LCA. The following table compares the indicators/principles with those from the UNEP/SETAC table. A similar exercise was undertaken in the Handbook for Product Social Impact Assessment (2014) by Pré Sustainability, but the exercise did not include Fair Trade, SDGs, nor the updated GRI guidelines.

Stakeholders	Sub-categories	[UNEP-SETAC09]	[GRI4]	[ISO26000]	Fair Trade Small Producer	Fair Trade Hired Labour	Fair Trade Ecocert (Responsible)	SDGs
Employee/Worker	Freedom of association and collective bargaining	X	X	X	X	X	X	
	Child labour	X	X	X	X	X	X	X
	Fair salary / Wages	X	X	X	X	X	X	X
	Working hours	X		X	X	X	X	
	Forced labour	X	X	X	X	X	X	X
	Equal opportunities and discrimination / Diversity	X	X	X	X	X	X	X
	Health and Safety	X	X	X	X	X	X	X
	Social benefits and social security	X	X	X	X	X	X	X
Consumer	Health & safety	X	X	X			X	
	Feedback mechanism	X	X	X				
	Consumer privacy	X	X	X				
	Transparency	X	X	X			X	X
	End of life responsibility	X	X	X			X	
Local community	Access to material resources	X		X			X	X
	Access to immaterial resources	X				X	X	
	Access to tangible resources							
	Delocalization and migration	X			X		X	X
	Cultural heritage	X			X		X	
	Safe & healthy living conditions	X				X		X
	Respect of indigenous rights	X	X	X	X	X	X	
	Community engagement	X	X	X		X	X	X
	Local employment	X	X	X	X	X	X	X
	Secure living conditions	X					X	X
Society	Public commitments to sustainability issues	X	X				X	X
	Contribution to economic development	X						X
	Prevention & mitigation of armed conflicts	X	X					
	Technology development	X		X			X	X
	Corruption	X	X	X				
Value chain actors not including consumers	Fair competition	X	X	X			X	X
	Promoting social responsibility	X	X	X		X	X	X
	Supplier relationships	X	X	X			X	X
	Respect of intellectual property rights	X		X				

Figure 6 : Social topics covered by external references compared to UNEP/SETAC

As seen in the table, the tools and methods cover employee and worker topics very well. This revelation is not surprising considering that CSR tools and methods have an original scope at the organizational/site level. Increasingly, however, we see that the scope of CSR reporting is becoming more extensive, covering consumers, local communities and societal issues (or example, the GRI 4 standards have updated supply chain indicators, increasing its scope of reporting).

Which standards are the most useful for a S-LCA?

The SA 8000 standard provides useful S-LCA information but it is only concentrated at a site level—not at an organizational level- and does not provide information beyond the scope of employees. Nonetheless, the SA 8000 complements topics where the GRI lacks (fair salary/working hours), and therefore the indicators could eventually be used to provide a more holistic picture.

ISO 26000, on the other hand, covers a broad scope of thematic in line with the UNEP/SETAC matrix. However, as discussed earlier, ISO 26000 approaches CSR topics in a qualitative way, and in a normative approach. Contrary to the GRI Standard, a company does not report information based on the ISO 26000 standard as it is more of a guideline on how to translate principles into concrete actions. In essence, the ISO 26000 provides the guideline and instruction on how to create a socially accountable organization, while the GRI provides the protocol to report on the actions.

Focus on the Global Reporting Initiative

As stated earlier, the Global Reporting Initiative protocol is the most widely used reporting protocol in the world, and can be applied by all organizations, regardless of the size, sector or location. Indeed, the interesting question is how to capitalize off the information already reported and gathered at a company level and use it for a social life cycle analysis.

However, it is worth noting that with all reporting initiatives there is a heterogeneity in the depth of reporting. Companies may report in accordance with the GRI protocol at a 'core' or 'comprehensive' level. As written in the GRI guidelines:

> *"There are two options for preparing a report in accordance with the GRI Standards: Core and Comprehensive. Core: This option indicates that a report contains the minimum information needed to understand the nature of the organization, its material topics and related impacts, and how these are managed. Comprehensive: This builds on the Core option by requiring additional disclosures on the organization's strategy, ethics and integrity, and governance. In addition, the organization is required to report more extensively on its impacts by reporting all the topic-specific disclosures for each material topic covered by the GRI Standards. These options do not relate to the quality of the information in the report or the magnitude of the organization's impacts. Instead, they reflect the degree to which the GRI Standards have been applied. An organization is not required to progress from Core to Comprehensive; it can choose the option that best meets its reporting needs and the information needs of its stakeholders."* (GRI Foundation, 2016, p. 21)

Therefore, a company will report on an indicator depending on 1) whether the topic is considered material (i.e. relevant) and 2) the comprehensiveness of reporting (core or comprehensive). As such, we must be wary that just because the indicators exist in the GRI protocol guidelines, it does not mean that a company necessarily reports on the indicator.

Nonetheless, if a company does report with the GRI protocol, they are likely to have information that can be useful in a S-LCA. Therefore, the GRI Standard was analysed and categorized based on the UNEP/SETAC categories. The following table summarizes this analysis.

Social themes/Sub-categories	Indicator Number/ Title		Social themes/Sub-categories
EMPLOYEE/WORKER			
Freedom of association and collective bargaining	402-1	Minimum notice periods regarding operational changes	
	407-1	Operations and suppliers in which the right to freedom of association and collective bargaining may be at risk	
Child labour	408-1	Operations and suppliers at significant risk for incidents of child labour	
Forced labour	409-1	Operations and suppliers at significant risk for incidents of forced or compulsory labour	
Equal opportunities and discrimination / Diversity	405-1	Diversity of governance bodies and employees	
	405-2	Ratio of basic salary and remuneration of women to men	
	406-1	Incidents of discrimination and corrective actions taken	
Health and Safety	403-1	Workers representation in formal joint management–worker health and safety committees	
	403-2	Types of injury and rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities	
	403-3	Workers with high incidence or high risk of diseases related to their occupation	
	403-4	Health and safety topics covered in formal agreements with trade unions	
Social benefits and social security	401-2	Benefits provided to full-time employees that are not provided to temporary or part-time employees	
	401-3	Parental leave	
	201-3	Defined benefit plan obligations and other retirement plans	
CONSUMER			
Health & safety	416-1	Assessment of the health and safety impacts of product and service categories	
	416-2	Incidents of non-compliance concerning the health and safety impacts of products and services	
Feedback mechanism	102-43 102-44	Approach to stakeholder engagement Key topics and concerns raised	
Consumer privacy	418-1	Substantiated complaints concerning breaches of customer privacy and losses of customer data	
Transparency	417-1	Requirements for product and service information and labelling	
	417-2	Incidents of non-compliance concerning product and service information and labelling	
	102-43 102-44	Approach to stakeholder engagement Key topics and concerns raised	
	102-2	Activities, brands, products, and services	
	417-3	Incidents of non-compliance concerning marketing communications	
End of life responsibility	301-3	Reclaimed products and their packaging materials	

LOCAL COMMUNITY		
Respect of indigenous rights	411-1	Incidents of violations involving rights of indigenous peoples
Community engagement	413-1	Operations with local community engagement, impact assessments, and development programs
	413-2	Operations with significant actual and potential negative impacts on local communities
	102-40	List of stakeholder groups
	102-42	Identifying and selecting stakeholders
	102-43	Approach to stakeholder engagement
	102-44	Key topics and concerns raised
Local employment	202-1	Ratios of standard entry level wage by gender compared to local minimum wage
	202-2	Proportion of senior management hired from the local community
SOCIETY		
Public commitments to sustainability issues	102-15	Key impacts, risks, and opportunities
Contribution to economic development	201-1	Direct economic value generated and distributed
	203-2	Significant indirect economic impacts
	203-1	Infrastructure investments and services supported
Prevention & mitigation of armed conflicts	413-1	Operations with local community engagement, impact assessments, and development programs
	413-2	Operations with significant actual and potential negative impacts on local communities
Corruption	205-1	Operations assessed for risks related to corruption
	205-2	Communication and training about anti-corruption policies and procedures
	205-3	Confirmed incidents of corruption and actions taken
SUPPLY CHAIN ACTORS		
Fair competition	206-1	Legal actions for anti-competitive behaviour, anti-trust, and monopoly practices
Promoting social responsibility	414-1	New suppliers that were screened using social criteria
	414-2	Negative social impacts in the supply chain and actions taken
Supplier relationships	414-1	New suppliers that were screened using social criteria
	414-2	Negative social impacts in the supply chain and actions taken
	414-1	New suppliers that were screened using social criteria
	414-2	Negative social impacts in the supply chain and actions taken
	204-1	Proportion of spending on local suppliers
	308-1	New suppliers that were screened using environmental criteria
	308-2	Negative environmental impacts in the supply chain and actions taken

Figure 7 : Concordance table between GRI Standard and UNEP/SETAC

As illustrated, for each subcategory we actually find multiple GRI Standard indicators that can be used to quantify or qualify the said category. This is particularly interesting because with each additional indicator, a company is more likely to have information on the subject.

Furthermore, this exercise also provided insight on the types of information that could be fruitful for an S-LCA analysis that go beyond the initial proposed UNEP/SETAC sub-categories. This illustrates that companies that report with the Global Reporting Initiative may already have a wealth of information and

indicators that can bolster the S-LCA analysis. The following indicators are in the GRI Standard that go beyond the initial UNEP/SETAC sub-categories:

- Employees:
  - Grievance mechanisms (103-2)
  - Professional training/training and education (404-1 to 3, 410-1, 412-3)
  - Remediation (406-1)
  - Compliance (419-1)
  - Investment and procurement practices (412-3)
  - Assessment (on human rights) (412-1)
  - Social dialogue (407-1)

- Consumers
  - Availability and accessibility of products (economic impacts for those on low incomes) (203-2)

- Local community
  - Public policy contributions (415-1)

Nonetheless, the GRI does not cover the following sub-categories in the UNEP/SETAC matrix:

- Employees
  - Fair Salary and Wages
  - Working hours

- Local Communities
  - Access to material and immaterial resources
  - Delocalization and migration
  - Cultural heritage
  - Safe and healthy living conditions
  - Secure living conditions

- Society
  - Technology development

- Supply chain
  - Respect of Intellectual Property Rights

However, these subcategories can eventually be complemented with proxy indicators or qualitative information that a company may provide for the analysis. For example, for the indicator on 'Secure living conditions' the country in which a company operates can have an index attributed to it using the SDG indicator 'Proportion of urban population living in slums, informal settlements'.
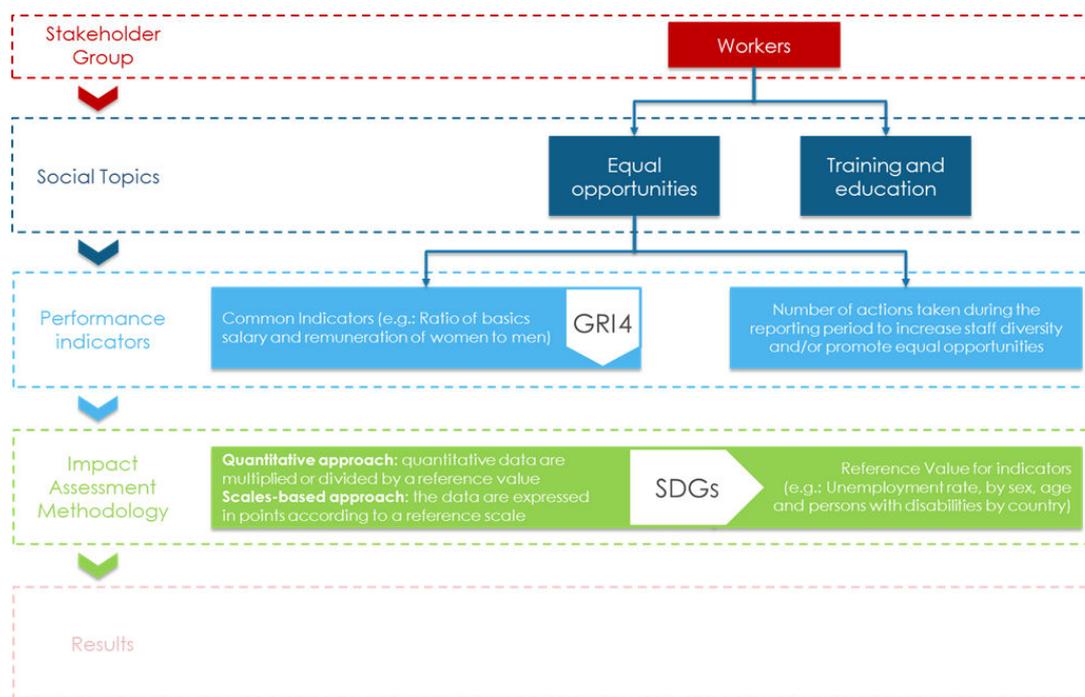
Figure 8 : Illustration of key components of Product Social Impact Assessment and interaction with GRI and SDGs

This exercise allowed for the exploration of possible links between CSR reporting methods and tools and S-LCA. This analysis is particularly relevant for companies that seek to undertake a S-LCA of their product, but have trouble understanding what type of information is sought. Indeed, companies that already report with the GRI Standard may already have crucial information required to undertake a S-LCA. This task highlights that a promising way forward is to harmonize the GRI Standard indicators with the S-LCA model.

The GRI is the most widely used CSR reporting tool in the world, and already encourages companies to report on information that can be relevant for a S-LCA – it is only logical to capitalize off this wealth of information readily available. For this reason, this task focused on the links between GRI4 and S-LCA. In addition, all the Score LCA active members (Total, Renault, EDF, Veolia, ENGIE) –reported with the GRI in 2016. Indeed, the GRI indicators that correspond to the UNEP/SETAC sub-categories should be explored more deeply and concretely on how they can quantitatively or qualitatively be harmonized into a S-LCA model. As the use of the GRI Standard will become more and more ubiquitous, standardizing and harmonizing S-LCA indicators based on the GRI indicators would be a useful undertaking. Furthermore, the SDGs indicators, although new, can be used as generic proxy indicators at a national level for LCA methodological sheets, and should be explored on how they can be integrated into the S-LCA model. At the same time SDG indicators can enhance the categorization of these indicators on business thematic related to social topic. Thus based on a materiality assessment of SDGs and which SDG are high priority concern for the organization, social topic can be selected and thus associated indicators. In addition, SDGs and social topic can be related to GRI4 indicators[10] or ISO 26000:2010 framework[11] in order to provide a holistic view between all these standards.

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[10] https://www.globalreporting.org/resourcelibrary/SDG_GRI_LInkage.pdf
[11] http://iso26000.info/wp-content/uploads/2017/02/ISO-26000-Protocol-ISO2600-and-SDGs-in-detail.pdf

<u>Conclusions and the way forward</u>

There is a need to specify and explain how S-LCA can be applied to support organisations in the assessment and reporting of their supply chains social risks, impacts and benefits.

Even if the GRI or ISO 26000 standards apply to "a company" and not a product they still mandate for companies to investigate the most "material" or "impactful" business relationships, may they be direct or indirect, and identify the issues at stake as well as their locations. This can be considered in LCA terms as a "hotspot" assessment process within their supply chains.

While stakeholder engagement and surveys are necessary components of a materiality assessment and due diligence process, a science-based process is also needed in order to bring consistency and comprehensiveness to the results. S-LCA as a tool can support to fulfil these requirements on materiality assessment and due diligence on three different levels [Benoit Norris and al, 2014]:

- Methods

  Methods are needed to enable the assessment of risks and performances throughout the value chain in a comprehensive, consistent but manageable way. The Life Cycle Inventory (LCI) and Impact Assessment (IA) methods developed within the field of S-LCA have the potential to bring structure, credibility and consistency to supply chain materiality assessment.

- Models

  Models are needed to inform about the supply chain activities, linkages and location. While a large number of companies have still very limited information on their suppliers, let alone second or third tiers suppliers, S-LCA models enable to by-pass this information gap by using trade or process models.

- Data

  Data are needed to support assessments by providing generic and site-specific information that will allow identifying hotspots and assessing performances. S-LCA requires its own data addressing relevant social issues. The UNEP/SETAC Guidelines on S-LCA include a flexible list of impact subcategories that cover issues mandated by most standards. With a first comprehensive S-LCA data source, the Social Hotspots Database (Benoit Norris et al., 2013), together with the PSILCA[12] database, can deliver extensive hotspots assessment at the level of the company, a company division or a product category.

Since the needs exist, the next step is to discuss how to make S-LCA as effective, understandable and reliable as it needs to be in order to be broadly utilized.

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[12] https://psilca.net/ Database for S-LCA developed by GreenDelta.

4. The state of the art of Social Life Cycle Assessment

This chapter presents the state of the art in S-LCA. In the first section, we focus on impact assessment in S-LCA, highlighting the differences existing between the different methods. The second section presents the results of the systematic literature review carried out about applications of S-LCA.

4.1. Methods for Social Life Cycle Assessment

The general framework of S-LCA was developed in the framework of the UNEP/SETAC Life Cycle Initiative taskforce (Grießhammer et al. 2006), and was published in the UNEP/SETAC Guidelines (UNEP/SETAC, 2009). The framework consists of four steps, i.e. goal and scope definition, inventory analysis, impact assessment and interpretation as regulated by ISO 14040/14044 (ISO 2006a, b).

The Goal and Scope definition phase defines the objectives and wideness of the study: it includes functional unit, system boundary, activity variables, unit processes, impact categories, subcategories, stakeholders' identification, social life cycle impact assessment methods and assumptions.

The second phase, Life Cycle Inventory analysis, includes data collection on unit processes activity variables used for prioritization, hotspots assessment, site-specific evaluation and impact assessment. Occasionally, new issues may be identified that could require to revise the goal and scope of the study.

Life Cycle Impact Assessment is the third phase. In this step, the life cycle inventory results are first classified into social impact categories and subcategories (referred to as classification) and then calculated for the subcategory indicators or endpoints (referred to as characterization).

Data validation and characterization are important components of the impact assessment phase. Both the positive and negative impacts of a product, service, or organisation life cycle are included.

The last phase is the life cycle interpretation. The results of life cycle impact assessment and life cycle inventory analysis are evaluated together in order to identify significant issues. Finally, conclusions are drawn in relation to the defined goal and scope. Social impact assessment methods have been developed to estimate the social impacts directly at the unit process activity. (Chhipi-Shrestha et al., 2015)

In this section, we focused on the third phase: Social Life Cycle Impact Assessment (S-LCIA). The purpose of S-LCIA is to provide a combination of: (a) aggregating some inventory data within subcategories and categories; and (b) making use of additional information, such as internationally accepted levels of minimum performance, to help understand the magnitude and the significance of the data collected in the Inventory phase (UNEP/SETAC, 2009). Therefore, S-LCIA may provide assessment of social and socio-economic impacts that can range from specific to very general, from final to preliminary, depending on which level of precision is reached in the summarization and the interpretation, which in turn is influenced by data availability.

This phase is structured along the following sub-phases: normalization, characterization and weighting.

Characterization is the step during which the data is analysed in order to assess its meaning in terms of its potential to cause potential social impacts. At this step, an implicit or explicit value judgment is made on the collected data. Finally, at the weighting step, the characterization results are given a different relative weight. The weighting can be based on the relative importance attributed to different subcategories (e.g., salary and working hours) inside an impact category (e.g., working conditions) and a stakeholder category (e.g., worker), or an equal weighting can be attributed to all results. It can also be based on the relative importance of the unit processes or the life cycle steps in the studied product system.

The S-LCA Guidelines (UNEP/SETAC 2009) distinguish two different S-LCIA approaches, type I and type II (Figure 9) (Parent et al. 2010).
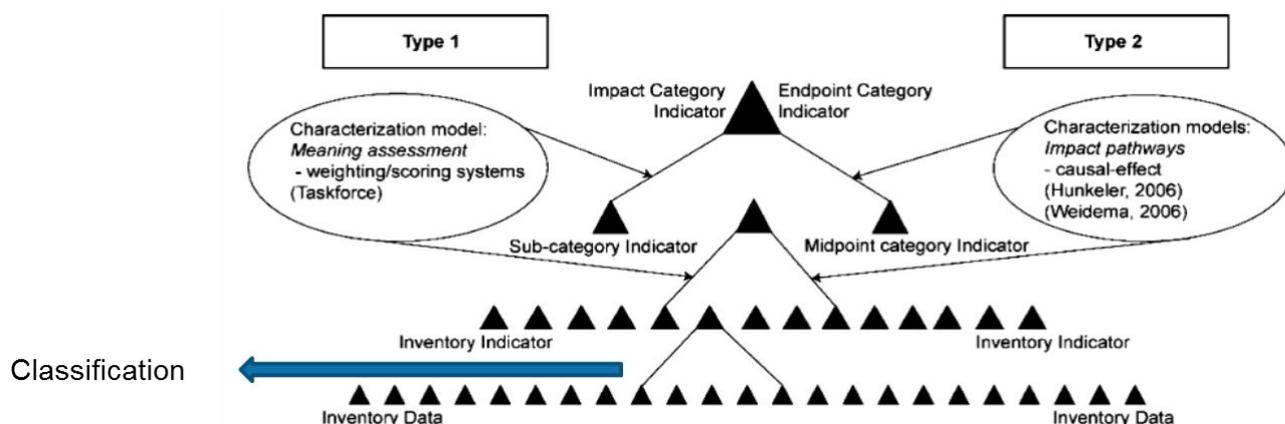
Figure 9 : Type 1 and type 2 impact assessment (adapted from Parent et al. 2010)

Parent et al. (2010) suggested that the difference between type I and type II lies in the characterization model (the evaluation method). Type I methods use performance reference points (PRPs) to assess inventory data. PRPs are typically defined as "internationally set thresholds or goals or objectives according to conventions and best practices" (UNEP/SETAC 2009, p. 72). Type II methods use characterization factors based on measurements of causal links in impact pathways. The existing SLCIA methods are graphically summarised in Figure 10: Existing SLCIA methods.
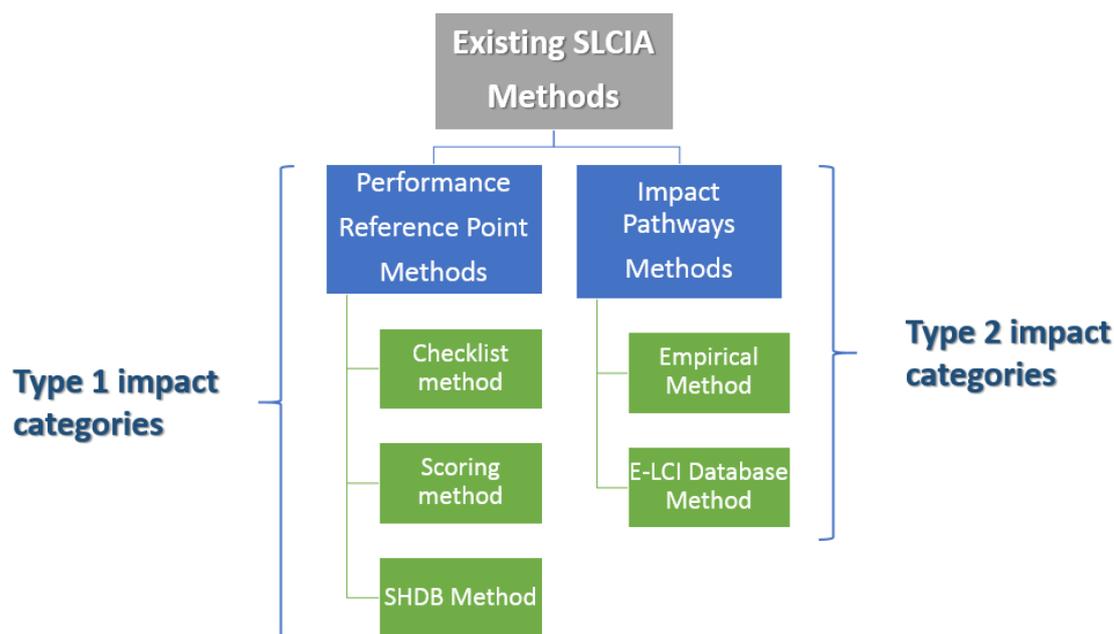
Figure 10: Existing SLCIA methods

Today there is not a specific methodology that prevails. Furthermore, a lot of authors are proposing their own methodology. Some steps are carried out simultaneously, while others are not always carried out, except for the data collection, like the weighting (which is often done implicitly, whereby all subcategories or life cycle steps are weighted at 1), and the final interpretation.

In literature, two reviews on S-LCIA have been carried out, by Russo Garrido et al. (2016) and Chhipi-Shrestha et al. (2015). The main findings of these reviews are reported below.

4.1.1. Type I

The Type I S-LCIA does not make use of causal-effect chains mainly because "cause-effect relationships are not simple enough or not known with enough precision to allow quantitative cause-effect modelling" (UNEP/SETAC, 2009).

Different types of data are collected in type I S-LCA studies. For example, Wu et al. (2014) classified them into organizations/companies, sector/industry, and country-level data and discussed the collection methods adopted for each type. Inventory data also vary as to whether they represent activities, immediate effects, or further effects. Indeed, "even though type I S-LCA always assesses a performance, a feature of a situation, and not an effect, a change" (Macombe et al., 2013), what we find in the literature is that this "performance" can be observed at different points along an impact pathway linking a product system to people's well-being—not only at the beginning of the pathway.

In numerous studies, Type I method use colour coding, scoring and a weighting system for aggregating the inventory indicator data to impact categories (e.g. human rights). They can aggregate qualitative and quantitative indicators.

Impact Categories (type I) used in S-LCA are defined in line with the goal and scope of the study and represent social issues of interest that will be expressed regarding the stakeholders affected and may be:

- Health and safety
- Human rights
- Working conditions
- Socio-economic repercussions
- Cultural heritage
- Governance

As far as characterization is concerned, there are no characterization models between subcategories and impact categories type I that are generally accepted by S-LCA practitioners.

The review carried out by Russo Garrido, highlights different Type I assessment methods (Figure 11) (Russo Garrido et al., 2016), based on: (1) norms and best practice; (2) norms and best practice and the socio-economic context of unit processes; (3) expert's judgment of companies' compliance with norms; (4) researchers' expert's judgment on companies' activities; (5) how a company or a sector or a country is positioned with regards to average sector, country, or worldwide performance; and (6) how the data associated with the social performance of a company or a sector compares to other alternative companies/sectors.

Figure 11: Different types of characterization method in SLCIA in type I (Russo Garrido et al., 2016)

In the following, a description of the different methods is reported, extracted and/or entirely taken from the work of Russo Garrido et al. (2016). [Please, refer to the publication for additional details]

(1) Assessments based on norms and best practices

This type of assessment is the most widely used and corresponds most closely to the original definition of a PRP assessment in the guidelines. It is typically performed with a binary or a four- to five-level scale, which correspond to a certain level of compliance with international, national, or sectoral norms or best practices.

(2) Assessments based on norms and socio-economic geographical context

Dreyer et al. (2010) and Sanchez Ramirez et al. (2014) propose to not only assess data on the basis of whether or not it meets norms and best practice standards, but also to consider the social, economic, and political contexts of the investigated companies.

However, both authors propose to take into account the geographical context quite differently. Sanchez Ramirez et al. (2014) propose the subcategory assessment method (SAM), which is based on a four-level scale (A, B, C, or D), pegged on a compliance level, which they name "basic requirement" (BR). The compliance and above compliance levels (A and B) are similar to that of other norms-based PRPs as discussed in the previous section. However, level C corresponds to organizations not fulfilling the BR and operating in a "negative context" (challenging socio-economic context), and level D corresponds to organizations not fulfilling the BR and operating in a "positive context" (Sanchez Ramirez et al. 2014). In other words, the worst performance level on the scale (level D) will be granted to organizations which do not comply with the BR even if located in a positive context, which should in fact promote the attainment of this BR.

Dreyer et al. (2010) propose a very different approach. Taking as an example the issue of labour rights, the authors propose a multi-criteria indicator that assesses the effort (will and ability) of a company to manage a given social issue, in line with existing norms, in this case ILO conventions.

Through a number of steps, the multi-criteria indicator score, which reflects corporate social performance, is then translated into a level of risk of social impacts actually occurring, mostly by considering the context of the company in terms of geographical location and industrial sector. A company demonstrating a weak management performance with regards to a given social issue and operating in an environment typically riddled with severe social risk will obtain a result pointing to a high risk in terms of social impacts.

(3) Assessments based on stakeholders' or experts' judgment of companies'/sectors' compliance to societal expectations or norms

Some authors propose to assess corporate performance by relying on stakeholders' perceptions or experts' judgments on the compliance to societal expectations of the companies investigated. In this type of approach, the data collected is stakeholders' or experts' input. Here, the characterization is performed upon collection, when stakeholders or experts are asked—on a multi-level scale—how they rate the social performance that may be associated to a corporate activity, based on their knowledge and experience.

(4) Identification of most salient issues based on researchers' expert judgment on company's activities

This approach corresponds to what the guidelines call "simple aggregation," whereby the researcher brings together qualitative or quantitative information into a single summary, within a subcategory, based on what are the most salient issues in his/her inquiry. For example, Bouzid and Padilla (2014) take ILO conventions as a general reference point to identify salient issues.

(5) Assessments based on how a performance is positioned with regards to a distribution of performances

Some characterization approaches focus on assessing a company, a sector, or a country, based on how it performs on social issues in comparison to other companies, sectors, or countries. The Social Hotspot Database (SHDB) adopts this approach for a number of its social indicators. It compares the data obtained for a sector-country (e.g., data for "sector average wage" in "wheat sector in China") with the worldwide distribution of data on this issue. The distribution is divided in quartiles—if the sector-country's data in question falls within the first quartile, it is considered at "low risk"; if it falls within the second quartile, it is considered at "medium risk"; and the last two quartiles correspond to "high risk" and "very high risk" (Benoît Norris et al. 2013). The SHDB characterization scheme intervenes in numerous studies which integrate SHDB results (Martínez-Blanco et al. 2014; Ekener-Petersen and Finnveden 2013).

(6) Assessments based on comparison between life cycle steps or alternative product systems

In this approach, a comparison is made between the inventory data associated to life cycle steps or alternative product systems. Here, the assessment simply relies on a simple comparison in which the data that reflects the best company performance is identified.

The characterization is always matched with an explicit or implicit weighting step. In order to obtain final results, this step usually occurs after characterization, but it can also, be carried out before or simultaneously.

There are two broad categories of weighting, those that are based on relative importance of different social issues and those that are based on the relative importance of unit processes or life cycle steps. Within these two categories, five main approaches have been identified: (1) implicit equal weighting of all subcategories, categories, unit processes, or life cycle steps; (2) prioritization of worse performance within a subcategory; (3) weighting according to stakeholders', experts', or users' perception of importance of issues; (4) weighting according to importance of issues based on UN conventions; and (5) according to a variable representing the relative importance of different life cycle steps/unit processes.

Different weighting approaches can be combined in one single study.

(1) Implicit equal weighting of all subcategories, categories, unit processes, or life cycle steps

This kind of weighing predicts that every sub-category has the same importance. For this reason, we cannot speak about a really weighting phase.

(2) Prioritization of worse performance within a subcategory

Worse performance is prioritized within subcategory: When more than one characterization indicator belongs to a subcategory, Ekener-Petersen and Finnveden (2013) suggested selecting the worst scored indicator as the result for the subcategory. Implicitly, a weighting factor of 1 is given to the worst scored indicator and 0 is granted to the rest of the indicators in the subcategory.

(3) Weighting according to stakeholders'/experts'/users' judgment of importance of issues

A number of approaches weighs the importance of social issues according to stakeholders', users', or experts' judgment. The techniques for doing so vary, from simple consultations, to ranking surveys on issues (Manik et al. 2013), to multi-criteria decision-making tools such as the analytical hierarchy process (AHP) (Hosseinijou et al. 2014).

(4) Weighting according to importance of issues based on norms and general literature

Another less explored approach is to weigh the importance of social issues according to internationally negotiated norms and literature about precursor rights, as proposed by Beaulieu et al. (2014). The authors base themselves on the ILO Declaration on Fundamental Principles and Rights at Work, the five pillars of the Decent Work agenda (rights at work, employment creation, social protection, and social dialogue), as well as the concept of precursor rights to propose a hierarchy among S-LCA subcategories.

(5) **Weighting according to an activity variable**

Characterization results for one unit process can be weighted according to the importance of the unit process relatively to the other ones of the system, i.e., the relative importance within the life cycle considered. The most common way to determine the relative importance of unit processes is through the use of an activity variable. An activity variable is a variable representing a quantifiable activity that can be measured at the different unit process and scaled to a FU (Norris 2006; Andrews et al. 2009). Technically, any quantitative inventory indicator scaled on a FU could serve as activity variable. However, working hours are the most used activity variables as it is coherent to weight all the issues related to the working conditions according to the number of working hours "generated" through the provision of a FU.

The previous sections have highlighted the multiplicity of approaches that are comprised within type I S-LCA today, in terms of the presence of some optional steps, and the different characterization and weighting steps that are addressed in the current literature. They have also put forward the idea that it is helpful to conceptually distinguish the characterization and the weighting steps from one another—these are often subsumed and intertwined under the term "characterization model" or "impact assessment method" in the literature. Separating characterization from weighting helps better allows understanding the differences and similarities between the evaluation methods proposed by practitioners.

It is also useful to gain greater clarity on what importance will be given to different characterized results—and in this process, what "bad performances" or "good performances" might be rendered more or less visible within the end results of the S-LCA. In this regard, approaches used in multi-criteria assessment methods could be explored in order to strengthen the transparency of weighting methods in S-LCA.

In the next section we explore the type II impact assessment method.

4.1.2. Type II

Impact pathways methods assess the social impacts of a product, service, or organisation system using impact pathways as characterization models comprised of midpoint indicators and/or endpoint indicators similar to environmental LCA (Parent et al. 2010). These methods are based on social effects and use cause-effect chains to estimate the impacts, and are mostly based on quantitative indicators. They are included in Type II impact assessment by UNEP/SETAC Guidelines (Parent et al. 2010) as Midpoint category and Endpoint Category.

Midpoint category and Endpoint Category.

Midpoint Category aims to cover an environmental problem that stands somewhere between the Inventory (i.e. an emission) and the final damage on the Area of Protection (UNEP/SETAC, 2009) (ex. Human Toxicity). On the other hand, endpoint categories seek to represent the environment damages caused to an Area of Protection (UNEP/SETAC, 2009) (Human Health, Ecosystems and Resources).

Generally, impact pathways methods involve quantitative indicators characterizing midpoints and endpoints. Researchers have used different techniques, which can be classified as the empirical method and the environmental Life Cycle Inventory (LCI) database method (Parent et al., 2010). The empirical method uses the data obtained from secondary sources such as literature, archive data or primary sources such as the data obtained from the field for use in empirical relations. However, environmental LCI database method uses the data from environmental LCI database which has been primarily prepared for E-LCA.

Empirical method

The empirical method involves the use of empirical formulas or rules in order to assess social impacts. There are a variety of empirical methods applied to S-LCIA as discussed below. For example, in one of the earlier works on S-LCA, Dreyer et al. (2006) proposed a conceptual S-LCA framework using ILO conventions. The pathway model (framework), from top to down, included an area of protection (human dignity and well-being) and midpoints (impacts of companies on employees). As a new concept, they included a two-layer social LCA method containing an optional and obligatory set of impact categories. In the obligatory set, a minimum requirement based on universal norms and local or country norms was included. In the optional set some self-determined context-specific parameters were included.

Although some impact categories and their indicators have been developed, the framework is still at an early stage and lacks a systematic framework for normalisation, weighting and aggregation. On the other hand, Weidema (2006) proposed QALYs (Quality Adjusted Life Years) as a unit of impact measurement for human well-being analogous to DALYs (Disability Adjusted Life Years) being used as a measurement unit for damage to human health in environmental LCA. He used six damage categories for human life: health; life and longevity; autonomy; safety, security and tranquillity; equal opportunities; and participation and influence.

A single social impact indicator, specifically health impact, was assessed empirically by some researchers. Feschet et al. (2012) assessed the social impact of a product using Preston pathway (curve), an empirical relationship, between real life expectancy at birth and real per capita income. The study has presented the health impact due to economic activity of the banana industry in Cameroon. Interestingly, they found that the activity of the banana industry would increase the life expectancy at birth in the country by five days over 20 years considering 200,000 tons export of bananas annually. In addition, Feschet et al. (2012) have suggested that the Preston curve is applicable when the four conditions are met: GDP per capita is less than 10,000 dollars; the given activity has a significant contribution to national GDP; the duration of the given activity is regular and long; and the added value generated by the activity is shared within the entire country. Although the authors mentioned it as a valid method for comparative purpose, it needs further research for its validity and refinement.

Some authors have assessed country-level social LCA.

For instance, Stamford and Azapagic (2012) assessed the social dimension of the sustainability of electricity options for the UK at the country level as a part of LCSA by considering the full life cycle.

An empirical method can also be applied using the data directly collected from the field. The collected data are site specific, and so impact assessment is also site-specific. This method increases the certainty of impacts assessed with respect to the location.

In conclusion, there is a wide variation in the empirical method applied in assessing social impacts. Cut-off criterion is an important issue, which has not yet been defined in S-LCA methodology.

Environmental LCI database method

In environmental LCI database method, the environmental LCI database is used for estimating social impacts. This approach is similar to environmental life cycle impact assessment. Hunkeler (2006) used an LCI database of E-LCA to compare the social impacts of two types of detergents. The methodology was based on midpoints and used labour hours as an intermediate variable. By the same system boundaries and a functional unit as of E-LCA, the existing LCI was transformed to a geographically specific LCI for each unit process. Then, the employment hours were calculated for each unit process and an overall employment table was computed. Finally, the social impacts were assessed using estimated regional characterization factors. However, the author mentioned this method as preliminary model.

Although this method attempts to connect S-LCA with E-LCA by including a geographic specificity in S-LCA, it is a process based model and does not account for the behaviour of a company, which is also an important aspect of S-LCA.

From these case studies, it can be said that the use of the environmental LCI databases for S-LCIA is the bridge for linking S-LCA and E-LCA and also maintains uniformity in functional unit, system boundary, and base data as far as possible. However, only a few social impacts such as health impact and employment are assessed by this method. In addition, it is mostly generic assessment. The many social effects caused by company behaviour cannot be captured by this method.

4.2. Case studies

To assess the case studies, a systematic literature review was performed. It sets up as a comprehensive review (and, where possible, a full one) of published articles, selected to address a specific question, which uses a systematic method to identify relevant studies, to minimize distortions and errors (Jesson and Lacey 2006). For this reason, the study of the main methods available in literature to implement a systematic review was performed.

The presented systematic review mainly considered the following methods: "Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The PRISMA Statement" (Moher et al. 2009) and elaboration document (Liberati et al. 2009); Standardized Technique for Assessing and Reporting on Reviews of Life Cycle Assessment (LCA-STARR) (Zumsteg et al. 2012); and "Guidelines for Systematic Evidence Review and Synthesis in Environmental Management" (Collaboration for Environmental Evidence 2013). The mentioned methods are in some aspects very similar, but they differ in the steps of the research that most define the object under analysis. Indeed, while the PRISMA method was born, and developed in the medical field, STARR-LCA has its object of study in LCA, and the last-mentioned method was developed as part of environmental management.

Considering the systematic review methods of the literature, the one carried out here was conducted following these steps: identification, double screening, and eligibility.

- Step 1: the case studies were selected.
- Step 2: the full text of all documents potentially eligible was evaluated based on previously identified criteria for inclusion/exclusion.
- Step 3: the papers (both the included and the excluded ones) were again screened by each author of this paper, independently.
- Step 4: the papers to be considered were identified (for the full list, refer to Annex 1).

Inclusion and exclusion criteria

The parameters for identifying the case studies are essential in order to answer the research questions and to reduce the likelihood of bias. These criteria made it possible to include or exclude case studies emerging from the research databases.

The main inclusion criterion regarded the methodology used to assess the social impacts; only those papers applying S-LCA were included in the review.

Even though grey literature is abundantly used nowadays, thanks to its easy distribution, the decision to not include it in this systematic review was likely to lead distortion due to the absence of a quality control of the papers themselves, which is instead guaranteed in peer reviewed publications.

The included studies cover a time span ranging from 2009 to August 2017. As the publication of the guidelines dates to 2009, it was decided not to consider the first applications of S-LCA (Labuschagne and Brent 2006; Manhart and Grießhammer 2006), even if these have been an incentive and an important practice for the following developments.

The analysed case studies were collected through the following search engines: Google Scholar, Scopus database, and inter-database Discovery Service (powered by EBSCO Host) accessed by the "G. d'Annunzio" University. The search was applied to titles and abstracts, using "AND/OR" operators. More precisely, the research on Scopus was performed in article title, abstract, and keywords; in Google Scholar selecting "anywhere in the article"; and in Discovery selecting "all text".

Results and discussion

The current review represents the evolution of previous papers (Di Cesare et al. 2014; Petti et al. 2014; Di Cesare et al. 2016; Petti et al. 2016). For the 65 case studies analysed in this report, even though they do not deviate from the 40 identified by the previous processing, they are still significantly different in terms of outcome produced.

We think important to clarify that the authors who developed the case studies considered the steps defined in the UNEP/SETAC Guidelines, borrowed from the ISO 14044 standard.

Fifty percent of the case studies were published in the International Journal of Life Cycle Assessment and 20% in the Journal of Cleaner Production. These are followed by Sustainability 7 %, the Journal of Industrial Ecology 7 %, and seven other journals, which altogether account for 17 % (Resources Conservation and Recycling, Materiaux and Techniques, Energy Policy, Integrated Environmental Assessment, New Medit Journal Impact Factors, Environmental Development, Procedia CIRP); two case studies are published in a collective volume, edited by Muthu (2015) (Revéret et al. 2015; Nemarumane and Mbohwa 2015), and a case study (Ciroth and Franze 2011) in a book edited by Green Delta TC. Seventy-six percent of the case studies applied the S-LCA methodology, while 24 % used the full methodology of life cycle sustainability assessment (LCSA). LCSA is defined as the integration of the E-LCA (environmental LCA), S-LCA, and life cycle costing (LCC) methods (Shau et al. 2011; Busset et al. 2014).

Temporal trends

In 2013, the year of publication of "The methodological sheets for subcategories in social life cycle assessment (S-LCA)" (UNEP/SETAC 2013) there was an increase of 700 % of the publications (Figure 12 : Temporal trend of studies), compared with the number of case studies published in 2012, followed in 2014 by a setback (−60 %). The reason for this is probably that the methodology is still incomplete and requires further development (Jørgensen 2013). It is also known that 2014 was an important year for the scientific community that deals with the S-LCA, thanks to two important meetings, the SETAC Europe 24th Annual Meeting (in Basel) and the 4th International Seminar on S-LCA (in Montpellier) (Macombe and Loeillet 2014). Many of the papers presented in these events will be published in scientific journals during this year. Indeed, since the early months of 2015, there was an increase in case studies, with the publication of eight new papers, which have already exceeded the number of the ones in 2014 (six). In 2016, the implementation of case studies has continued to grow.

On the base of data collected till August 2017 it seems that the year 2017 will keep unchanged the number of case studies published.
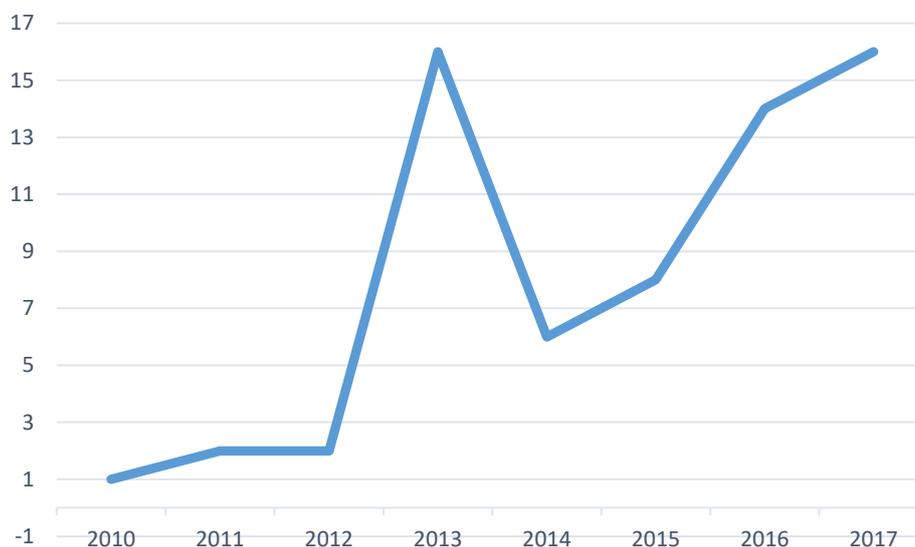
Figure 12 : Temporal trend of studies

Object of study

The object of study of the analysed papers was grouped into the following three different areas (
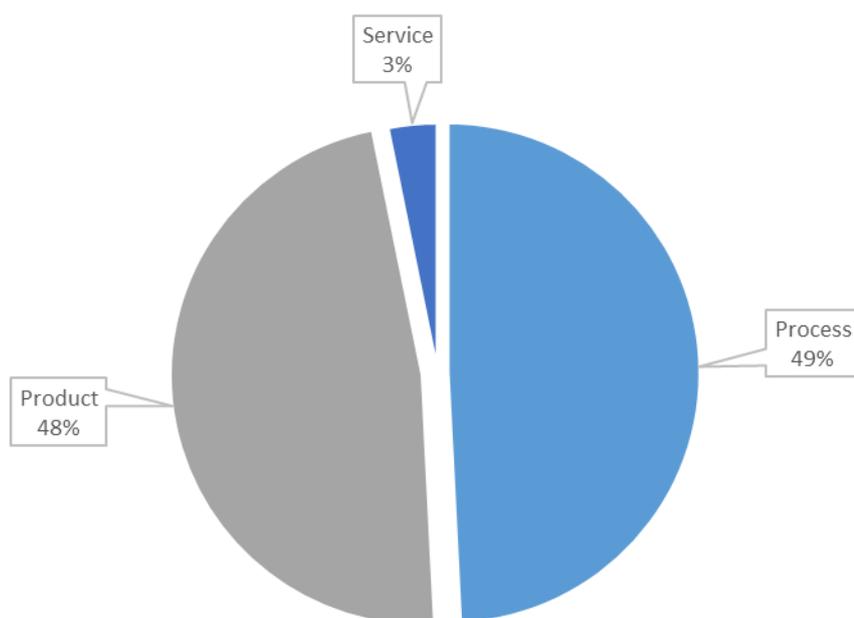
Figure 13): 60 % regard a product (the analysed products are in 26 % of cases in the "food" category), 25 % studied a service, and 15 % analyse a process.
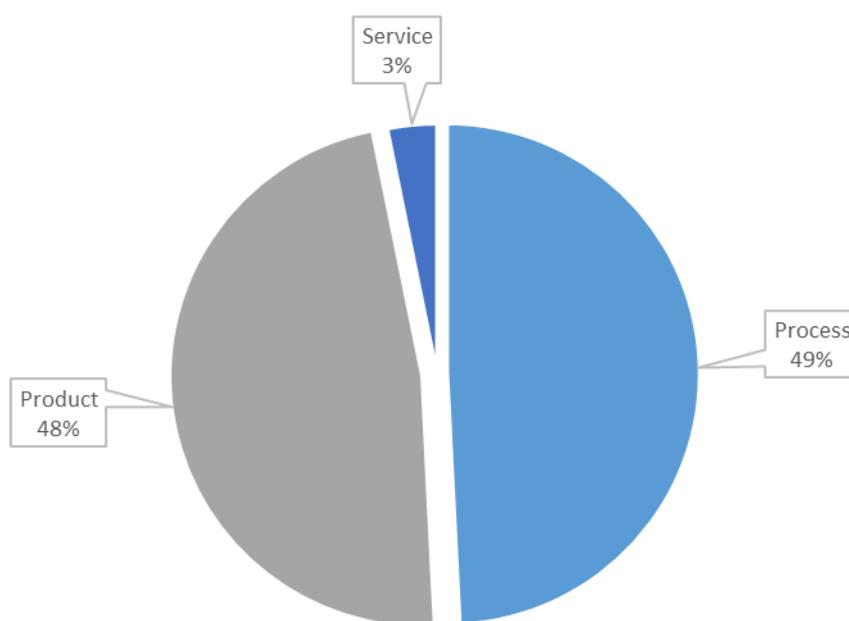
Figure 13 : Object of study

Sector of application

As for the field of application in which the considered case studies were performed, the most explored was manufacturing, with a percentage of 38 % (Figure 14). While in the remaining papers, 22 % of case studies were found to be in the energy sector, e.g., photovoltaic (Traverso et al. 2012; Yu and Halog

2015) and biofuel (do Carmo et al., 2017; Macombe et al., 2013; Manik et al., 2013; Ren et al., 2015); 22% in the agri-food sector; 21 % in the waste management sector; and one study dealt with tourism (Arcese et al. 2013). A thorough reading of this data shows an unforeseen perspective; it was expected that the scope of the most interested sectors would be of high-risk social and socioeconomic problems, while the sectors analysed appear to be the areas with a strong environmental aspect. This is probably due to the fact that S-LCA was born as part of a broader assessment of goods and services with a view to sustainable development. Within this overall assessment, the E-LCA and S-LCA definitely have a lot in common. Indeed, the guidelines (UNEP/SETAC 2009) clearly state the differences between the two methods in the first pages (p. 38). This may have resulted in an interpretation that promotes focus on practitioners in sectors with environmental stakes.
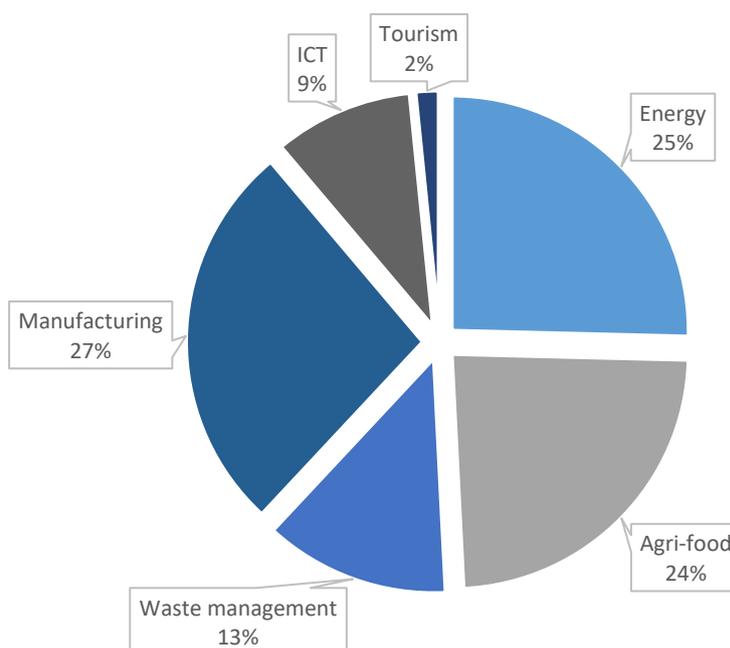
Figure 14: Sector of application

Geographical area

Following the classification fundable in UN (2014), the authors calculated that the 48 % of case studies are implemented in "developing economies" while the 46 % in "developed economies", probably because countries with elevate social hotspots. This demonstrates that the "social context" does not influence the number of studies developed in a geographical area.

For the 61 analysed case studies, Europe can be certainly regarded as the continent in which most of them are concentrated (Figure 15: Geographical area of reference of the studies). In this analysis, all the countries were taken into account and considered individually, even when the supply chain of a product was distributed in various continents; in three papers, the reference was to the world. It is

interesting to note that the continent in which most of the research is conducted is Europe, with its low levels of risk in social or economic concerns.

Perhaps because, according to Mattioda et al. (2015), the highest concentration of researchers is located in the Old Continent (Denmark, Sweden, Netherlands, and Germany). Another valid reason may be the difficulty in finding certain types of data (especially qualitative and those being socially sensitive) in developing countries.

Nevertheless, there is hope that in the future, the S-LCA will be increasingly applied in those fields and in those places where it can contribute, effectively and efficiently, to improve the conditions of the stakeholders involved.
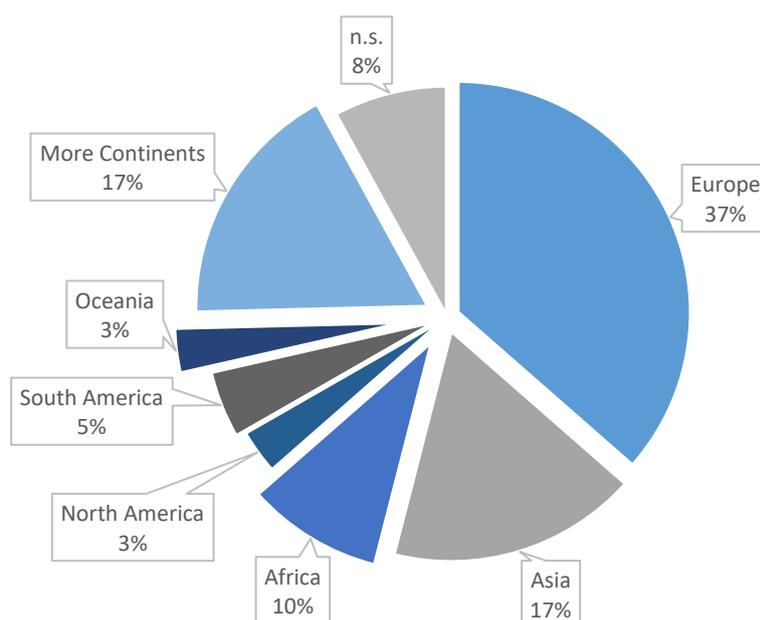
Figure 15: Geographical area of reference of the studies

Main methodological issues

The main methodological issues of S-LCA, are often borrowed from E-LCA. However, different importance is given to data and semi-quantitative and qualitative indicators compared to E-LCA. For example, as the guidelines clarify, when dealing with this kind of data, the impacts will not be expressed in relation to the functional unit (FU) as in ELCA. In this regard, even some authors (e.g., Zamagni et al. 2011) spoke in favour of a non-FU based S-LCA perspective.

In 22 % of the cases, the FU is not specified as well as the system boundaries Figure 16: Functional unit reported in analysed case studies, whereas the reference flow is not specified in 79 % of cases. In one of the analysed papers (Umair et al. 2015), the authors, having used only qualitative data in their research, state that the impacts cannot be expressed in a FU.
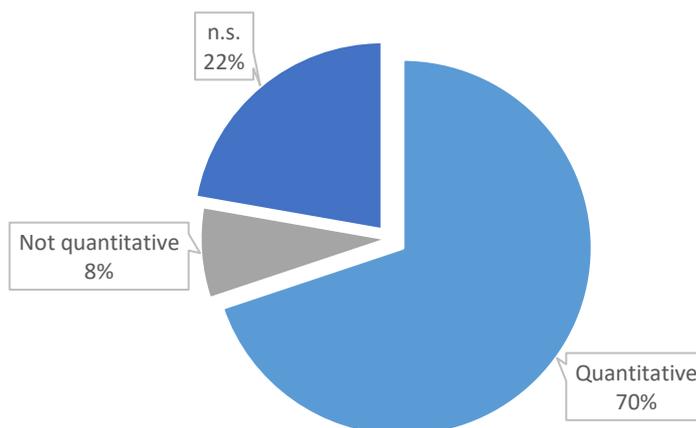
Figure 16: Functional unit reported in analysed case studies

Furthermore, concerning the System Boundaries (SB), one should remember that scientific evidence is still necessary regarding the ability to define the boundaries in S-LCA, such as in E-LCA; indeed, as Lagarde and Macombe (2013) suggested, and according to the discussion on the scope of S-LCA in the previous sections, these are not always identical.

In 68 % of the selected papers, the SB were divided into and restricted to single phases of the life cycle (Figure 17: System boundaries). In addition, the SB were defined as a reference system without however considering some of the important processes, such as transport (e.g., Nemarumane and Mbohwa 2015; Umair et al. 2015). In one of the case studies (Macombe et al. 2013), the assessment of biofuel from three different raw materials is carried out at three distinct levels: company, regional, and state levels. The SB were considered "from cradle-to-gate". Nevertheless, the predominant trend remains that of SB "from gate-to-gate" (24 %) and "from cradle-to-gate" (41 %).

Figure 17: System boundaries

The Impact Assessment (IA) is definitely the most fragmented phase; as shown in the paper of Wu et al. (2014), there are many different IA methods, which can use type I and type II impact categories. This may be due to the fact that the S-LCA method was only drafted and not standardized (Zamagni 2012). This has caused a proliferation of models and/or different techniques, also by the same author, which can be deemed useful as the demand for S-LCA impact assessment methods could no longer wait for a scientific and shared method (Macombe et al. 2013).

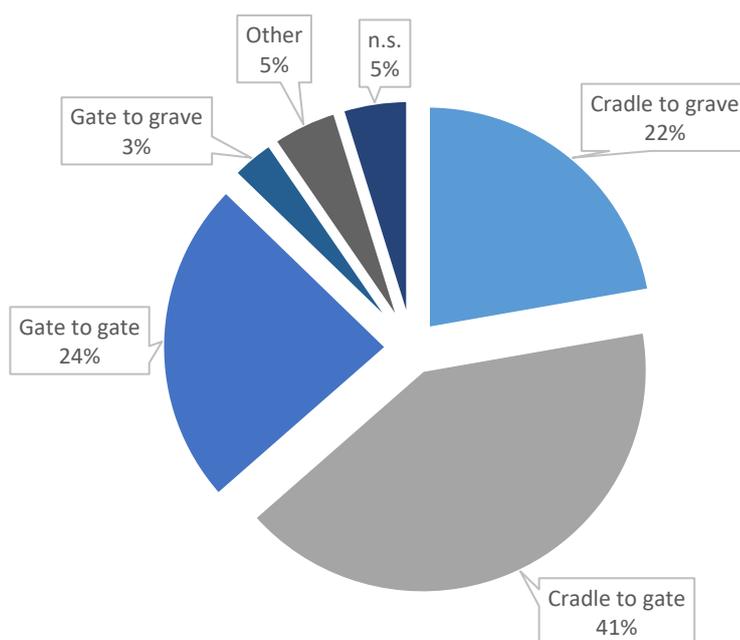As there is no question about the complexity of the matter and the need for further study, the authors stress the need (as emphasized by Macombe et al. 2013) at first to clearly define the meaning of important terms, such as "social performance", "social effects", and "social impacts". Particular attention should be paid to the latter concept, often confused with social effects, partly because of the difficulties to make a scientifically complete analysis.

It appears, from this review, that in five cases (Foolmaun and Ramjeawon 2013a; Martínez-Blanco et al. 2014; De Luca et al. 2015; Revéret et al. 2015; Umair et al. 2015), more than one IA methodology has been applied, and five new IA methodologies were developed and presented (Ciroth and Franze 2011; Aparcana and Salhofer 2013a; Ekener-Petersen 2013; Foolmaun and Ramjeawon 2013a; Ren et al. 2015). The Social Hotspot Database (SHDB) (Benoît-Norris et al. 2012) was used in nine cases (e.g., Martínez-Blanco et al. 2014; Ekener-Petersen et al. 2014; Touceda et al. 2016; Zamani et al. 2016), three of which (Martínez-Blanco et al. 2014; Revéret et al. 2015; Touceda et al. 2016) used it in combination with other methods, Life Cycle Working Environment (LCWE), USEtox™ and Potential Hotspot Analysis (PHA).

The stakeholders mostly taken into consideration were **workers and the local community**. In contrast, the less considered were value chain actors and consumers. In 6 % of the cases, the stakeholders mentioned were not explicitly taken from the guidelines, while in 4 % were not specified at all. That which immediately comes to evidence is the lack of consideration of the value chain actors, central to a comprehensive life cycle approach.

The importance of the value chain in the life cycle thinking (LCT) approach is the full range description of activities which are required to bring a product or service from its conception, through the distinct phases of production and delivery, to its final consumers and end-of-life management.

The positive impacts: a questionnaire

To explore positive impacts in the analysed S-LCA studies, the evidence of at least one positive impact occurred in 59 % of cases, neither a negligible figure nor a confirmation of the existence of both research and analysis of positive impacts in practice. Moreover, most of the social issues in the present guidelines have negative impacts (Ekener-Petersen 2013). In addition, S-LCA completes the E-LCA regarding the social and socio-economic aspects, but, as it is clear that the social consequences of a supply chain are

different from their environmental impacts (Clift 2014), equally, all impacts detected by the two methods should be considered in different ways. The two methods differ in the meaning they give to the term "impact"; in E-LCA, impacts are almost seen as negative, even if positive environmental impacts emerge. In principle, when looking at the environment, it is better not to have impacts at all (UNEP/SETAC 2009). Instead, in S-LCA, this vision has helped to consider the absence of negative issues, such as child labour, as a positive impact (Jørgensen et al. 2008; Ciroth and Franze 2011). Of course, for some authors, the problem is already in the definition of positive impacts, as they consider them like the environmental ones.

These impacts can also defined as "related to issues that may add value in themselves, such as job creation or capacity building" (Ekener-Petersen 2013, p. 44). The sum of positive impacts that a product, people, or organizations create can constitute the so-called "handprint". A handprint of people or organizations shows that it is possible to have a net positive impact, when the good done and the positive changes promoted are larger than their footprint (Norris 2013). This perspective triggers a positive loop in spreading positive impacts. The outlined view is confirmed in the questionnaire prepared by Petti et al. (2014), which was filled in by 20 authors of papers and experts in the field of S-LCA. When asked about the definition of a positive social impact, the replies were split between those who would define it as a net positive effect of an activity on a community and the well-being of individuals and families and those who see it more as a performance that goes beyond compliance. Moreover, the question on whether a positive social impact is merely an improvement related to the previous situation, 50% of those interviewed agreed, 39% did neither agree nor disagree, and 11 % did not agree. For 76 % of them, the classification of an impact as "positive" could be regarded as a subjective issue, whereas the 90 % considered it to be context related. The 84 % affirmed that positive social impacts should be assessed as in the case of negative ones, 11 % disagreed, and 5 % had no opinion on this. In all the analysed case studies, the authors have identified positive impacts, but how these were detected appears to be a universe of heterogeneous methods and techniques.

There is no agreement on whether the UNEP/SETAC subcategories can also be regarded as positive impacts or whether it would be necessary to set new subcategories to identify positive social impacts. Regarding the introduction of new subcategories, one of the experts suggested using the cause-effect relations, already studied and certified in social sciences, to develop positive social pathways. All the interviewees agreed that researching in the context of positive impacts is useful to the general research advancement on social impacts.

Positive impacts were not considered in 47 % of the investigated cases; this was not because the products/services under study had no positive impacts of any kind but because the authors did not specify them. In the remaining 53 % of the cases, positive impacts were recorded and cited; they were identified in 20 subcategories, 76% of which were attributable to the UNEP/SETAC ones (Benoît-Norris et al. 2013) and closely related to the stakeholders. Local employment was considered an important positive impact with a percentage of 21 %, followed by 13% for improved health and safety; 11 % for

increase in economic development; 5 % for better working conditions, increased consumer privacy, and technology development; and 3 % for decrease in child labour, increase in the freedom of association, increased transparency, decrease in forced labour, equal opportunities, access to material, and immaterial resources. The remaining 24 % of the positive impacts (non-attributable to the UNEP/SETAC subcategories) were: increased income, cooperation contracts, diversification, psychological working conditions, social acceptance, improved physical area reputation, improved environmental impacts, and access to information.

Conclusions

How it is reported in Petti and Campanella (2009), the S-LCA of a product presents, as well as it happens in every methodology, some strengths and weaknesses. The main problems regard, for example, how to relate quantitatively the existing indicators to the functional unit of the system, how to obtain specific data for the regional S-LCA (it might happen to have a scarce availability of data, or a total lack of them for different processes or activities), how to decide among qualitative or quantitative indicators, how to quantify all impacts properly, or how to evaluate the results. (Klöpffer, 2008). The strength of the methodology is that it makes the assessment of the product more complete, adding its social aspects to the environmental and economic ones. The S-LCA would allow companies to fully consider sustainability and, providing information about the potential social impacts on people, caused by the activities in the life cycle of their product, it would facilitate them to conduct business in a socially responsible manner (Dreyer et al., 2006; Hauschild et al., 2008).

The development of literature and the increase in the number of implemented case studies are helping the growth and widespread use of LCT and of the life cycle-based methodologies, in such a way so as to allow the E-LCA, LCC, and S-LCA to play a central role in helping to define the best policy options that lead to sustainable development.

Bearing in mind this key mission, it is important to emphasize that a great interest on social issues and LCT is observed. Such attention is, however, more directed to social issues rather than the methodology of the S-LCA itself.

Even about the main methodological issues, what emerges is a lack of a complete definition. This is particularly evident when the methods of IA are analysed and the difficulty in identifying a unique and shared method is denoted. This probably stems from the fact that currently in the guidelines, there is no detailed list of methods for the implementation of the IA stage (especially for the retrieval and processing of qualitative data) that are promoted by the task force. This confusion also arises from the misunderstanding on the goal and scope of S-LCA, which is sometimes regarded as corporate social responsibility (CSR), forgetting that S-LCA was developed to consider impacts vertically (through the supply chain). CSR, on the contrary, makes "horizontal" assessments; the focus is, indeed, on the impact of an organization (Choi 2015).

4.3. Users of Social Life Cycle Assessment

In this part, we propose a panorama of S-LCA actors. This panorama cannot claim an exhaustive census of all the actors of the world. It was carried out via our knowledge of the actors in this field and, with the exception of public information available directly on the websites of previously identified actors. This panorama has been focused on French, and European actors.

The following table summarizes the main actors of S-LCA. For better readability, the actors were classified alphabetically and by type. Thus, it is proposed the following typology for classification of these actors:

- Laboratories and academic research teams;
- Industrial technical centres, professional institutes, professional federations, and competitiveness clusters;
- Industrial actors (companies, private organizations…);
- Associations: NGOs and professional associations.

This list is not exhaustive. However, it lists the actors recognized as "major", either by their competence in S-LCA, by their level of involvement in the subject, or, independently of S-LCA, by the level of intrinsic recognition in their field (or by combination of these factors).

Organization	Description	Website
Laboratories, academic research teams and others research institutes		
Aalborg University	*Denmark*	*http://www.en.aau.dk/*
Center for Advanced Life Cycle Engineering (CALCE)	*Performing lifetime and lifecycle assessments on electronic products*	*http://www.calce.umd.edu/*
Center For Life Cycle Analysis of Colombia University	*Colombia*	*http://www.clca.columbia.edu/*
CIRAD	*The French organization for agronomic research and international cooperation for the sustainable development of tropical and Mediterranean regions.*	*http://www.cirad.fr*
CIRAIG	*Center of expertise in the life cycle*	*http://www.ciraig.org*
ELSA (IRSTEA, CIRAD, INRA, SUPAGRO, EMA)	*Environmental Lifecycle and Sustainability Assessment*	*http://www.elsa-lca.org*
Finnish Environment Institute - Syke	*Finland*	*http://www.syke.fi/en-US*
French Agency for the Environment and Energy Management (ADEME)	*Manage the operations having for object the environmental protection and the control of the energy.*	*http://www.ademe.fr*

Gent University	*Belgium*	*https://www.ugent.be/en*
Harvard Extension School/New Earth	*USA*	*http://www.extension.harvard.edu/*
Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture - IRSTEA	*A European player in environmental research*	*http://www.irstea.fr*
Italian National Agency for New Technologies, Energy and Sustainable Economic Development - ENEA	*Italy*	*http://www.nerghy.eu/rs_members/enea-ente-per-le-nuove-tecnologie-lenergia-e-lambiente/*
LCA to go	*Development of a box with Internet tools with the aim of encouraging the appeal to the ACV in SME (small and medium-sized enterprise).*	*http://www.lca2go.eu/*
Luxembourg Institute of Science and Technology - LIST	*Luxembourg*	*https://www.list.lu/*
Massachusetts Institute of Technology - MIT	*USA*	*http://web.mit.edu/*
National Renewable Energy Laboratory (NREL)	*Leader in the field of LCA of energy technologies, created the U.S. Life Cycle Inventory Database*	*http://www.nrel.gov/*
Permanent representation of France with the European Union	*Environmental Unit*	*http://www.rpfrance.eu/*
Pontificia Universidad Catolica del Peru	*Peru*	*http://www.pucp.edu.pe/*
Royal Institute of Technology	*Sweden*	*https://www.kth.se/en*
Saskatchewan Research Council (SRC)	*Offers valuable industry and government-driven research and development including LCA*	*http://www.src.sk.ca/industries/environment/pages/carbon-accounting-and-life-cycle-assessments.aspx*
Technische Universität Berlin	*Germany*	*http://www.tu-berlin.de/menue/home/*
UNICH	*Italy*	*https://www.unich.it/*
Universidade Tecnológica Federal do Paraná - UTFPR	*Brazil*	*http://www.utfpr.edu.br/*
Université de Montpellier	*France*	*http://www.umontpellier.fr/*
Université du Québec à Montréal	*Canada*	*http://www.uqam.ca/*
University of Sydney – USYD	*Australia*	*https://sydney.edu.au/*

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Industrial technical centres, professional institutes, professional federations, and competitiveness clusters		
Roundtable for Product Social Metrics	A group of experts from large companies who join forces for addressing social sustainability issues at product level.	http://product-social-impact-assessment.com/
ELSA-PACT	Industrial Chair on the evaluation of life cycle sustainability	http://www.elsa-pact.fr/language/en/
ENEC (European Network of Ecodesign Centres)	Platform of information exchange, experiences and best practice in the field of the eco-design.	http://www.ecodesign-centres.org/
EUROPEN (European Organization for Packaging and the Environment)	Represent the industry of the packaging and the environment.	http://www.europen-packaging.eu/
Plastics Europe	Represent the industry of the plastic in Europe (except bioplastic).	http://www.plasticseurope.org/
Industrial actors		
Ahold Delhaize	Food retail groups (supermarkets, e-commerce, sustainable retailing)	https://www.aholddelhaize.com/en/home/
AkzoNobel	Paints and coatings company	https://www.akzonobel.com
BASF	Chemical company	https://www.basf.com/fr/fr.html
BMW GROUP	Luxury vehicle, motorcycle, and engine manufacturing company	https://www.bmwgroup.com/en.html
Covestro	Manufacturers of premium polymers	http://www.covestro.com/en
DSM	Global science-based company active in health, nutrition and materials	http://www.dsm.com/corporate/home.html
Good Year	Tire Company	www.goodyear.eu
L'Oréal	Cosmetics	http://www.loreal.com/
Mahindra Sanyo Special Steel Private Limited (MSSSPL)	Manufacturer of Carbon, Alloy & Tool Die Steels in As Cast, Forged, Rolled, Turned, Heat treated and Ring forged supply condition	http://www.mahindrasanyo.com/
Mark & Spenser	Retail (Food, Clothing and home products)	http://www.marksandspencer.com/
Nestlé	Nutrition, Health and Wellness Company	http://www.nestle.com/
PHILIPS	Development of electric light, LED, and intelligent lighting systems	http://www.lighting.philips.com/main/home

Reckitt Benckiser	*Multinational consumer goods company (producer of health, hygiene and home products)*	*http://www.rb.com/*
Solvay	*Chemistry*	*http://www.solvay.com/en/index.html*
Steelcase	*Metal Office Furniture Company*	*https://www.steelcase.com/*
The Chemical Company	*Chemistry*	*https://thechemco.com/*
Vattenfall	*Energy generation, distribution, sales and trading*	*https://corporate.vattenfall.com/*
Vebego	*Company that operates internationally in the areas of facility services, healthcare and sheltered employment*	*http://www.vebego.com/default.aspx?culture=en-GB&sc=6*
Associations: NGOs and professional associations		
Score LCA	*Association which aims at promoting and at organizing a collaboration between various bodies to favor THE ACV and its application.*	*http://www.scorelca.org/*
United Nations Environment Programme (UNEP)		*http://web.unep.org/*
Society of Environmental Toxicology and Chemistry (SETAC)		*http://www.setac.org/*
European Environment Agency	*IEA3 unit: Production, sustainable consumption and waste management.*	*http://www.eea.europa.eu/fr*
ECEEE (European Council for Energy Efficient Economy)	*Promotion of the energy efficiency and the eco-design at the European level.*	*http://www.eceee.org/*
European Eco-Management and Audit Scheme (EMAS)	*Tool allowing companies and organizations to estimate and to improve their environmental performances.*	*http://ec.europa.eu/environment/emas/index_en.htm*
CD2E	*Association which aims at accompany environmental actors (companies, laboratories, communities) and the economic sectors of the Region towards the eco-transition*	*http://www.cd2e.com*
avniR	*[avniR] by cd2e founded in 2009, is a collaborative platform and a resource centre that initiates and supports the economic transition of sectors throughout new development models based on Life Cycle Thinking.*	*http://www.avnir.org/EN/*
Consultancy: consulting and consulting firms, consultants		
Cycleco	*http://cycleco.eu/*	

EcoAct	http://www.eco-act.com/
Ecoinnovazione	http://www.ecoinnovazione.it/
EVEA-Conseil	http://www.evea-conseil.com/
GreenDelta	http://greendelta.com/
Groupe Ageco	http://www.groupeageco.ca/
PRé	https://www.pre-sustainability.com/
PWC	http://www.pwc.fr/fr/vos-enjeux/developpement-durable-responsabilite-societale-ecobilan-pwc.html
Quantis	http://www.quantis-intl.com/fr/index.php
RDC Environment	http://www.rdcenvironment.be/
SOLINNEN	http://www.solinnen.com/

Figure 18: Actors of Social LCA

As you can see in the table above, all type of actors are seeking to use and improve S-LCA. Most of the actors from research field are from Europe and USA, due to the strong interest of LCA methodology from the past and social impact assessment.

The table illustrates as well the large number of actors of the industrial sectors represented: automotive, energy, waste, electronics, cosmetics… However some sectors are in advance in this field, and even started developing specific methodology and framework on S-LCA, as example:

- **Food & Drink:**
    - "*Lignes directrices pour la réalisation d'analyses de cycle de vie - Secteur des produits laitiers au Québec*" (Couture & al. 2011)
    - "Social impacts and life cycle assessment: proposals for methodological development for SMEs in the European food and drink sector" (Julie Smith & al., 2014)
- **Construction**: "Developments in Social Life Cycle Assessment (S-LCA) for Life Cycle Sustainability Assessment (LCSA) – application to the construction and demolition sector in France" (Anne-Lise Fevre-Gautier et al. 2012)
- **Cosmetics**: Methodological framework for social impact assessment of a cosmetic product (L'Oréal, 2015)

Indeed, the past decade have seen the evolution of sustainability metrics and methodologies on the business sector. However, while the largest companies have well-established company-level social compliance programmes which comply with international and industry standards, there is no general agreement on how to assess social sustainability at product level (Fontes, 2014). This demand has

foster S-LCA research field, and beyond companies and industrial sector, there is a large panel of research teams working on S-LCA subject.

4.4. Which requirements on Social Life Cycle Assessment exist on standards?

As described in the previous sections, and as demonstrated also by the results of the state of the art, S-LCA is a young methodology, for which still methodological developments are needed, together with applications for testing the method and improving it. As such, it can be considered quite new in the research and application agenda; however, it has already proved to be of interest for many users (4.3 Users of Social Life Cycle Assessment), who are claiming for an increased robustness of the method. From this perspective, a standardization of the methodology would represent a step forward: current guidelines on S-LCA are built upon the ISO 14040 and 14044, but - given the peculiarity of the methodology and the distinctive features of S-LCA compared to E-LCA – a specific standard for S-LCA would be necessary.

Currently there are not initiatives in place for including S-LCA in the standardization process, and there is not also an explicit reference to S-LCA in existing standards. Within the Technical Committee ISO/TC 207 Environmental Management it is under discussion the proposal to revise the scope by broadening it, i.e. from purely environmental aspects to the sustainability ones, including also economic and social aspects: however, this does not imply that new standards to address these components will be developed. Currently, the standardization process is ongoing for the evaluation of the externalities (ISO 14008 - Monetary valuation of environmental impacts and related environmental aspects; ISO 14007 - Environmental management: Determining environmental costs and benefits – Guidance), whose activities have started in 2015 and 2016, respectively.

The lack of a short term project on S-LCA standardization was expected, as the standards are developed when there is a clear demand by industry, which is currently looking with interest at the S-LCA methodology, and testing it and developing tailored approaches. However, the demand of S-LCA studies and applications seems to be not explicit, because:

- It is still not perceived the values of S-LCA compared to other methodologies for the assessment of social impacts and performances, due to the lack of clarity about the scope of each approach;

- Social evaluations are a sensitive topic, which – if not communicate properly – can be misunderstood by the targeted users, and generate "social washing";

- Someone could question the robustness of the evaluation due to the subjectivity necessarily involved in the assessment of social aspects, which are based on values – and values depend on people.

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Even if an explicit reference to S-LCA cannot be found in the already available and in the under-development standards, there are however three main drivers for the use of S-LCA, which in future could led to a standardization activity:

- The Directive 2014/95/EU on disclosure of non-financial and diversity information by certain large undertakings and groups (large public-interest entities with more than 500 employees) entered into force on 6 December 2014. The Directive has been designed in a non-prescriptive manner, and leaves significant flexibility for companies to disclose relevant information in the way that they consider most useful: S-LCA could provide a reference methodology for the quantification and reporting of the social aspects.

- Sustainable Procurement, i.e. the process according to which public authorities integrate economic, social and environmental consideration in the procurement of goods, services or works at all stages of the project. Currently, a proposal on how to include social requirements is addressed in the "Buying Social: A Guide to Taking Account of Social Considerations in Public Procurement", which is not based (yet) on S-LCA. The topic is on the agenda of many countries, and in Rome, on May 30, within the Italian presidency of G7, a workshop will be held on etic procurement, during which also the S-LCA will be discussed as a methodology for quantifying social aspects in the procurement process.

- S-LCA can contribute to the assessment of the social impacts and performances into the already existing standards, in particular EN 16309:2014+A1:2014 Sustainability of construction works - Assessment of social performance of buildings - Calculation methodology

Prior to any standardization process, the S-LCA needs to be further strengthened in terms of methodological developments, but it can already provide support to the quantification of social aspects in the several decision-making situations for which a standard approach has not been formalized yet, and which could benefit from a structured methodology.

5. Analysis for a use in Social Life Cycle Assessment (product, service or organization)

S-LCA provides information on social and socio-economic aspects for decision-making, instigating dialogue on the social and socio-economic aspects of production and consumption, in the prospect to improve performance of organizations and ultimately the well-being of stakeholders.

This bibliographic study has enabled the identification of the main trends in the use of Social LCA (Figure 19: Uses in social LCA). Based on 61 case studies, **the review revealed that most of the cases (64%) are currently lead in a research aim. However, 20% of them mentioned socio-design as one of their main goals and 18% of the case studies were carried out in the aim of facilitating decision-making. Finally, the optimization of the supply chain represents a main goal in only 5% of the cases, followed by Risk management in 2% of the cases.**

It is important to note that for the same case study, several uses for S-LCA have been identified, which explains why the distribution according to the different types of uses is higher than 100%.
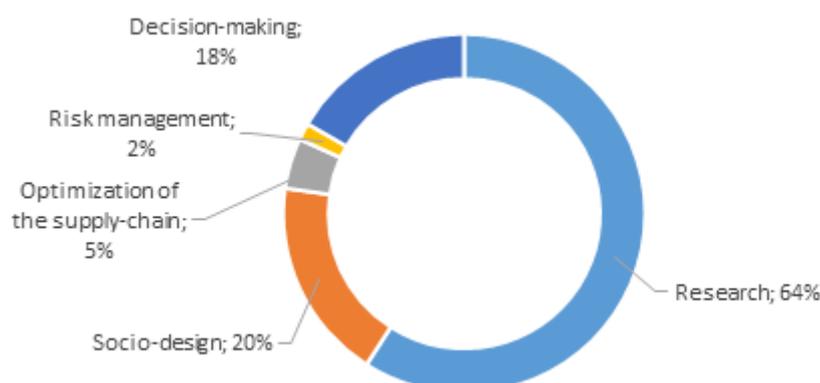
Figure 19: Uses in social LCA

- **Research**

Indeed, there is still a large field of research regarding S-LCA approach. The review revealed that 39% of the case studies in the **"Research" category** were focused on developing assessment methods and frameworks for S-LCA (addressing issues on new impact subcategories, indicators, characterization models, weighting factors…). Lot of them (20%) sought to apply UNEP/SETAC Guidelines for S-LCA, and 15% of the case studies aimed to put an existing framework into practice. In addition, 17% of the case studies aimed to identify the social hotspots of the product/systems analysed, conducted literature reviews in the aim to highlight the development needs for S-LCA. The rest of them focused on a diverse set of goals such as: comparing social and environmental effects; propose a questionnaire for conducting the stakeholder's interviews; build a pathway between social issues and the functioning of a product chain; evaluate the existing databases; combine S-LCA with two research tools; or address

positive social impacts in social life cycle assessment (S-LCA).

- **Socio design**

Otherwise, concerning the 20% of the case studies that mentioned **"Socio-design"** as one of their main goals, products analysed belong to a various set of sectors, among them: electronics industry; food industry; waste; sports industry; energy; automotive industry; heavy industry…

For example, in their S-LCA case study Wang et al. (2016) sought to demonstrate how the assessment of social impacts could help identification of the potential for improvement of labour practices through the illustrative example of an integrated circuit (IC) packaging company. Thus, the S-LCA technique was used to assess the impacts of the production processes of three IC packaging factories on the labour conditions of their factory workers. The proposed method highlighted the significant impacts of such processes and demonstrated its potential advantage by systematically and effectively identifying the labour impact hotspots, which could assist managers in devising strategies that could improve the labour situations within their organizations.

- **Decision-making**

Regarding the **"Decision-making"** category of case studies, the main goals sought were to:
- Provide quantitative information that contributes to decision making;
- Provide recommendations at the company and policy level to facilitate decision-making;
- Provide useful findings for better informed decision making;
- Create an understandable yet comprehensive presentation of S-LCA results to support decision making;
- Compare products, systems or different scenarios to each other to determine which products/systems/scenario are the most sustainable and should be promoted;
- Develop methodologies that allow aggregating subcategory indicator performances of the different activities along the product system into stakeholder dimensions to facilitate decision-making;

As an example, Yu and Halog (2015) conducted a study aiming to assess whether solar photovoltaic (PV) is really a sustainable option for Australia's energy transition on the project level. Despite a good environmental and economic performance, the S-LCA concluded that social performance of the project was not as good as expected. Among other conclusions, this study showed that more awareness and training activities should be organized to promote social acceptance of the solar project.

- **Optimization of the supply chain**

Finally, the case studies that looked for the "**optimization of the supply chain**" used the S-LCA as a way to:

  - Improve packaging systems and transportation in a sustainable way;
  - Help the industry to identify the crucial issues and then to improve the processes and equipment towards more sustainable alternatives;
  - Identify options for reducing potential negative impacts through manufacturing in global value chains.

For example, in their S-LCA case study Albrecht et al. (2013) analysed and compared European fruit and vegetable transport packaging systems, namely single-use wooden and cardboard boxes and reusable plastic crates considering environmental, economic, and social impacts. For all three systems, optimization potentials regarding their environmental life cycle performance were identified. However, the assessment of the economic and the social dimensions in parallel is important in order to avoid trade-offs between the three sustainability dimensions.

- **Risk management**

In some case studies, S-LCA was led in the aim of manage social risk. As an example, Zimmer et al. (2017), developed a model to efficiently estimate and assess social risks along global supply chains. The focus was on the upstream supply chain of actors. The model was applied to a case study of a German premium car manufacturer to demonstrate and validate the approach at the hand of a supplier selection. The results showed that there are huge differences in the social risks associated with different suppliers as well as different risk structures along the n-tier chain. This helps prioritizing any projects with the aim to improve the living and working conditions.

6. Limits of Social Life Cycle Assessment

As mentioned earlier, the development of S-LCA for products is still an emerging methodology. Thereby, this sub-section will deal with the limitations raised by the review of the different case studies and of the methodological approaches. In addition, also the limits of S-LCA compared to other approaches and methodologies for evaluating social impacts/performances have been analysed.

6.1. Hindrances raised by the case studies

Some hindrances have been identified and categorized in 4 types (Figure 20: Hindrances raised by the case studies review). It is important to note that for the same case study, several limitations have often been raised, which explains why the distribution according to the four types of obstacles is higher than 100%.
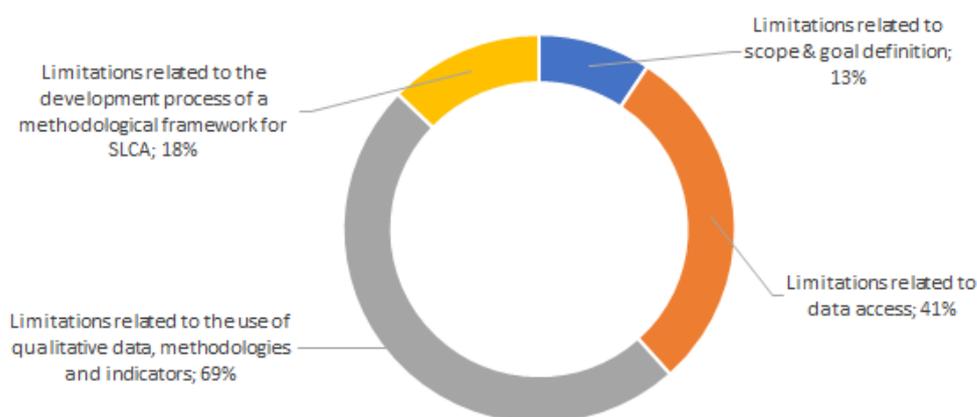
Figure 20: Hindrances raised by the case studies review

- **Use of qualitative data, methodologies and indicators**

The figure above, reveals that in most of the cases **the limitations encountered (69%) were related to the use of qualitative data, methodologies and indicators**. Indeed, the review showed that when conducting S-LCA, the selection, quantification, weighting and comparison of social indicators appeared as a major difficulty (33%), for the following main reasons:

- linking the social indicators with the functional unit of the system/product (7%), as social performances are not always directly related to unit processes but rather to the way a company interacts with its stakeholders;
- aggregating inventory data with semi-quantitative and semi-qualitative information (5%);
- many indicators being difficult to quantify and can be assessed only in qualitative terms;
- building impact pathways (5%);
- assessing the use phase (7%) - considered as too much specific.

Furthermore, among the other difficulties confronted by the authors we can cite:

- Lack of indicators covered by the available databases;
- Capturing in a meaningful way using traditional quantitative single criterion indicators;
- Integrating qualitative data into the assessment;
- Aggregating negative and positive impacts;
- Lack of subcategories to assess impacts related to aspects that are at a higher level in the hierarchy of needs.

- **Data access**

The second main category of limitations revealed by the review (mentioned in 41% of the case studies) was the ones related to **data access**. Indeed, like in environmental LCA, such assessment methodology will never be exhaustive. The current social LCA Methodologies allows highlighting hotspots and improvement and requires a mix of specific and generic data. However, the gathering of data to perform an assessment can be time consuming and the **use of generic data raises limitations in term of data accuracy**.

In fact, the available generic databases as the SHDB is based on a risk approach of country and sector which do not reflect the real behaviour of the actors of a product value chain. Therefore, S-LCA practitioners are often confronted to **the lack of data, especially at regional and the sectoral level**. Furthermore, despite the fact that the literature recognizes that data which are the most specific to the product should be privileged, **product-specific data are not always available**. Therefore, corporate level data will be used very often, notably for supply chain actors**.**

To facilitate data gathering at the company level, there is an urge for the development and the implementation of indicators that companies already collect within other standards and requirements into the LCA databases.

As suggested by Traverso (2012), it is also clear that the necessity to implement case studies to calibrate indicators and weights has a high importance, and at the same time, S-LCA has **to deal with the trade-off between validity and applicability.**

In addition, the current methodologies implies to collect information in **several tools and reporting frameworks of the company that do not communicate and use several nomenclatures**. This complicates the data collection in most of the cases.

To this difficulty, can be added the subjectivity of social data which makes its quantification and interpretation even more complex.

At least, this review demonstrates the great need for harmonization regarding S-LCA approach (databases, indicators, tools, methodologies…).

- **Limitations related to the development process of a methodological framework for S-LCA**

18% of the case studies of this review mentioned limitations regarding the development process of a methodological framework for S-LCA. In fact, there is currently a lack of consensual and standardized framework for S-LCA, which makes it difficult for S-LCA practitioners to easily lead this kind of studies. In addition, globally recognized standards do not exist and dealing with the trade-off between validity and applicability in S-LCA remains a real challenge.

Another limit raised by the authors is the difficulty to establish a link between E-LCA and S-LCA when both were to be conducted simultaneously on a single study, as proposed by UNEP/SETAC on life cycle sustainability assessment.[13]

Finally, the lack of a formal presentation of the S-LCA results makes the decision-making process even more difficult. Indeed, to support decision making, LCSA results are faced with the challenge of how to take complex and potentially confusing data and present it in a straightforward manner to decision makers who may not be experts in this field (Traverso et al., 2012). Therefore, the creation of an understandable yet comprehensive presentation of LCSA results is a major challenge for research.

- **Goal and Scope**

Regarding scope and goals, the difficulties raised by the review concern the definition of:

- **Cut-off criterion** which is an important issue that has not yet been defined in empirical method (Fan et al., 2016);

- **System boundaries**: there is still a debate on how to set the system boundaries of S-LCA. On one hand, some authors such as Dreyer et al. (2010) defend an approach close to CSR vision of focusing on the conduct of the company and its social impacts instead of analysing social impacts of a product through the entire life cycle. On the other hand, other practitioners support the idea of doing an assessment from cradle to grave but excluding the parts that does not change significantly the general conclusions of the assessment (Foolmaun et al., 2013). As a guiding approach, two different perimeters should be considered in S-LCA: a physic layer, which correspond to the technology-oriented approach in LCA, which allows to better define the production cycle and the entire life cycle phases; an effect layer (effect-oriented approach) that allows the identification of the affected stakeholders and the related effects (Zanchi et al., 2016).

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[13] http://www.lifecycleinitiative.org/wp-content/uploads/2012/12/2011%20-%20Towards%20LCSA.pdf

- ▪ ***Functional unit***: as mentioned in the study by Chen et al. (2016), most of the social impacts in S-LCA do not depend on, and are not necessarily proportional to, physical flows but reflect the influence of company behaviour with respect to stakeholders (Jørgensen et al. 2008), which leads to the problem of linking impacts based on semi-qualitative and semi-quantitative subjective data to a functional unit. In addition, the use of a functional unit in S-LCA implies the adoption of linearity, i.e. the impact increases proportionately to the functional unit. However "it is true only for a certain range of values of the functional unit. In nature, most response phenomena trace a sigmoid" (Macombe and Loeillet [74:42]). Moreover this has serious drawback from the practical point of view (Zamagni et al., 2011). In S-LCA it's necessary to determine the conditions of use some relationships, to specify the intervals in which the decision maker can "legitimately hope that the proportional relationship does not betray reality" (Zamagni et al., 2016).

- • **Role of stakeholders**

Currently how integrate stakeholders' needs into the assessment for making the analysis as much context-based as possible, and how to select the relevant stakeholders is not fully addressed. In fact, the assessment has to take into account not only the experts' opinions but also the viewpoints of other subjects, who may be directly and indirectly affected (De Luca et al., 2015). By using participative techniques, the stakeholders' involvement can be used to make legitimate and adherent to reality (Zamagni et al., 2016:231).

6.2. Limits of Social Life Cycle Assessment in relation to other methodologies for social evaluation

S-LCA has been developed building upon current and existing methodologies and guidelines for evaluating the social impacts of organisations and technologies, such as the CSR and the GRI, to mention a few. All these methodologies differ mainly in terms of scope of the analysis (product vs technology vs organisation), which in turns affect the setting of the study, the data needed and their typology (qualitative vs quantitative) and the type of results achieved (impact vs performance vs effect vs information). This diversity of scope is functional to define which methodology is most suited for which application: as for the environmental assessment, there is not a one-size-fit all methodology to address the social impacts but all of the existing ones serve specific applications and respond to well-defined and different questions.

In addition to this consideration, it should be also considered that - within the scope of S-LCA - there is room for interpretation and further refinements. In fact, S-LCA has been developed with the general and ultimate aim to improve the well-being of stakeholders, by enhancing the performance of organizations. At the same time, the Guidelines provide a broad definition of social impacts, defined as those that may affect stakeholders along the life cycle of a product and may be linked to company behaviour, socioeconomic processes and impacts on social capital. This definition embeds the literature on Social Impact Assessment and Technology Assessment by including the socio-economic processes and impacts on social capital, however this is currently addressed to a limited extent. However, currently this broad focus is addressed in practice only to a limited extent, due to the limited knowledge on impact pathways mechanisms, to the developments needed at methodological level, to the limited availability of well-structured case studies and, last but not least, the lack of a shared view on what S-LCA should promote.

However, as pointed out in the analysis carried out in chapter 3, the S-LCA presents a clear added value compared to the other methodologies, in particular:

- the focus on the overall life cycle, which goes beyond the single plant or organisation, but allows to address the whole value chain, so to avoid any burden shifting among different social aspects and stakeholders;
- the quantitative nature, according to which performances can be measured, as a starting point for setting up improvement measures, with the ultimate goal of strengthening the value chain, and thus reducing risks in operations;
- the capability of using the S-LCA results for a sustainability assessment, when integrated with E-LCA and LCC results. In fact, the framework for a Life Cycle Sustainability Assessment (LCSA) allows for integrating S-LCA results, thus providing the opportunity for a comprehensive assessment of the product system at hand.

Currently, the main limits - beside the need for methodological developments and further applications, as previously pointed out - consist in the novelty of the method: the GRI and the other social assessment approaches are well known both at company and institutional level, and as such they benefits from visibility and recognisability. S-LCA needs to gain recognisability, and this can be done working both on the methodological development and on the applications. In this regard, S-LCA can benefits from the knowledge developed in other approaches, in particular the GRI, so as to broaden the coverage of social indicators. This in turn would allow to align the way in which the social issues within the organisation are accounted for and to move towards a harmonised system for the social accounting.

7. Methodological feature for the integration of social aspects in Life Cycle Assessment and case studies

7.1. Comparison between Social and Environmental Life Cycle Assessment

The main difference between Social LCA and Environmental LCA is the scope. Indeed, S-LCA aims to assess social-economic impacts of a product throughout its life cycle, while E-LCA only focuses on the environmental aspects by collecting information on physical quantities related to the product. S-LCA will go further and collect additional information on organization-related aspects along the value chain.

Nevertheless, there are several similarities between the two approaches. S-LCA and E-LCA are both iterative procedures that requires a huge amount of data and encourage peer review when communication to the public or comparative assertions are planned. Despite the fact that both procedures do not have the purpose to provide information on whether or not a product should be produced, they provide useful information for decision-making.

Furthermore, based on UNEP/SETAC suggestion, S-LCA and E-LCA share a common structure based on the ISO 14040 series framework although there are some specificities for each of the S-LCA phases (goal and scope definition, life cycle analysis, life cycle assessment and interpretation).
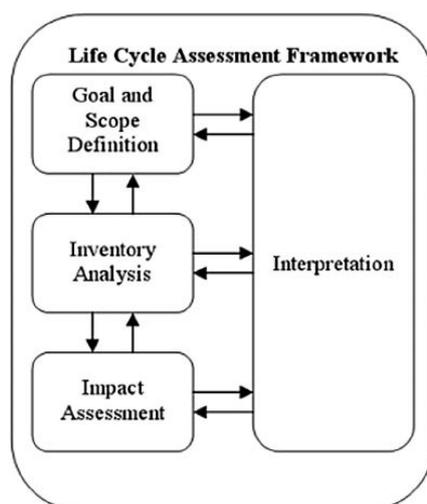
Figure 21 : ISO 14040-44 framework

The LCA approach consists of four steps in which an iterative approach must be adopted (going back and forth between steps to improve the analysis as indicated in the chart). It has been decided to compare both approach based on this steps

- **Goal and scope definition**

E-LCA	S-LCA
Goal and objectives	
E-LCA is used to model environmental flows (energy flows,…) in terms of potential environmental impacts using mathematical models describing the technological[14] and environmental mechanisms that take place once the substance has been emitted. It can be used for : • Driving product innovation and environmental improvement; • Backing marketing claims with scientific analysis; • Supporting a public commitment to understand the environmental impacts of products; • Raising sustainable investment capital; • Communication via Environmental Product Declaration; • Attending the increased consumers and regulatory environmental expectations;	S-LCA is used to model positive and negative externalities in terms of social performances related to stakeholders and social categories, using specific aggregation methods. It can be used for : • comparison between different products, processes or companies; • Identifying potential improvements to products or processes (JORGENSEN et al., 2008). • Providing business decision support to enable them to manage their business responsibly; • Identifying the consequences of an action on individuals, organizations or social macro-systems (BECKER, 2001) • designing value chains with the most positive social impacts and least negative social impacts (FESCHET, 20 14) • Engaging dialogue with stakeholders • Managing potential risks to a global or specific scale
Both E-LCA and S-LCA provide useful element for decision making, even if it's not self-sufficient.	
Scope of the evaluation	
E-LCA is a multi-criteria (climate change, eutrophication...) and multi-step (manufacturing, distribution…) methodology for analysing potential environmental impacts. Evaluation focused on the criteria.	S-LCA is a multi-category (Stakeholder categories: Workers, Local community…, and impact categories: Human rights, working conditions….) methodology for analysing social impacts. Evaluation focused on Stakeholders and impact categories.
Both approaches could be carried out on a product, a service or an organization.	

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[14] Technological mechanisms are causal relationships that connect the level of two activities. E.g., the input of electricity needed for the manufacturing of a good.

Functional Unit	
Provides a reference in relation to which inputs and outputs are standardized (in the mathematical sense) The FU is expressed according to the production process.	Results of S-LCA could be expressed according to a functional unit (FU), even if in some cases, it could be difficult to specify data according to it. As mentioned in the study by Manik et al. (2013), in S-LCA, not all the data is relevant to express a process. It is therefore impossible to aggregate them according to a functional unit along the life cycle. In this case, the organization can also be chosen as the basis of the unit, as described in the methodological framework of Ramirez et al. (2014). However, if a product supports several services, it is possible to propose one FU per service if no product comparison is envisaged. Some use the FU only to list the main inputs and services involved in the life cycle (Couture et al., 2012). Thus, the debate remains: 34% of the 35 cases analysed (All sectors) choose a quantitative FU, while 51% choose a qualitative FU and 14% do not choose it according to a study by Petti et al. (2014).
The product utility is required to be described in functional terms, both in E-LCA and S-LCA.	

System boundaries	
Determines the basic processes that must be included in the E-LCA according to the chosen scope. In practice, and according to the different case studies, it's more easy to include all the different life cycle steps in E-LCA than in S-LCA, for example social assessment of use phase is not well analysed in literature compared to E-LCA due to lack of information and methodologies. In E-LCA, several cut-off criteria are used to decide inputs to be included in the analysis, such as mass, energy and environmental impact. Cut-off criteria can be used in S-LCA based on the same principle, but with some specificities (use of non-physical parameters as social impacts, intensity or relation to the scope…)	Contrary to the process-approach taken in E-LCA, an organizational approach is taken when defining the product system for a S-LCA, because social impacts are generally determined by the conduct of the companies which are engaged in the life cycle. The organizational approach requires a method to relate the social profiles of the companies involved in the life cycle to the product, and research is needed to analyse and test alternative methods. Many authors agree that the boundaries of a S-LCA must be similar to those of E-LCA (O'BRIEN et al., 1996, KLÖPFFER, 2003, HUNKELER & REBITZER, 2005, HUNKELER, 2006 in LAGARDE & MACOMBE, 2012). The main reason is to facilitate the integration of an S-LCA with an E-LCA (HUNKELER & REBITZER, 2005). It is possible, however, that this criterion constitutes a limit to the definition of the boundaries of the system and that the study neglects important relations between actors. It is therefore important to be able to define when to use similar boundaries between the two LCAs and when it is not necessary (REAP et al., 2008). The question of the similarity of the boundaries of the system is discussed by other authors. They consider that activities can have a minor impact on the environment but must still be considered from a socio-economic perspective (KRUSE et al., 2009). In most cases, the lack of data for S-LCA limits the system to be delimited (Martínez-Blanco et al., 2014). Some delineate their systems on the basis of the definition of hotspots, via a Social Hotspot Database, by the literature (Andrews et al., 2009) or on the basis of the geographical context (Siebert et al., 2014). Others (Martínez-Blanco et al., 2014), in the case of fertilizers and industrial compost, have delimited their system by including significant flows in terms of quantity and working time, resulting in quasi- Similar to those of the E LCA.

● **Life cycle Inventory**

E-LCA	S-LCA
Data collection	
For both approaches and according to the scope of the study to: ● Data could be collected at a Country / Regional / Sectorial / Company / Site level ● A data quality assessment is possible	
Data collection is focused on physical quantities related to the product.	Data collection along the life cycle is as demanding as in E-LCA, but are focused on the organization-related aspects along the chain. Subjective data is used in S-LCA, due to qualitative indicator. Assessment methods are more sensitive to location for S-LCA, compare to E-LCA, whose commons methods are not site specific. The data source will differ compared to E-LCA, due to the use of non-physical quantities.
Database	

There is multiple databases around the world: Ecoinvent, Agribalyse... all of them provide some specific environmental data on materials and processes to a national or regional level. The databases and quality of them are one of the issues to the representativeness of the results.	Possibilities to use database as: SHDB, PSILCA; or Ecovadis to carry out a hotspot assessment with generic data. Indeed this database can be used to identify hotspots and / or use them in the S-LCA analysis. The SHDB is based in particular on international conventions and standards to set the levels of certain indicators. Nevertheless, in some cases this database is not yet complete enough to be systematically used. Thus, in the case of sectoral or geographical particularities, an approach on a finer scale than the national scale is necessary. However, the data in the SHDB are still, at present, at the state level. PSILCA uses a multi-regional input/output (MRIO) database, called Eora. Eora can claim to cover the entire world economy, on an industrial sector basis. It is also possible, but more tedious, to use stakeholders to determine these hotspots (Manik et al., 2013).
Tools	
Due to the state of methodological development and the use of E-LCA different software are proposed to carry out E-LCA: Simapro, EIME, Gabi, Team, and OpenLCA... These software provide almost the same basic functionalities in order to assess environmental impacts	Some of these software offer some additional functions to assess social impacts (e.g.: Simapro, Gabi, OpenLCA), and even the possibility to import social databases. However due to the indicators and the use of qualitative data, most of the case studies have been carry out with no specific tool.

- **Life cycle analysis**

E-LCA	S-LCA
Classification and Characterization	
Classification and characterization depend on the methodologies. Multiple indicators and methodologies are available (IPCC; CML; ReCiPe; ILCD, etc) There are a consensus on some parameters.	Need to justify if a category or a subcategory of impact is excluded. Need to take into account the relevance of stakeholder perspectives and impact categories intensity.

Indeed some set of indicator proposed are recommended for a specific sector.	No default sets of sub-categories or indicators are recommended, guidelines provide only examples of indicator. Sectoral approaches try to figure it out, by proposing some sectoral frameworks adapted to a specific context. UNEP / SETAC has also developed one scorecard per impact subcategory (a total of 31), which includes examples of indicators relevant to the impact sub-category under consideration, as well as units of measure and the data sources (Benoît-Norris et al., 2011a). In some cases, the data sources can also be based on interviews with workers and other stakeholders (Benoît Norris et al. (2013).
	The intensity is used to focus the evaluation to relevant hotspot.
The assessment is focused on impacts. Benefits are highlights in comparison of other solution. • Midpoint assessment: Aims to cover an environmental problem that stands somewhere between the Inventory and the AoP, • Endpoint assessment: Seeks to represent the environment damages caused to an Area of Protection	Positive and negative impacts are assessed. The characterization models are different as described previously in this report, section 4: • Meaning assessment: Aggregation of indicators using scoring and weighting systems derived from **"Performance Reference Points" (Taskforce)** • Impact pathways methods: passing through midpoint indicators and, potentially, endpoints, with causal-effect relationship (Hunkeler, 2006 & Weidema, 2006)
Normalization and weighting factors can be used to aggregate results. Aggregation is used as well in SLCA, but based on subjective data.	Data quality are an issue in both approaches, even if the methodology is different up to the approach, it is sought to minimize the uncertainty in their results. However scoring approach using user-defined scale based on qualitative data are a source of heightened uncertainty.

- **Interpretation**

E-LCA	S-LCA
Analyse and interpretation	
The interpretation must take into account all relevant parts of the study : • Identification of significant issues; than can be a phase of the life cycle, or a specific environmental impact. The identification of the origins of these issues led to find the environmental contributors (inputs or outputs). However due to the use of generic databases, the assessment, for E-LCA and S-LCA give the potential impact and not necessary the real impact. Thus it is sometimes difficult to make a choice based on these information. • Evaluation of the study (including completeness and consistency). • Conclusions, and recommendations according to the goal and scope of the study: eco-design optimization of the production techniques, selection of the best option in terms of environmental point of view...	Compare to an E-LCA: • The identification of significant issues is focused on socio-economics impacts, and on stakeholders. Due to the data collection in site specific level, conclusion and hotspot can be very different than the conclusion of an E-LCA. • The evaluation of the results depends of the methodology and data chosen. Due to the qualitative data used or performance scale defined, the variability and dependency have to be a priority of checking and concern. • In terms of conclusions and recommendations, they are still based on the goal and scope of the study, even if they may be different (socio-design, decision making, identification of the stakeholders impacted, or identify some specific concerns...) In addition to these three steps, UNEP SETAC advocate to mention the quality of stakeholder relations (level of commitment in the study).

• For both approaches a critical review can be carried out in order to ensure:
     o The consistency of the methods used in relation to the standards in force;
     o The scientific and technical validity of the methods used;
     o The appropriateness and reasonableness of the data used in relation to the objectives of the study;
     o The reflection of the interpretations given the limitations identified and the objectives of the study;
     o Transparency and consistency of the study report.	

Figure 22: Comparison between E-LCA and S-LCA

Despite those differences, both approaches S-LCA and E-LCA are highly complementary regarding sustainable development. Indeed, while Environmental LCA does not provide global information allowing a full sustainable decision-making, S-LCA can provide the additional information needed, allowing the decision-makers to apprehend the big picture of the product, service, or organisation life cycle impacts.

The LCA of an ecolabeled Notebook conduct by Ciroth and Franze (2011) is a good example of the complementarity of the two approaches. This case study aimed identify social and environmental hot spots in the whole life cycle of the notebook, in order to understand and improve its sustainability performance. The second goal of this study was to provide recommendations on company and policy level. And finally, on a more general level, aim was to apply the UNEP/SETAC guidelines for S-LCA on a complex product. The study was based on one recent, lightweight laptop of the Taiwanese company ASUSTeK that is certified according to the EU Ecolabel as functional unit.

System boundaries

According to the case study report, the system boundaries are defined as follow: the analysed ASUS notebook is produced in China. In this case it is ordered in Brussels, Belgium via internet and delivered there. The computer is used in an office for 4 years. After the use phase the laptop is submitted to a collecting point. It is assumed that 20% of collected laptops are reused; therefore it is modelled that 20% of the notebook is transported for reuse to China and the remaining 80% are sent to a recycling site in Belgium. Further, it is assumed that the reuse phase takes 2 years. The reused computer is recycled in China, because the laptop is out of reach for the take back system of ASUS which covers only Taiwan, Europe, North America, and India (Ciroth et al., 2011).

The figure below summarises the investigated product for the social and the environmental perspective.
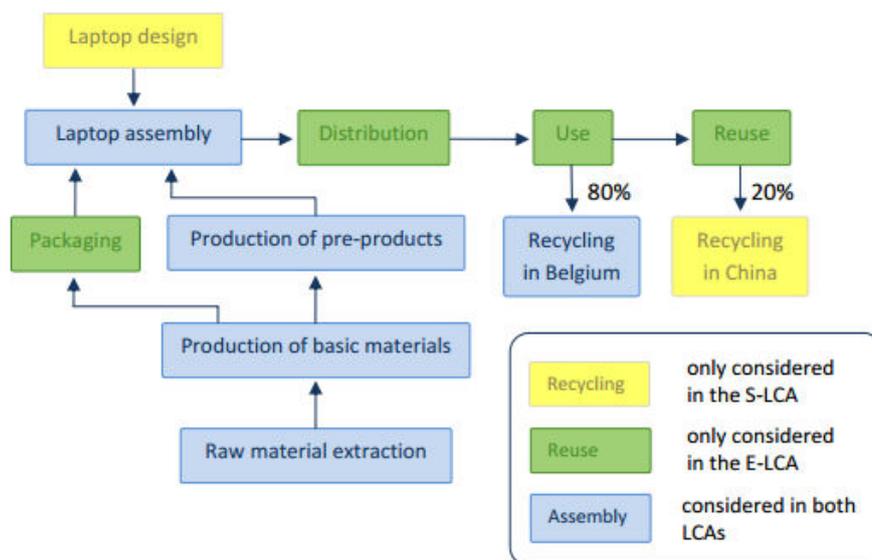
Figure 23: Flowchart of the product system for the S-LCA (source: Ciroth et al., 2011)

This flowchart illustrates how complementary can be the two approaches regarding the system boundaries. As for S-LCA packaging, energy generation, distribution, and transportation processes with upstream chains are out of consideration, they are comprised in E-LCA. Indeed, these processes are supposed to have mainly positive social impacts; thus there are no social hotspots expected. Furthermore, it can be noticed that the use and reuse phase are not considered in the social dimension.

This can be explained by the lack of indicators applicable to those phases in the UNEP/SETAC approach for S-LCA which was developed to show the performance of companies and sectors respectively. The aspects regarding consumers (such as consumer health and safety, transparency, and after sales services) are included in the stakeholder group consumers. Similarly, concerning the environmental approach some phases couldn't be included in the analysis. This includes the informal recycling in China which was not part of the environmental analysis due to lacking data. Thus, for E-LCA, the end-of-life phase comprised only a WEEE-conform disposal in Belgium. However, the recycling phase together with laptop design phase could be comprised in the S-LCA. In this way, by gathering the two approaches the whole life cycle could be evaluated.

Interpretation of the results

Regarding the interpretation of the results the two approaches can also be considered as complementary. Indeed, despite the fact that environmental and social hotspots are partly congruent, for instance with respect to mining operations or the production phase, the interpretation of the inventories have showed that E-LCA and S-LCA are different in various aspects and in this way they can be complementary allowing a larger view of the life cycle and more enlightened decision-making. As an example, as mentioned above informal recycling operations could not be considered in the E-LCA due to lack of data but it is assumed that this process shows up also an environmental hotspot. However, the S-LCA revealed that the informal recycling are connected to serious societal problems. Thus, the combination of the two approaches highlights the importance of taking into account recycling issues in a sustainable decision-making, despite the fact it was not included in the environmental assessment. In the same way, the E-LCA showed that use phase have a noticeable contribution to the environmental burden, and also have to be taken into account even if not comprised on the S-LCA approach.

Recommendations and sustainability improvement

Finally, this case study also shows how S-LCA and E-LCA can be additional regarding the recommendations they provide. Indeed, the recommendations made at the end of the environmental assessment can also improve social dimension. For instance, changing the process, and more precisely eliminating or reducing hazardous substances, or using biodegradable materials will improve environmental impact and as well as workers health. Another example: the development of local supply chains has many advantages as it increases the cooperation and the spatial closeness to the suppliers enabling more transparency. And in parallel, it reduces the emission GHG and consumption of gas.

7.2. Experimentation

In order to provide operational recommendations that are relevant and applicable during S-LCA, an experimentation was conducted through a practical case study based on literature. No additional data collection, elaboration or setting of the system under analysis has been performed.

7.2.1. Step 1: Definition of scope

The product chosen is a **Photovoltaic module** (PV module). In order to provide an overview of results that can be obtained by S-LCA, the present case study is based on literature instead of on a field data collection. Relying on existing bibliographic sources, this case study focused on two main stages of PV module's life cycle:

- **Manufacturing phase:**
    - Traverso, M., Asdrubali, F., Francia, A., & Finkbeiner, M. (2012). Towards life cycle sustainability assessment: an implementation to photovoltaic modules. *The International Journal of Life Cycle Assessment*, *17*(8), 1068-1079 ;
    - Yu, M., & Halog, A. (2015). Solar photovoltaic development in Australia—a life cycle sustainability assessment study. *Sustainability*, *7*(2), 1213-1247 ;
- **End of life phase:**
    - Ciroth, A., & Franze, J. (2011). *LCA of an ecolabeled notebook: consideration of social and environmental impacts along the entire life cycle.* Lulu. com.

However, to initiate modelling, it is important to define the objectives and issues on which the products depends on (regulations, standards, etc.) and the stakeholders involved in the product's life cycle.

a) Goals

Thereby, the main goals of this case study are: (1) to show the applicability and practicability of S-LCA; (2) to highlight the social hotspots raised by the analysis regarding production and end of life phases; (3) to show how those results may complete classical LCA and other social approaches (GRI reporting, ISO 26000,…); (4) and how it may support decision-making.

b) Methodology

The three literature sources relied on UNEP/SETAC Life Cycle Initiative (2009) methodology to assess the social impact of the manufacturing of the PV module and end of life.

c) Boundaries

The boundaries of the modeled system are detailed on the following illustration (*Figure 24*).
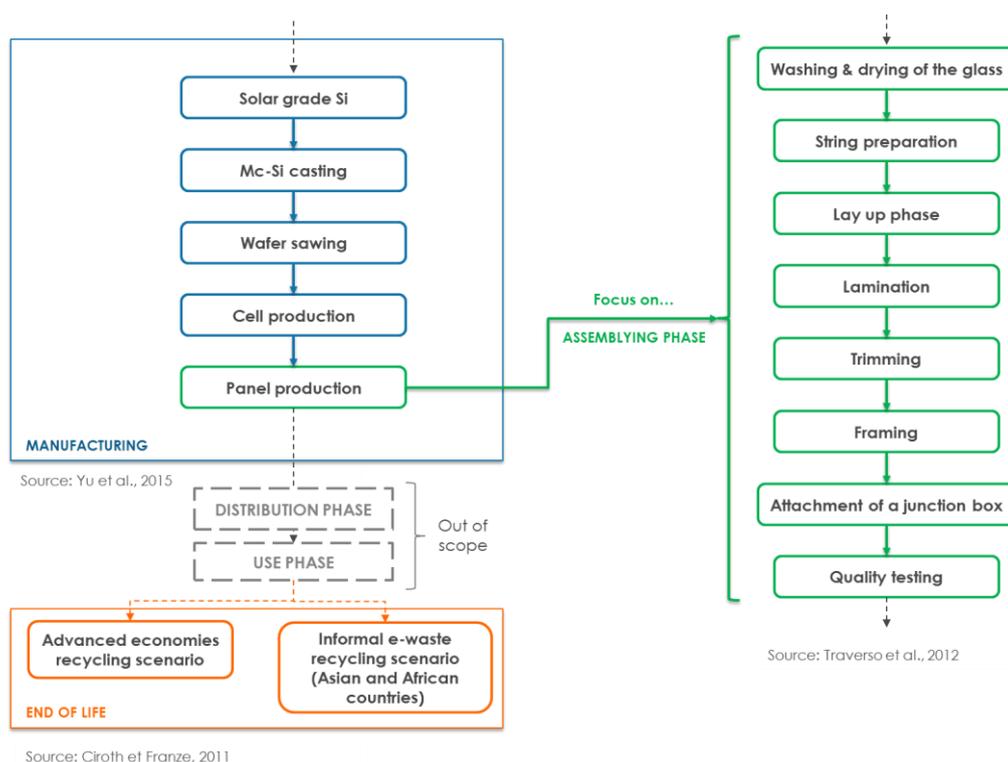
Figure 24: Detailed scope of PV module S-LCA case study based on literature (Ciroth et Franze, 2011; Traverso et al., 2012; Yu et al., 2015)

On this base, distribution and use phases will be considered as out of scope for the following analysis. Indeed, assessing the use phase represents a major challenge. For now, available methodologies focused on production, distribution and end-of-life aspects; therefore, use stage aspects require further development (UNEP/SETAC, 2009). Concerning distribution phase, the lack of data has conditioned its exclusion from the scope of the present study.

Yu et al (2015) case study intended to assess whether solar photovoltaic (PV) was really a sustainable option for Australia's energy transition on the project level. In this context, a life cycle sustainability assessment was conducted on a 1.2 MW flat-roof mounted PV solar array called UQ Solar regarding its environmental, economic and social performances. For the needs of the present case study, only the results regarding social performances of UQ Solar will be used, and more precisely results concerning manufacturing phase. To complete data and social assessment, the present case study also refers to Traverso et al. (2011) case study which focused on the life cycle sustainability assessment of assembly step of PV modules using Italian and German primary data.

Finally, given the lack of data regarding PV modules end of life phase, the present analysis referred to Ciroth and Franze (2011) case study on social and environmental impacts of an ecolabeled notebook during its entire life cycle. Indeed, PV modules and e-waste are considered sharing similar recycling channels[15], thus, the data and results from the social assessment of laptop's end of life phase may be considered as relevant for the present case study.

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[15] Since 2014, the European Directive 2012/19 / EU has been transcribed into French law by Decree 2014-928 on waste electrical and electronic equipment and used electrical and electronic equipment. This Decree integrates solar panels into its scope.

d) Stakeholder's

All manufactured products generate social impacts that can be either positive or negative. As an impact is always linked to a receiver, stakeholders have to be defined.

As the boundaries of the present study are delimited at an organizational level, the assessment must be made against different stakeholders' interests in each stage, starting from the organizations producing PV modules to the organizations dealing with end-of-life treatment.

In each stage of the life cycle, different stakeholders/organizations are involved. Therefore, the literature sources on which the present case study relies on applied the UNEP/SETAC stakeholder's categories and subcategories to assess the social impact of the PV modules, as presented in the next section (*Figure 26*).

7.2.2. Step 2: Data collection

As previously mentioned, the present study is based on literature. The table below summarizes the data origins, the methodology and the period covered by data collection according to the three sources.

Life cycle phase	Source	Origin of data	Period covered	Data collection methodology
Manufacturing	Traverso et al., 2011	Italy	2008	The data of the assembly step are mainly primary data collected from the companies (internal databases, questionnaires, interviews, reporting tools…).
		Germany	2008 and 2009	
	Yu et al., 2015	Australia	2012	Some data were collected from reports, websites and literatures. Others, comes from existing databases with appropriate adaption to Australian situations.
End of life	Ciroth et Franze, 2012	Belgium (Formal recycling sector)[16]	Approximately 80% of the data sources of the social inventory are from the years 2008 until 2010	Data obtained from governmental and non-governmental organisations, corporate websites, sustainability reports, and literature as well as internet research. In addition, questionnaires were sent to the laptop producer and 1st tier suppliers. In several cases interviews with workers were conducted.
		China (Informal recycling sector)		

Figure 25: Information on data collection

The data were collected based on stakeholders and subcategories identified. However, not all stakeholders' categories and subcategories were included on this analysis. The table below is based on the UNEP/SETAC approach and presents the stakeholder's categories and subcategories addressed on each life cycle phase included on this case study according to the literature sources.

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[16] Although the study considers only the recycling in Belgium as industrial nation, it is assumed that the results can in general be transferred to the recycling sector in other advanced economies. This approximation is also valid with regards to the informal recycling sector which considers exclusively the illegal recycling in China. Thus, in Ciroth et Franze's case study, it is assumed that the conditions can be transferred to other Asian and African countries that are also involved in informal e-waste recycling.

Stakeholders categories	Sub-categories	Life cycle phases			
		Manufacturing		End of life (Ciroth et Franze, 2012)	
		(Traverso et al., 2011)	(Yu et al., 2015)	Formal recycling sector	Informal recycling sector
Workers	Freedom of association and collective bargaining		X	X	X
	Child labor	X	X	X	X
	Forced labor		X	X	X
	Fair salary	X	X	X	X
	Working time	X	X	X	X
	Discrimination	X	X	X	X
	Health and safety	X	X	X	X
	Social benefits/social security	X	X	X	X
Local community	Access to material resources			X	X
	Access to immaterial resources			X	X
	Delocalization and migration			X	X
	Cultural heritage			X	X
	Respect of indigenous rights			X	X
	Safe and healthy living conditions			X	X
	Secure living conditions			X	X
	Local employment			X	X
	Community engagement			X	X
Society	Public commitments to sustainable issues			X	X
	Contribution to economic development		X	X	X
	Prevention and mitigation of conflicts			X	X
	Technology development			X	X
	Corruption		X	X	X
Value chain actors	Fair competition				
	Promoting social responsibility		X		
	Supplier relationships		X		
	Respect of intellectual property rights				
Consumers	Health and safety				
	Feedback mechanism				
	Transparency				
	End of life responsibility				

Figure 26: Stakeholder's categories and sub-categories addressed by life cycle phase included on this case study.

As shown on the previous table, "Consumers" stakeholder's category will not be included on this analysis. Indeed, the stakeholder group "consumers" is often considered with regard to the use phase which is not included in the literature sources.

In addition, the stakeholder "value chain actors" will also be considered as out of scope as it is not contained in the social inventory of addressed sources, except for PV's manufacturing phase of the S-LCA case study leaded by Yu et al (2015).

7.2.3. Step 3: Assessment of impacts

a) Indicators

Evaluating social performance of each life cycle phase is not an easy task. Indeed, each source has its own scoring scale:

- Traverso et al. (2011) used a grey gradient were dark grey colour represents a bad performance of the indicator and so on;
- Yu et al. (2015) analysis was based on a 9-level scale, ranking the indicators' results from -4 to +4.
- Ciroth et Franze (2012) used a 6-level scale, ranking the indicators' results from 6 to 1 (1 being a positive impact).

For enhanced communication and reading, and to harmonize the data collected from the different sources, each subcategory is assessed by different indicators

b) Characterization

As explained in section 4.1, characterization is the step during which the data is analysed in order to assess its meaning in terms of its potential to cause social impacts. At this step, an implicit or explicit value judgment is made on the collected data. At the weighting step, the characterization results are given a different relative weight or an equal weighting can be attributed to all results. The S-LCA guidelines (UNEP-SETAC 2009) distinguish two different SLCIA approaches, type I and type II (Figure 9: Type 1 and type 2 (Parent et al. 2010)), which differs essentially by their characterization model (the evaluation method) as suggested by Parent et al. (2010).

Although there are others scoring system, the colour scale has been chosen for this case study in order to ensure a certain consistency with the sources. Therefore, the S-LCA conducted can be considered as a type I S-LCA. Thus, **the indicators have been normalized to a 5-level scale, ranking the indicators' results from -2 to +2.**

Traverso et al., 2011	Yu et al., 2015	Ciroth and Franze, 2012		Present study
Advanced performance	4 (extremely positive)	1 (positive effect)	+2	Advanced performance
	3 (very positive)			
Good performance	2 (positive)	2 (lightly positive effect)	+1	Good performance
	1 (lightly positive)			
Basic performance	0 (indifferent)	3 (indifferent)	0	Basic performance
Low performance	-1 (lightly negative)	4 (lightly negative effect)	-1	Low performance
	-2 (negative)			
Bad performance	-3 (very negative)	5 (negative effect)	-2	Bad performance
	-4 (extremely negative)	6 (very negative effect)		

Figure 27: Correspondence table for different reference scales used by the literature sources

c) Results

The scoring of the data collected has made it possible to assess the social performance and to identify the social hotspots linked to each PV modules' life cycle phase. The results of this social impact assessment are presented in the following table.

Figure 28: Results of the S-LCA

Stakeholders categories	Sub-categories	Examples of social indicators used by the sources	Life cycle phases					
			Manufacturing				End of life	
			Traverso et al., 2011			Yu et al., 2015	Ciroth et Franze, 2012	
			German module (2008)	German module (2009)	Italian module (2009)	Australia (2012)	Formal recycling sector Belgium (2008-2010)	Informal recycling sector China (2008-2010)
Workers	Freedom of association and collective bargaining	Presence of unions within the sector and description of their influence	N/A	N/A	N/A	-1	+2	-2
	Child labour	The production site/organization has policies against employing children and a compliance management program exists if children are to be found to be working in a factory.	0	0	0		+2	-2
	Forced labour	Frequency of forced labor in the country/sector	N/A	N/A	N/A		+2	+2
	Fair salary	Wage level of the worker with lowest income and description of payment performance of the sector	-2	-2	+2		+2	-1
	Working time	Hours of work per employee and month in average	+2	-2	+1		+2	-2
		Number of days without work per week						
		Description of how over time is handled						
	Discrimination	% of women in the labor force	+2	-1	-2		no data	no data
		Ratio or salary of women to wages of men in sector						
		Number of disabled workers						
	Health and safety	Accident rate at work	-2	+2	0	-2	+1	-2
		Number of lost workdays for injury and illness	-2	+2	+2			
		Workers' exposure to toxic and hazardous metals and chemicals	-2	+2	+2			
		Fatal accidents	0	0	0			
	Social benefits/social security	Family benefits	+2	-1	-2	+1	+2	-2
Score - Workers category			0	0	0	-1	+2	-2

Stakeholders categories	Sub-categories	Examples of social indicators used	Life cycle phases					
			Manufacturing				End of life	
			Traverso et al., 2011			Yu et al., 2015	Traverso et al., 2011	
			German module (2008)	German module (2009)	Italian module (2009)	Australia (2012)	Formal recycling sector Belgium (2008-2010)	Informal recycling sector China (2008-2010)
Local community	Access to material resources	Existence of projects to improve community infrastructure	N/A	N/A	N/A	N/A	+2	-1
	Access to immaterial resources	Presence of community education initiatives and community service programs	N/A	N/A	N/A	N/A	no data	1
	Delocalization and migration	Number of resettle that can be attributed to the sector	N/A	N/A	N/A	N/A	1	no data
	Cultural heritage	Respect of the sector regarding local cultural heritage including language, social and religious practices, knowledge and traditional craftsmanship as well as cultural spaces and objects and does not determine them in any way	N/A	N/A	N/A	N/A	no data	no data
	Respect of indigenous rights	human right issues faced by indigenous people in the country	N/A	N/A	N/A	N/A	no data	no data
	Safe and healthy living conditions	Sector effort to improve the environmental performance	N/A	N/A	N/A	N/A	1	-2
	Secure living conditions	Sector policies related to private security personnel	N/A	N/A	N/A	N/A	no data	0
	Local employment	% of work force hired locally	N/A	N/A	N/A	N/A	+2	1
	Community engagement	Description of community engagement of the sector	N/A	N/A	N/A	N/A	no data	-1
Score - Local community category							1	-1
Society	Public commitments to sustainable issues	The organization publicly display commitments on sustainable development	N/A	N/A	N/A	+1	-1	-1
	Contribution to economic development	Economic situation of the country and relevance of the considered sector for the economy	N/A	N/A	N/A		1	1
	Prevention and mitigation of conflicts	Risk of conflicts with regard to the sector and measures to reduce the risk	N/A	N/A	N/A		not relevant	-1
	Technology development	Sector effort in technology development regarding eco-friendliness	N/A	N/A	N/A		1	-1
	Corruption	The organization has anti-corruption, integrity and compliance policies	N/A	N/A	N/A		-2	-2
Score - Society category						+1	-1	-1

d) Interpretation of the S-LCA results

The present study reveals that social hotspots can be found in both studied PV module's life cycle phases.

- **Manufacturing phase**

Regarding manufacturing phase, the stakeholder's category which is most concerned by negative social impact is Workers. Indeed, several hotspots can be observed with particular regards to minimum wage, discrimination, and social benefits (Traverso et al., 2011). In Yu et al. (2015) case study (which focused on the assembly step of manufacturing phase), the main hotspot concerns health and safety sub category, mostly because of toxic/hazardous materials emissions, which appears to be the main challenge underlying PV modules production.

- **End of life**

The results of PV module's end of life social impact assessment varies widely between the two studied scenarios, i.e. formal recycling sector and informal recycling sector.

Indeed, the recycling sector in advanced economies (formal recycling sector) is in general rather not connected with significant social issues. According to Ciroth et Franze (2012), the sole social hotspot, which could be revealed, is corruption and fraud respectively. Fraud and corruption are widespread and enable the illegal shipment of e-waste to developing countries and emerging economies.

Regarding the informal recycling sector, numerous social hot spots could be disclosed. Among them, the lack of governmental control causes poor working conditions, lacking environmental standards, and missing engagement regarding sustainable development (Ciroth et Franze, 2015).

The table below details the social hotspots identified by the literature case studies per life cycle phase.

Stakeholders categories	Social Hotspots	Manufacturing	End of life
Workers	**Freedom of association and collective bargaining**	The hotspots identified on this phase are mostly due to the crisis that has forced the company (from Traverso's case study) to focus on the economic performances and taking social matters to the second place.	There are no trade unions in the informal sector.
	Child labour		It is common that children help their parents to disassemble e-waste. Although, this kind of child labour is basically tenable, the working conditions and the health effects are not acceptable. Children are exposed to harmful fumes and heavy metals.
	Fair salary		N/A
	Working time		N/A
	Social benefits/social security		The informal sector does not pay social benefits.
	Health and safety	During the manufacturing, many toxic and hazardous metals and chemicals can be generated to harm workers who work around them. For example, sawing c-Si wafers may generate silicon particulate matter that can pose inhalation problems. Especially, in China, the problems would get more serious as environmental regulatory enforcement is low.	The simple techniques as burning of cables and acid bath pose severe health effects. Workers do not wear suitable protective clothes. The risk of occupational incidents is very high.

Local community	**Access to material resources**	N/A	Although the recycling of e-waste serves the recovery of materials, the illegal recycling has negative impacts on the access to material resources. First, the workshops have no environmental management or initiate infrastructure projects. Secondly, the inappropriate techniques pollute water, soil, and air.
	Safe and healthy living conditions	N/A	As mentioned above the applied techniques contribute considerable to the local environmental burden, what has severe health effects for workers and residents. There are no sector efforts to minimize the use of hazardous substances.
	Community engagement	N/A	The informal recycling sector does not engage in CSR activities.
Society	**Public commitment to sustainable issues**	N/A	The workshops did not implemented codes of conduct.
	Prevention and mitigation of conflicts	N/A	The risk of conflicts is very high and the sector does not try to reduce this risk.
	Technology development	N/A	The informal sector uses outdated technologies and techniques. There are no investments in technology development or efforts to use more environmentally sound procedures.
	Corruption	N/A	Corruption is widespread. Otherwise the informal sector could not exist in this way. Already the import of e-waste to China is prohibited.

Figure 29: Description of social hotspots of PV modules' S-LCA

e) Added value of S-LCA results

First of all, the present study shows that there is a need for broad improvements of labour conditions (Ciroth et Franze, 2015) regarding employees' health and safety but also wage levels, working hours and social benefits. **Those results could enhance social performance of the concerned companies by helping them to build a targeted strategy for future development of social policies. It's also a way to manage social risk thanks to the identification of the social hotspots.**

As this case study illustrates, while other social approaches such as GRI reporting, Fair Trade International, EcoCert, ISO 26000, SDG's (described in section 3) allows companies to collect social information through social KPI's, **S-LCA goes further by allowing them to quantify and qualify their performance**: is it a good or a bad performance? Which are the social issues the company should be worried about? Which one can the company improve?

Another advantage of S-LCA results is that they can be considered a **valuable tool to support decision-making processes** that involve different stakeholders with different knowledge and background (Traverso et al., 2012). Indeed, as developed in the further section (7.2.4), **the results of S-LCA can be presented in various ways, allowing to: adapt the communication meanings to the targets (decision makers, civil society, researchers…); simplify and/or aggregate the results per stakeholder/category/life cycle phase.**

f) <u>Sensitivity study and limitations of S-LCA results</u>

Despite all the advantages of S-LCA approach, the interpretation of the results remains a difficult task as it is an organizational, geographical, sectoral and site-specific approach. Given that, the results can vary widely between two different countries, sites or years, as illustrated by the results of the present case study.

For instance, regarding the 3 scenarios of PV modules' manufacturing phase (Traverso et al., 2011), the results are very different from a country to another (Germany and Italy), and especially from a year to another (German scenario 2008/2009). In fact, the authors explained that the difference comes from a crisis suffered by the German company which was forced to focus on the economic performance and to push the social matters into the background. **This example shows that S-LCA results are highly linked to the context, and must be carefully interpreted, especially when the year of that collection is not same for all the indicators.**

In addition the methodological framework of each case study may be different from one source to another, due to the lack of harmonization and standardization in terms of indicator, weighting scale, qualitative information, source used, among others. These differences generate some difficulties in terms of interpretation of the results between the sources, due to the lack of comparability.

Another probable cause of misinterpretation might be the scoring and weighting of the results. To illustrate this point, a sensitivity analysis was leaded on the results.

As seen in section 4.1.1., there are two main categories of weighting, those that are based on relative importance of different social issues and those that are based on the relative importance of unit processes or life cycle steps. Within these two categories, five main approaches have been identified: (1) implicit equal weighting of all subcategories, categories, unit processes, or life cycle steps; (2) prioritization of worse performance within a subcategory; (3) weighting according to stakeholders', experts', or users' perception of importance of issues; (4) weighting according to importance of issues based on UN conventions; and (5) according to a variable representing the relative importance of different life cycle steps/unit processes.

As the present case study is based on literature, the focus was made on approaches (1), (2) and (4). Indeed, approach (3) would require stakeholders' consultations, ranking surveys on issues and/or multi-criteria decision-making tools such as the analytical hierarchy process (AHP), which are not compatible with a literature based case study. In the same way, approach (5) would also require further information, such as an activity variable to determine the relative importance of unit processes.

Thereby, **approach (1) will be considered as the baseline scenario** as this kind of weighing predicts that every sub-category has the same importance. The second approach that will be tested is **prioritization of worse performance within a subcategory** by given a weighting factor of 1 to the worst scored indicator and 0 is granted to the rest of the indicators in the subcategory.

Finally, the **indicators will be weighed according to the importance of social issues according to internationally negotiated norms and literature about precursor rights,** as proposed by Beaulieu et al. (2014)[17]. The authors base themselves on the ILO Declaration on Fundamental Principles and Rights at Work, the five pillars of the Decent Work agenda (rights at work, employment creation, social protection, and social dialogue), as well as the concept of precursor rights to propose a hierarchy among S-LCA subcategories. Using this benchmark, a three-level scale was established. The S1 level corresponds to issues directly related to fundamental principles and workers' rights (threshold of maximum severity). The S2 level corresponds to issues directly related to the specific challenges of migrant workers in terms of their employment contracts, as well as other issues related to wages and health & safety (less severe than S1). Finally, the S3 level was granted to the remaining issues, which deal mostly with working conditions (least severe level). All levels are described in the figure below.

S1	**Issues directly related to the ILO's fundamental rights and principles declaration and Decent Work Agenda** Child labor, freedom of association, forced labor, discrimination and practices that negatively affect human dignity
S2	**Issues relating to wages, health and the formalization of the employment relationship by the contract** Salaries and benefits, health & safety, labor relations and job insecurity, workers' housing (when provided by the employer)
S3	**Other issues** Failure to offer legally imposed social security benefits, excessive working hours, failure to provide overtime pay

Figure 30: Social issues priorisation - source: Beaulieu et al. (2014)

The indicators from S1 categories will be weighted by a factor 3, S2 by a factor 2 and S3 by a factor 1. Given the 5 levels scale used on the present study, when the obtained score is higher than +2 or -2, those maximum scores will be kept.

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[17] Beaulieu, L., Russo Garrido, S., Hamaide, F., & Revéret, J. P. (2014). From potential hotspots identification to social issues prioritization. *Social LCA in progress. C. Macombe et D. Loeillet. Montpellier, CIRAD*, 115-122.

The results of both sensitivity analysis are presented on the following tables:

Stakeholders categories	Sub-categories	Manufacturing		End of life (Ciroth et Franze, 2012)		Total Score
		Traverso et al., 2011	(Yu et al., 2015)	Formal recycling sector	Informal recycling sector	
Workers	Freedom of association and collective bargaining	no data	-1	+2	-2	
	Child labour	0		+2	-2	
	Forced labour	0		+2	+2	
	Fair salary	-2		+2	-1	
	Working time	-2		+2	-2	
	Discrimination	-2		+2	-2	
	Health and safety	-2	-2	+1	-2	
	Social benefits/social security	-2	+1	+2	-2	
Score - Workers category		-2	-1	+2	-2	-2
Local community	Access to material resources	N/A	N/A	+2	-1	
	Access to immaterial resources	N/A	N/A	no data	1	
	Delocalization and migration	N/A	N/A	1	no data	
	Cultural heritage	N/A	N/A	no data	no data	
	Respect of indigenous rights	N/A	N/A	no data	no data	
	Safe and healthy living conditions	N/A	N/A	1	-2	
	Secure living conditions	N/A	N/A	no data	0	
	Local employment	N/A	N/A	+2	1	
	Community engagement	N/A	N/A	no data	-1	
Score - Local community category		N/A	N/A	N/A	-1	-1
Society	Public commitments to sustainable issues	N/A	+1	-1	-1	
	Contribution to economic development	N/A		1	1	
	Prevention and mitigation of conflicts	N/A		no relevant	-1	
	Technology development	N/A		1	-1	
	Corruption	N/A		-2	-2	
Score - Society category			+1	-1	-1	-1

Figure 31: Sensitivity analysis – approach (2) prioritization of worse performance within a subcategory

Stakeholders categories	Sub-categories	Life cycle phases				Total Score
		Manufacturing		End of life (Ciroth et Franze, 2012)		
		Traverso et al., 2011	(Yu et al., 2015)	Formal recycling sector	Informal recycling sector	
Workers	Freedom of association and collective bargaining		-2	+2	-2	
	Child labour	0	-2	+2	-2	
	Forced labour	0	-2	+2	+2	
	Fair salary	-2	-2	+2	-2	
	Working time	+1	-1	+2	-2	
	Discrimination	-2	-2	+2	-2	
	Health and safety	-2	-2	+2	-2	
	Social benefits/social security	-2	+1	+2	-2	
Score - Workers category		-2	-2	+2	-2	-2
Local community	Access to material resources			+2	-1	
	Access to immaterial resources			no data	1	
	Delocalization and migration			1	no data	
	Cultural heritage			no data	no data	
	Respect of indigenous rights			no data	no data	
	Safe and healthy living conditions			1	-2	
	Secure living conditions			no data	0	
	Local employment			+2	1	
	Community engagement			no data	-1	
Score - Local community category				1	-1	-1
Society	Public commitments to sustainable issues			-1	-1	
	Contribution to economic development			1	1	
	Prevention and mitigation of conflicts		+1	no relevant	-1	
	Technology development			1	-1	
	Corruption			-2	-2	
Score - Society category			+1	-1	-1	-1

Figure 32: Sensitivity analysis - approach (4) weighting according to importance of issues based on UN conventions

As showed by the tables above, the methodology of scoring may radically change the results. Indeed, both weighting approaches results on a lowest general performance comparing to the baseline scenario (Figure 26: Results of the S-LCA). Thus, it is essential to keep that in mind when interpreting the results, and especially when comparing the social performance of a product to another. This is why experts should manage it, because it could lead to a false aggregate evaluation results.

However, weighting the selected indicators can also be very useful and make the S-LCA results more accurate. In this case, it is important to wisely select the weighting approach. The best scenario would be to have a consultation process for choosing the weights, so the decision and the following evaluation are transparent.

7.2.4. Step 4: Communication

To support decision making, LCSA results are faced with the challenge of how to take complex and potentially confusing data and present it in a straightforward manner to decision makers who may not be experts in this field. Therefore, the creation of an understandable yet comprehensive presentation of LCSA results is a major goal of this research (Traverso et al., 2011).

In order to assess the efficiency of the message conveyed by S-LCA results, four modes of display will be tested according to the following models:

- Score by theme (stakeholders/impact categories) qualitative & quantitatively.
- Unique quantitative & qualitative note;

a) **Quantitative thematic display**

The first proposed display is a quantitative thematic table which presents the detailed score by stakeholder category and sub-category. This kind of display should be preferably used when the targeting is an expert audience.

Stakeholders categories	Sub-categories	Life cycle phases				Total Score
		Manufacturing		End of life (Ciroth et Franze, 2012)		
		Traverso et al., 2011	(Yu et al., 2015)	Formal recycling sector	Informal recycling sector	
Workers	Freedom of association and collective bargaining	no data	-1	+2	-2	
	Child labour	0		+2	-2	
	Forced labour	0		+2	+2	
	Fair salary	-1		+2	-1	
	Working time	0		+2	-2	
	Discrimination	-1				
	Health and safety	0	-2	+1	-2	
	Social benefits/social security	-1	+1	+2	-2	
Score - Workers category		0	-1	+2	-2	-1
Local community	Access to material resources			+2	-1	
	Access to immaterial resources			no data	1	
	Delocalization and migration			1	no data	
	Cultural heritage			no data	no data	
	Respect of indigenous rights			no data	no data	
	Safe and healthy living conditions			1	-2	
	Secure living conditions			no data	0	
	Local employment			+2	1	
	Community engagement			no data	-1	
Score - Local community category				1	-1	0
Society	Public commitments to sustainable issues			-1	-1	
	Contribution to economic development			1	1	
	Prevention and mitigation of conflicts		+1	no relevant	-1	
	Technology development			1	-1	
	Corruption			-2	-2	
Score - Society category			+1	-1	-1	-1

Figure 33: Qualitative thematic display of the PV modules' S-LCA results

b) Qualitative thematic display

This second display is more graphic and could be used in a communication goal. Indeed, it could present the key results of the assessment, assuming that one graph would be presented for each stakeholder's category. In the following figure, the Workers category was chosen.
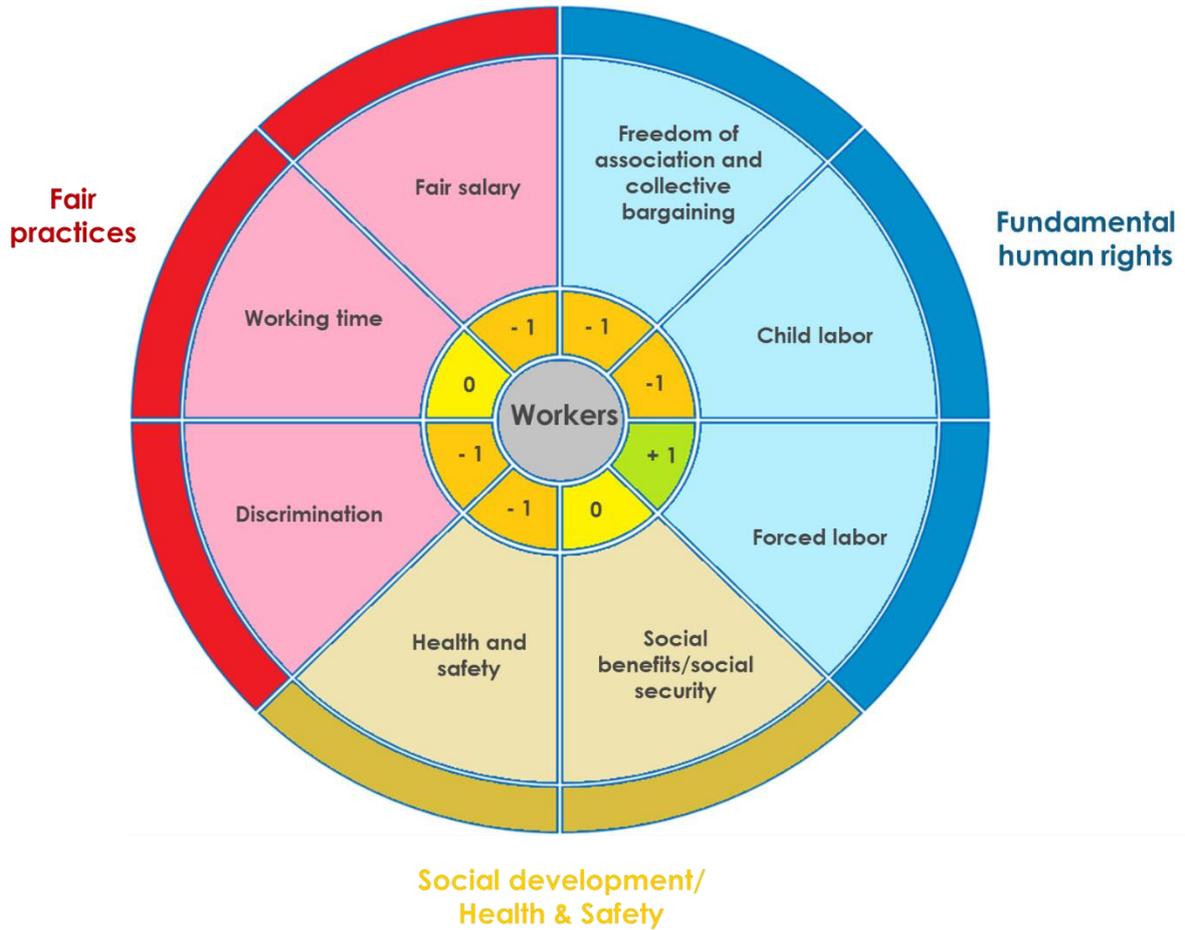

Figure 34: Quantitative thematic display for Workers stakeholder category (based on Methodological framework for social impact assessment of a cosmetic product (L'Oréal, 2015))

c) Single quantitative & qualitative score display

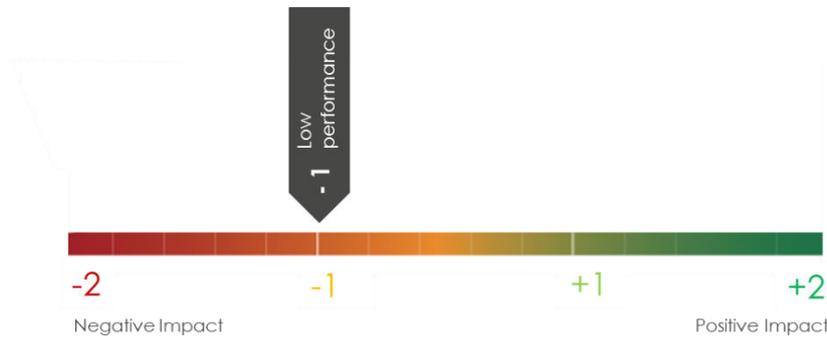If a single score is needed, the two following display could be considered.

Figure 35: Single quantitative score display of the PV modules' S-LCA results

Figure 36: Single qualitative score display of the PV modules' S-LCA results

Thereby, relevancy of the presented displays depends of the final objective of the assessment and the public aimed. The following table summarizes the advantages and drawbacks of the several ways/levels of results presentation that could be adjusted in function of the initial objectives:

Results display	Advantages	Drawbacks
Score by theme (stakeholders/impact categories) qualitative & quantitatively	- Identification of hotspots and drive of conception choices - Ensure transparency	- Complexity to apprehend
Unique quantitative & qualitative note	- More understandable for the external communication	- Not recommended by the current guidelines since less transparent

Figure 37: Results presentation options

8. Perspectives and conclusions

Through the UNEP-SETAC Guidelines for S-LCA of products and the complementary methodological sheets (UNEP-SETAC, 2013) the field of S-LCA started establishing a framework building on the ISO 14040 and 14044 LCA standards. Through conferences, published journal articles, seminars and industry group publications (Pre, 2014), the methods are spreading, evolving and gaining in maturity. However, the analysis carried out clearly pointed out that it is an evolving field, and main developments are envisaged, both at the level of methodology and results 'interpretation and communication.

We have identified the following main areas of developments, together with recommendations for moving forward S-LCA.

- **Criteria and indicators for S-LCA**.

Several and different sets of social indicators exist, developed within different methodological frameworks, for different purposes and with a different resolution. Besides, the identification of a universally accepted list of social indicators does not seem to be the right approach, if not misleading, because "[…] no fundamental theory exists that allows us to delineate social indicators from a coherent theory of what matters in society" (Carrera and Mack 2010).

Thus, the challenge is to select the most appropriate indicators for a given situation, considering that, for the social aspects, the following aspects need to be considered:

- social aspects can be weighted in highly different ways by different stakeholders, in different geographic contexts;
- social evaluations change very quickly over time;
- data availability is quite poor and its reliability is questionable;
- ambiguity exists in terminology (social impacts, social sustainability, social aspects, social indicators), data (qualitative, quantitative, semi-quantitative) and methods of measurement (S-LCA, Social Impact Assessment, etc.) (Parris and Kates 2003).

In fact, while environmental indicators and methodology have been identified and can be considered robust enough for the assessment of many environmental impact categories (even if improvements are always under development), the social assessment is characterised by an increased complexity due to the qualitative aspects which play an important role in the evaluation process.

The indicators selection is a key aspect for S-LCA, as they define what is being measured, and as such, affect the results of the assessment. Common and structured approaches for selecting them have not been developed yet, and the different applications available in literature present different approaches, most of which are driven by data availability and not by the relevance of the social aspect at hand. Some indicators are considered relevant for the sector at hand according to literature review outcomes, or to the Social Hotspot Database results (Zanchi et al., 2017). In some other cases, indicators have been

selected according to their capabilities to reflect both positive and negative social effects of the given case study.

A recent review on this topic (Sureau et al., 2017) pointed out a variety of approaches, which are not always consistent with the framework they belong to.

Recommendation 1

- Clarify in the application the rational for the choice of indicators (Iofrida et al., 2016; Sureau et al., 2017; Zanchi et al., 2017);
- Use selection criteria and techniques that reflect the values of the stakeholders, such as participatory approaches (Sureau et al., 2017)

- **Impact assessment**

As discussed throughout the report, currently with S-LCA it is possible to measure social performances and not social impacts, due to the lack of valid impact pathways and the challenges that exist in developing them. Despite the ambition to be objective in the impact assessment, the process is nevertheless limited by the knowledge and information available to those performing the assessment. Because of the issues raised about subjectivity, incompleteness and representativeness and lack of causal relationship models, transparency in documentation of inventory and impact assessment is the key to the credibility and usefulness of S-LCA results (Umair et al. 2015).

Impact pathways are currently under development, both for specific applications and also more general, which might be implemented on many different grounds. However, the lack of (a broad coverage of) impact pathways shall not be a reason for not using S-LCA, as also the information provided by the assessment of social performances is valuable for supporting the decision-making process.

As far as social performances are concerned, their assessment also need to be structured. Currently, several approaches exist that differ for the data collected and their positioning along the impact pathway, the scaling of inventory data on the functional unit, characterization and weighting steps. In addition, in most of the cases the authors develop their own approach for the characterisation step, without testing – if not in a few cases – previously developed methods.

Recommendation 2

- Encourage the development of social impact pathways, trying to build up approaches that can cover a large number of applications;
- Further strengthen the assessment of social performances, by means of:
    - Clarify the positioning of indicators on the impact pathway as midpoint/endpoint impacts or as stressors (Sureau et al., 2017);
    - Integrate stressor variables in the assessment, i.e., reasons for midpoint impacts.
    - Focus on approaches that include a concern for norms, geographical location, and stakeholders' input for the characterization and weighting steps.

- **System boundary definition**

So far, most if not all of the S-LCA applications do not cover the full life cycle, due mainly to the difficulties in collecting data and information on upstream and downstream processes out of the control of the organisation. In addition, currently the definition of the system boundaries is carried out considering only the technological system, i.e., the system made of the technical processes only, without properly considering the different stakeholders positioned at the different level of the life cycle.

Furthermore, within the technological system, the production stage has been the main focus of S-LCA applications, and workers has been the most addressed stakeholders. Assessing the consumption and use phase also remains a great challenge. Indeed, in S-LCA, the use phase has been acknowledged as so specific that it demands a special approach that is still not clearly defined. A car is a good example of where the use phase can be complex in that a local community can be affected in terms of health and safety during the use of the car as well as by how plants are managed.

Recommendation 3

- In SLCA applications, broaden the scope of the assessment so as to include the whole life cycle;
- Develop and select criteria and indicators able to cover consumption and use stage;
- When defining system boundary, consider both causal relationships (as currently done in LCA) and social relations too, the latter driven by stakeholders

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- **Positive impacts**

Regarding the assessment of positive impacts, it would be necessary to dwell more on conceptualisation of theoretical roots and, subsequently, to test these through the development of case studies.

There is wide agreement that indicator sets for positive aspects are needed: the Taskforce did not develop a universal indicator set as a basis for all further S-LCA applications. Besides, current discussion on indicators for measuring sustainable development goals (UN 2015b) may benefit from a more structured, rigorous and agreed approach to the assessment of positive impacts along supply chains. It is important that future development of positive indicators will be able to capture to which extent to a product system is contributing to, e.g. sustainable development goal 3 (on good health and well-being), 5 (gender equality), 8 (decent work and economic growth) just to name a few.

What can be hoped for is therefore a careful assessment which is able to capture all the possible positive impacts, giving value to local peculiarities that can be solutions to social issues, with a perspective of assessing what can allow and encourage the growth of human capital as a real opportunity for sustainable development.

The real question is: "what does S-LCA and more in general LCT represent?" The answer lies in that, alone, one cannot obtain results and the winning logic to manage the production of goods and services (especially in an era of globalization) is to open up and create "alliances" with the other stakeholders involved in the value chain, while respecting and protecting the identity of each one. By doing so, S-LCA, as all LC-based methodologies, educates and instils the systemic logic of relationship and mutuality, where if the "other" does well, it represents the good.

It is therefore necessary to clarify, as much as possible, the outlines of the methodology, in order to concentrate all the efforts towards a greater robustness for the fundamental task of education that S-LCA has in building sustainability.

Recommendation 4

- Identify social evaluation criteria to establish what is to be considered as "positive", together with a deep analysis of the context: in what way might the context evolve after an improvement has occurred? These interrogatives are of fundamental importance especially considering possible application of SLCA in contexts such as policy impact assessment.
- Jointly discuss on how S-LCA can be used to promote collaboration along the supply chain for the benefits of all the actors, while guaranteeing a fair competition.

The data currently available in S-LCA databases support mainly in identifying social hotspots at the country and broad economic sectors while lack specificity (Fan et al., 2016). However, as S-LCA is mainly a site-specific practice, it also demands location-specific data for modelling the system because of the significant cultural and economic differences between countries that can influence social impacts (Benoît Norris 2013). Suitable high spatial and temporal resolution data are scarce and are not found in many LCA databases and collecting such data can be quite difficult. Then, in turn, the limited availability of site-specific data restricts the number of impact subcategories that can be used for S-LCA (Agyekum et al., 2016). Furthermore, as suggested by Rugani et al. (2014), future life cycle oriented databases that are intended for use in consequential assessments, should systematically include information about anticipatory experiences, if they exist. This is particularly true for S-LCA, which can use those databases for prospective analysis of new or emergent technologies in market systems.

Recommendation 5

- Improve database's specificity by increasing the granularity of data at regional and sector level;
- Improve the development of tools and assessment software for S-LCA (Zamagni, 2012). Ideally these tools should be compatible with available E-LCA tools which could lead to an expansion of research and applications combining (environmental) LCA, LCC and S-LCA (Valvidia et al., 2012) for a life cycle-based sustainability assessment.

- **Practice in S-LCA**

Another main research issue regarding S-LCA field is that more experiences and case studies need to be carried out. As mentioned in a study by Baumann et al. (2013), the method development within the field of LCA is more efficient and effective when it is based on case studies, as history has shown and the systems theory literature suggests. Indeed, case studies can support to develop a guidance in an important manner and enable practitioners to work out meaningful results, by pushing companies, NGOs, and research institute to collect data and build relative database (Traverso et al., 2016). This would help improving the exploitability of the S-LCA approach and highlighting operational needs.

> **Recommendation 6**
> - Perform S-LCA studies with a critical attitude, addressing current limitations and testing different approaches, especially in relation to the type I characterization and weighting step.

- **Communicating S-LCA results**

The creation of models for the presentation and communication of S-LCA results is also an important perspective to be developed, as it can influence and facilitate decision-making as previously mentioned. S-LCA is first and foremost a multi-criteria and multi-step assessment, a balance between completeness, and popularizing results need to be found. Based on the multiple initiatives launched on LCA and associated communication (French environmental labelling, Product Environmental Footprint…), the feedbacks from this experimentation need to be transpose to S-LCA. And in a long-term, the objective will be to replicate this experimentation to S-LCA in order to find a consensus on the framework and the best way to present the results according the targets and the stakeholders.

> **Recommendation 7**
> - SLCA is a multi-criteria and multi-phase analysis which can make the outcomes difficult to understand. Therefore, it is very important to manage the balance between scientific popularization, scientific rigor and transparency.
> - To ensure transparency, the score by theme (stakeholders/impact categories) qualitative & quantitatively displays should be used to drive conception choices;
> - Unique quantitative & qualitative note are not recommended by current guidelines; therefore, they should be used only for external communication when a more understandable result is needed.

- **Creation of a label based on social criteria**

As the range of labels widens, the need for simple and unique communication between stakeholders is increasingly felt. In this context, the development of S-LCA opens up the opportunity to create a multi-criteria, multi-stakeholder social label that takes into account the whole life cycle of the product. Currently, the development and use of environmental labels and declarations are governed by the ISO 14020 series. ISO 14024 provides advice on how to develop criteria, compliance systems and procedures for the development of eco-labels by independent bodies; and ISO 14025 regulates Type III environmental declarations on the life cycle of a product to enable comparisons between products fulfilling the same function. It will be possible to adapt these requirements for S-LCA. Social display throughout a single social label has 3 main goals: (i) for consumers: provide information to drive their choices and behavior; (ii) for companies: enhance responsible-conception and promote their social performance; (iii) for all stakeholders: avoid greenwashing practices; and provide information based on a robust methodology.

> **Recommendation 8**
> - Following the format provided by Environmental labels and declarations, S-LCA could be used as a methodological framework to develop social labelling and declaration. For instance, an annex addressing social issues could be added to ISO 14025, following the example of what is done in France regarding health and comfort information which are added to Environmental Product Declarations.
> - Thus, the standardization of the methodology and the communication of the social display would make it possible to provide comprehensible, comparable, truthful and robust science-based information on the the whole life cycle of the product.

- **Interdisciplinary approach for S-LCA**

The available methodologies are not yet fully aligned with other ongoing global initiatives. Overall, social metrics are considered to be a new and evolving area in which all companies are attempting to develop (Fontes et al., 2014). Therefore, cooperation of S-LCA approaches with other initiatives should be an important research field for the next years and can be used as a tool for other approaches.

> **Recommendation 9**
> - Social aspects can be assessed through a variety of tools – analytical tools, procedural and management tools, monitoring, reporting and communication tools. Although various tools cannot replace one another, they can be complementary.
> - S-LCA can be coupled to GRI or ISO 26000 standards as they can be considered in LCA terms as a "hotspot" assessment process within their supply chains;
> - S-LCA as a methodology can support to fulfil the requirements on materiality assessment and due diligence;
> - S-LCA models enable to by-pass the information gap suffered by many companies regarding the supply chain activities, linkages and location by using trade or process models;

SOCIAL LCA, SUSTAINABLE DEVELOPMENT, CSR: STATE OF RESEARCH? WHAT ARE THE METHODOLOGICAL NEEDS?

Figure 38 below shows a roadmap based on the time and resources needed for the implementation of the above-mentioned recommendations.
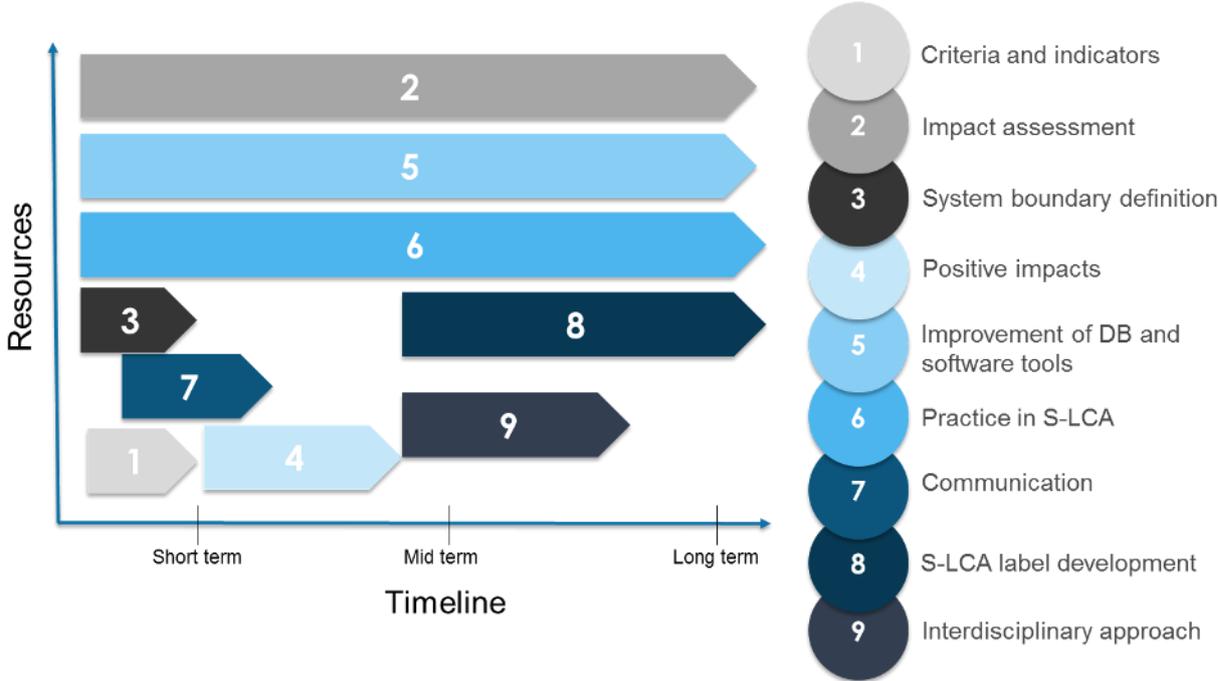

Figure 38: Roadmap

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9.1. Annex 1: S-LCA papers on theoretical frameworks reviewed

Author	Year
Benoît and Vickery-Niederman	*2011*
Benoît et al.	*2011*
Benoît et al.	*2010*
Benoît Norris	*2012*
Benoît Norris	*2014*
Benoît Norris and Revéret	*2015*
Benoît Norris et al.	*2012*
Benoît Norris et al.	*2011*
Bocoum et al.	*2015*
Chhipi-Shrestha et al.	*2014*
Cinelli et al.	*2013*
Dreyer et al.	*2010*
Dreyer et al.	*2006*
Ekvall	*2011*
Finkbeiner et al.	*2010*
Fontes	*2014*
Grießhammer et al.	*2006*
Hsu et al.	*2013*
Hutchins and Sutherland	*2008*
Jørgensen	*2010*
Jørgensen	*2013*
Jørgensen et al.	*2008*
Jørgensen et al.	*2009*
Jørgensen et al.	*2010a*
Jørgensen et al.	*2010b*
Jørgensen et al.	*2012*
Kloeppfer	*2008*
Lehmann et al.	*2011*
Lehmann et al.	*2013*
Macombe et al.	*2011*
Mathé	*2014*
Moberg et al.	*2009*
Neugebauer et al.	*2014*
Norris	*2006*
Parent et al.	*2010*
Parent et al.	*2013*
Pelletier et al.	*2013*
Petti and Campanella	*2009*
Pizzirani et al.	*2014*
Reitinger et al.	*2011*
Sala et al.	*2013*
Sanchez Ramirez and Petti	*2011*
Sanchez Ramirez et al.	*2014*
Swarr	*2009*
Wu et al.	*2014*
Zamagni et al.	*2011*
Zamagni et al.	*2013*

9.2. Annex 2: S-LCA case studies reviewed

Authors	Year	Title
Agyekum et al.	2017	Environmental and social life cycle assessment of bamboo bicycle frames made in Ghana
Albrecht et al.	2013	An extended life cycle analysis of packaging systems for fruit and vegetable transport in Europe
Aparcana and Salhofer	2013	Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies
Arcese et al.	2013	Social Life Cycle Assessment as a Management Tool: Methodology for Application in Tourism
Arvidsson et al.	2016	A method for human health impact assessment in social LCA: lessons from three case studies
Aschehoug et al.	2016	Management of Social and Ethical Impacts from the Product Life Cycle of High End Wrought Aluminium Products
Baumann et al.	2013	Does the Production of an Airbag Injure more People than the Airbag Saves in Traffic? Opting for an Empirically Based Approach to Social Life Cycle Assessment
Bouzid and Padilla	2014	Analysis of social performance of the industrial tomatoes food chain in Algeria
Chang et al.	2015	Environmental and Social Life Cycle Assessment of welding technologies
Chen & Holden	2017	Social life cycle assessment of average Irish dairy farm
Ciroth and Franze	2011	LCA of an Ecolabeled Notebook. Consideration of Social and Environmental Impacts Along the Entire Life Cycle
Corona et al.	2017	Social Life Cycle Assessment of a Concentrated Solar Power Plant in Spain: A Methodological Proposal
De Luca et al.	2015	Social Life Cycle Assessment and Participatory Approaches: A Methodological Proposal Applied to Citrus Farming in Southern Italy
do Carmo et al.	2017	Addressing uncertain scoring and weighting factors in social life cycle assessment
Dong & Ng	2016	A modeling framework to evaluate sustainability of building construction based on LCSA
Ekener et al.	2016	Addressing positive impacts in social LCA—discussing current and new approaches exemplified by the case of vehicle fuels
Ekener-Petersen and Finnveden	2013	Potential hotspots identified by social LCA—part 1: a case study of a laptop computer
Ekener-Petersen and Moberg	2013	Potential hotspots identified by social LCA–Part 2: Reflections on a study of a complex product

Ekener-Petersen et al.	2014	Screening potential social impacts of fossil fuels and biofuels for vehicles
Fan et al.	2016	Evaluation for social and humanity demand on green residential districts in China based on SLCA
Feschet et al.	2013	Social impact assessment in LCA using the Preston pathway - The case of banana industry in Cameroon
Foolmaun and Ramjeeawon	2013 a	Comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET) bottles in Mauritius
Foolmaun and Ramjeeawon	2013 b	Life cycle sustainability assessments (LCSA) of four disposal scenarios for used polyethylene terephthalate (PET) bottles in Mauritius
Franze and Ciroth	2011	A comparison of cut roses from Ecuador and the Netherlands
Hannouf & Assefa	2017	Subcategory assessment method for social life cycle assessment: a case study of high-density polyethylene production in Alberta, Canada
Hossain et al.	2017	Development of social sustainability assessment method and a comparative case study on assessing recycled construction materials
Hosseinijou et al.	2014	Social life cycle assessment for material selection: a case study of building materials
Hu et al.	2013	An approach to LCSA: the case of concrete recycling
Lemhann et al.	2013	Social aspects for sustainability assessment of technologies—challenges for social life cycle assessment (SLCA)
Lolli et al.	2016	Waste treatment: an environmental, economic and social analysis with a new group fuzzy PROMETHEE approach
Luthe et al.	2013	A Systems Approach to Sustainable Technical Product Design - Combining Life Cycle Assessment and Virtual Development in the Case of Skis
Macombe et al.	2013	Social life cycle assessment of biodiesel production at three levels: a literature review and development needs
Manik et al.	2013	Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia
Martínez-Blanco et al.	2014	Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment
Mirdar Harijani et al.	2017	Multi-period sustainable and integrated recycling network for municipal solid waste - A case study in Tehran
Moriizumi et al.	2010	Simplified life cycle sustainability assessment of mangrove management: a case of plantation on wastelands in Thailand
Nemarumane and Mbohwa	2015	Social Life Cycle Assessment in the South African Sugar Industry: Issue and Views

Neugebauer et al.	2017	Calculation of Fair wage potentials along products' life cycle e Introduction of a new midpoint impact category for social life cycle assessment
Pastor et al.	2017	Social aspects of water consumption: risk of access to unimproved drinking water and to unimproved sanitation facilities—an example from the automobile industry
Petti et al.	2016	An Italian tomato "Cuore di Bue" case study: challenges and benefits using subcategory assessment method for social life cycle assessment
Ren et al.	2015	Prioritization of bioethanol production pathways in China based on life cycle sustainability assessment and multi criteria decision-making
Reuter	2016	Assessment of sustainability issues for the selection ofmaterials and technologies during product design: a case study of lithium-ion batteries for electric vehicles
Revéret at al.	2015	Socioeconomic LCA of Milk Production in Canada
Rugani et al.	2014	Towards prospective life cycle sustainability analysis: exploring complementarities between social and environmental life cycle assessments for the case of Luxembourg's energy system
Sanchez Ramirez et al.	2016	Subcategory assessment method for social life cycle assessment. Part 2: application in Natura'scocoa soap
Siebert et al.	2017	Social life cycle assessment indices and indicators to monitor the social implications of wood-based products
Souza et al.	2016	Social life cycle assessment of first and second-generation ethanol production technologies in Brazil
Subramanian et al.	2017	Assessing the social impacts of nano-enabled products through the life cycle: the case of nano-enabled biocidal paint
Touceda et al.	2016	Modeling socioeconomic pathways to assess sustainability: a tailored development for housing retrofit
Traverso et al.	2012	Towards life cycle sustainability assessment: an implementation to photovoltaic modules
Traverso et al.	2016	Towards social life cycle assessment: a quantitative product social impact assessment
Tsalis et al.	2017	A social LCA framework to assess the corporate social profile of companies: Insights from a case study
Umair et al.	2015	Social impact assessment of informal recycling of electronic ICT waste in Pakistan using UNEP SETAC guidelines
Valdivia et al.	2012	A UNEP/SETAC approach towards a life cycle sustainability assessment—our contribution to Rio+20
van Haaster et al.	2017	Development of a methodological framework for social life-cycle assessment of novel technologies
Vinyes et al.	2013	Application of LCSA to used cooking oil waste management

Wang et al.	2016	An analytical framework for social life cycle impact assessment—part 2: case study of labor impacts in an IC packaging company
Weldegiorgis and Franks	2014	Social dimensions of energy supply alternatives in steelmaking: comparison of biomass and coal production scenarios in Australia
Wilhelm et al.	2015	An overview of social impacts and their corresponding improvement implications: a mobile phone case study
Yıldız-Geyhan et al.	2017	Social life cycle assessment of different packaging waste collection system
Yu and Halog	2015	Solar Photovoltaic Development in Australia—A life cycle sustainability assessment study
Zamani et al.	2016	Hotspot identification in the clothing industry using social life cycle assessment—opportunities and challenges of input-output modelling
Zimmer et al.	2017	Assessing social risks of global supply chains: A quantitative analytical approach and its application to supplier selection in the German automotive industry