Social Life-Cycle Assessment: An Introduction

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Introduction

The inclusion of social aspects into mainstream sustainability management, tools, and methodologies has gained in prominence in recent years. An increasing number of initiatives promoting supply chain due diligence have been positioning social issues as a central concern. Leading corporate social responsibility reporting frameworks, such as the Global Reporting Initiative (GRI) G4, Integrated Reporting, and SASB, have been issuing guidance encouraging companies to reflect upon and report on organizations' significant social impacts. Emerging disclosure legislation has also brought the topic to the forefront, for example, the United States' Securities and Exchange Commission (SEC) Conflict Mineral Rule, the United Kingdom Modern Slavery Act, or the California Transparency in Supply Chains Act.

Amidst this context, Social Life-Cycle Assessment (SLCA) has developed over the past two decades as a tool for Corporate Social Responsibility (CSR) (Corporate Social Responsibility has been defined as the appropriation and implementation of the logics and principles of sustainable development to the business domain (Capron and Quairel-Lanoizelée, 2004; Yedder and Farhoud, 2009). SLCA provides a holistic, systemic, and rigorous tool to understand social issues that may arise in the value chains of products and services sustaining human life today. It is a series of methods aiming to assess the potential positive and negative social (SLCA focuses on potential "social and socioeconomic impacts" (UNEP-SETAC, 2009). For simplicity's sake, the term "social" will be used in this article.) impacts associated with the life cycle of products, processes, and services (a framework is also currently being developed for the assessment of potential social impacts of organizations) (adapted from UNEP-SETAC, 2009). The potential impacts considered are those which can be experienced by key stakeholders, who are present throughout most of the life cycle, for example, workers, local communities, and consumers. **Fig. 1** presents the main life cycle steps in the life of a product.

The scope of SLCAs' product systems can vary. A product system corresponds to the portion of the life cycle of a product which will be considered in a study—in SLCA, it is made up of all the organizations that are involved in the unit processes (unit processes are the smallest portion of a product system for which data can be collected for, representing specific production, consumption, or disposal activities (UNEP-SETAC, 2009)) which are involved in the production, use, and disposal of a product. Some focus on few life-cycle steps or unit processes. However, more comprehensive studies cover as many life-cycle steps of a product as possible. In doing so, they not only focus on the product and its main constitutive materials (known as the "foreground") but also on the multiple value chains that support the extraction or production of these materials (known as the "background").

SLCA can be performed on its own or combined with an environmental life-cycle assessment (ELCA) and/or a life-cycle costing assessment (LCC). Given its relatively recent development, it is not at present a consolidated and standardized tool for assessment. However, its practice is framed by internationally recognized guidelines (see Section "**Guidance for SLCA**"), and it is being increasingly called upon by private and public decision-makers alike.

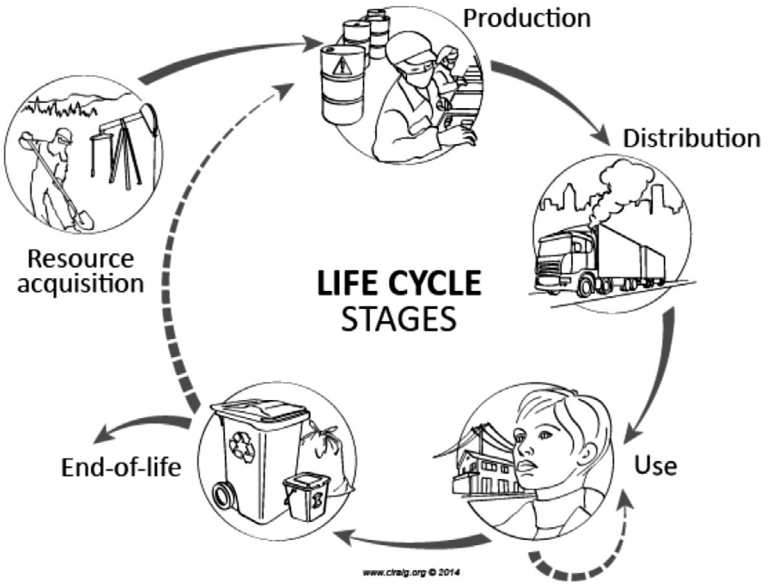

Fig. 1 Life-cycle stages.

Origins and Key Characteristics

SLCA draws its origins in environmental life-cycle assessment (ELCA). It was originally conceived as a social complement to ELCA. Like ELCA, it not only makes use of industrial ecology modeling and accounting frameworks but also draws from concepts and frameworks from the field of Corporate Social Responsibility (CSR), including CSR issues mapping, stakeholder theory, and reporting and audit indicators (adapted from Benoît Norris and Revéret, 2015). In particular, the ISO 26000 Guidelines for Social Responsibility (ISO 2010) and the Global Reporting Initiative (GRI) G3 Guidelines (GRI 2006) were an important backdrop to SLCA development.

Since 1996, over 100 scientific articles and case studies have been published on the topic, the majority in the *International Journal of Life Cycle Assessment* and the *Journal of Cleaner Production*. Moreover, an increasing number of case studies have been carried out by and for private and public sector actors, using SLCA methodology or else drawing heavily upon it. Larger scale, multistakeholder consortium-type initiatives that have contributed to the development and increasing operationalization of SLCA include UNEP's Life-Cycle Initiative, the Sustainability Consortium (in the context of its *Sustainability Measurement and Reporting Systems* (SMRS) initiative), the World Business Council for Sustainable Development (WBCSD) (the WBCSD chemical Sector initiative will lead to the development of the publication *Life-Cycle Metrics for Chemical Products* (probable release in 2016)), and the Roundtable for Social Metrics (the initiative was led by PRE Consultants and it involved 12 large companies and culminated in the publication of the *Handbook for Product Social Impact Assessment* in 2015).

For newcomers to SLCA, a question that often arises is "What does SLCA offer that is not already made available by other tools and methodologies which capture the 'social' dimension of sustainability"? The tools in question are, for example, social audits, norms (e.g., ISO 26000, SA 8000), certifications (e.g., Fairtrade, Rainforest Alliance), reporting frameworks (e.g., GRI), human rights impact assessments, or social impact assessments.

While SLCA shares some aspects with the earlier-mentioned tools, it also has some key characteristics of its own. First and foremost, its emphasis on life-cycle perspective is its most distinctive feature. While some other tools are focused on bringing to the forefront information about other actors in the value chain (e.g., first degree suppliers), few tools will cast their analysis as far and wide in the life cycle as SLCA. However, it shall be noted that results about portions of the life cycle located very far upstream will be captured in a general and generic manner due to methodological and data challenges. Moreover, SLCA offers the unique combination of life-cycle perspective, product focus as initial point of inquiry, and a focus on a broad range of stakeholders—all in one tool. This means that SLCA is a method most apt at looking at "the big picture," rather than providing rich detail on a specific life-cycle step. Its strength lies in its broad perspective.

Type I and Type II SLCA

Broadly speaking, two main approaches to SLCA coexist at present time (Jørgensen et al., 2008; Parent et al., 2010; Wu et al., 2014; Chhipi-Shrestha et al., 2014). These are commonly known as Type I and Type II SLCA, also known, respectively, as "Social Performance SLCA" and "Impact Pathway SLCA."

The difference between the two approaches lies in how they apprehend potential social impacts. In Type I SLCA, potential social impacts are assessed based on a proxy—social performance. The implicit logic is that these performances provide an approximation as to what the presumed social impacts further down the line might be. Thus Type I SLCA focuses on assessing the social performance (as will be discussed in Section "**Potential Social Impacts, Social Performance and Social Risk**," results of Type I SLCA are also often expressed in levels of social risk) of organizations involved in the life cycle of a product, by looking at their practices (behaviors) and determining whether they meet, or not, societal expectations in terms of social responsibility.

Type I SLCA studies focus on a range of social issues, such as working conditions, health and safety, and relations with the local community (see Section "**Guidance for SLCA**"). They focus on assessing the social performance or the product system at the company level or sector level. Type I SLCA represents the lion's share of SLCA studies today (Wu et al., 2014) in part because it is operational (albeit still in development) and adapted to the scale of companies and their supply chains.

Meanwhile, Type II SLCA distinctive feature is that it assesses potential social impacts by attempting to model the link between the source of an impact and its impact on human well-being (called impact pathways). (Impact pathways are the chain or causal relations which can be traced between activities and their ultimate social outcomes.) Examples of impact pathways which have been the focus of recent SLCA research include the impact of income on life expectancy (Feschet, 2014), or income distribution on infant mortality rate (Bocoum et al., 2015). Type II SLCA typically focuses on a single impact pathway per study, and the analysis is usually performed at a macroscale (e.g., at national or sector level, not company level). Currently, most work in Type II SLCA pertains to the realm of research—a better understanding of impact pathways is bound to be the subject of research for years to come, the results of which could bring tremendous added value to SLCA.

While acknowledging the fundamental work carried out in Type II SLCA, the present article focuses mostly on Type I SLCA, given its current degree of operationalization and use in the field of sustainability.

Guidance for SLCA

Following an extensive consultation process among academics and practitioners in the emerging field of SLCA, the *Guidelines for SLCA of products* (UNEP-SETAC, 2009) were published in 2009. The document constitutes the main guidelines for the conduct of an SLCA. They put forward a general methodological framework comprising a series of steps. The framework is aligned with ISO 14040 and 14044 norms, with certain adaptations in order to take into account the specificities of the assessment of social aspects.

The guidelines are presented as "a map, a skeleton, and a flash light for stakeholders engaging in the assessment of social and socioeconomic impacts of products life cycle" (UNEP-SETAC, 2009, p. 5). While they establish a baseline for defining how SLCA can be carried out, they provide a lot of flexibility and space for experimentation to the researcher/practitioner. In doing so, they rightfully recognize the fact that SLCA is still in development—while there is a rising consensus on key principles and methods, there is still room for further development.

In recent years, other publications focusing on providing guidance on SLCA have been developed, with strong involvement by the private sector. These build on the concepts and approaches developed in the guidelines, as well as corporate level standards (GRI, 2013; ISO, 2010). They also propose paths for implementation, in particular with regard to data collection and evaluation. *The Handbook for Product Social Impact Assessment* was published in 2015 as a result of the Roundtable for Social Metrics, a private sector collaborative project, led by Pre Consultants. The Life-Cycle Metrics for Chemical Products (probable release in 2016), developed under the umbrella of the WBCSD, will propose a methodology specifically to be used in the Chemicals sector.

Uses of SLCA

As a tool for CSR, Type I SLCA aims to provide insights to decision-makers on the social sustainability impacts of product life cycles. It does so by identifying social hotspots within a product system—that is, where the most important potential social impacts are likely to arise. For each of these steps, it will identify who are the affected stakeholders and what types of social issues they are likely to face.

Some studies compare different scenarios—for example, different product alternatives, modes of production, or end-of-life options—and provide a general portrait of the potential social impacts that the options appraised give rise to. However, given that SLCA results often rely on a mix of qualitative and quantitative results, as well extensive generic data, comparative studies tend to provide general results, highlighting general trade-offs and tendencies, rather than precise comparative results.

As can be appraised from published studies, SLCA results can be used in many different ways by private, public, and civil society actors, namely:

- To support/orient supply chain management and monitoring: For example, social hotspots identification can help in assessing whether internal/external monitoring systems are comprehensive enough or should be reinforced in critical hotspot locations.
- To inform responsible purchasing strategies: For example, providing information to help identify priorities, shape product requirements, etc.
- To improve the design and development of new products: For example, prioritizing certain materials with stronger social profile, favoring design options for the benefit of certain stakeholders (e.g., end-of-life workers, consumers), and working with purchasing teams to improve the social profile of certain materials.
- To inform long-term strategic decisions and public policy: For example, contributing to a materiality analysis by providing information about potential social impacts on stakeholders. Or by comparing scenarios associated with different business models or different policies.
- To support external communications regarding CSR performance/social sustainability of a product: to clients, suppliers, or consumers.
- To educate about/understand social issues in the life-cycle of products.

Key Concepts

Potential Social Impacts, Social Performance, and Social Risk

While the source of impacts in ELCA lies in the materials and energy involved at each step of the life cycle, potential social impacts do not generally originate from these same sources. There is a consensus that the majority of social impacts originate from the practices/behaviors and the economic contributions from organizations which are involved in the life cycle of the product, rather than the production processes themselves (UNEP-SETAC, 2009; Dreyer et al., 2006).

The guidelines define social impacts as the social consequences from an activity—both direct and longer-term social change processes (UNEP-SETAC, 2009, p. 69). SLCA's chief object of interest is thus the potential social consequences of the practices/behaviors (summed up as "activities" in SLCA parlance) of organizations involved in the life cycle, on their stakeholders. As depicted in Fig. 2, the social impacts emanating from an organization's activity can be conceptualized with a "chain of causality" or "impact pathway," between organizations' activities and long-term impacts on well-being.

As an assessment tool, SLCA focuses on identifying "potential" social impacts, rather than confirming actual impacts. The actual causal chain between an activity and its consequences is often unknown and nonquantified. As a result, most of SLCA studies today focus on assessing the social performance of organizations involved in the life cycle. This assessment is based on observations regarding organizations' activities and their immediate effects (first two points in Fig. 2). The implicit logic is that these performances provide an approximation as to what the presumed social impacts further down the line might be. Implicit in this assessment is the hypothesis that a good performance suggests the potential presence of potential positive impacts down the causality chain. Inversely, poor/bad social performance suggests potential negative impacts down the causality chain.

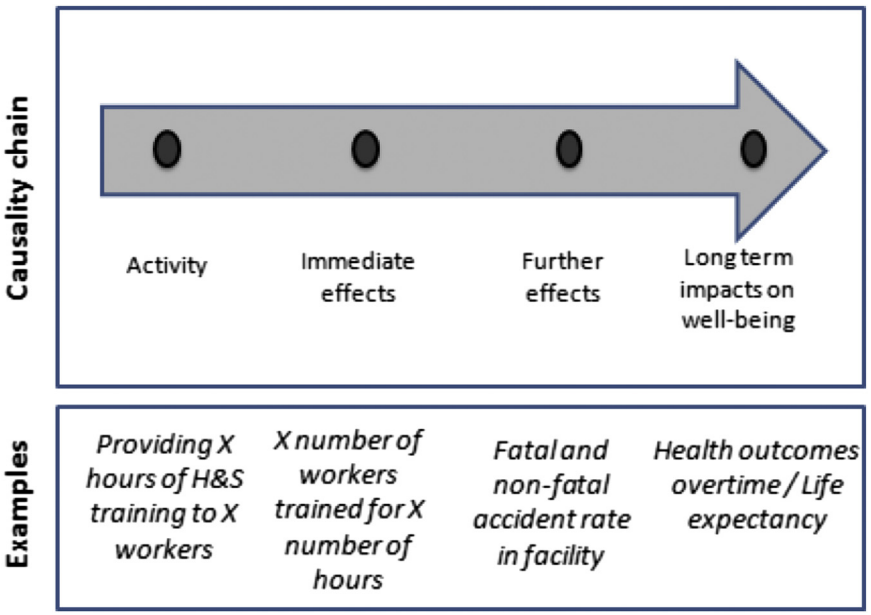

Fig. 2 Causality chain between activity and long-term social impacts. Adapted from Maas, K., Liket, K. 2011. Social impact measurement: classification of methods. p. 32 and WBCSD. 2013. Measuring socio-economic impact—a guide for business. World Business Council for Sustainable Development, p. 39.

Some authors and practitioners prefer to use the term "social risk" (instead of social performance) especially in the context of short studies (e.g., screening). The level of social risk will reflect the estimated likelihood of encountering instances of noncompliance with regard to a social issue studies (e.g., level of risk of encountering child labor in a given sector). Social risk assessment is also based on observations or statistics regarding organizations' activities and their immediate effects (see **Fig. 1**). It is usually performed using generic data—data which reflects sector-level performance, as opposed to data pertaining to specific organizations. In this case, a high level of risk is indicative of potential negative impacts in the causality chain.

Stakeholder Categories and Impact Categories and Subcategories

Type I SLCA practice focuses on the concept of assessing, at each step of the life cycle of a product, a range of potential social impacts likely to be experienced by a range of stakeholders. A stakeholder category is a cluster of stakeholders that are expected to have shared interests due to their similar relationship to the investigated product systems (UNEP-SETAC, 2009, p. 50). The guidelines propose to consider five Stakeholder Categories. Together, they represent the human being groupings most likely to be affected by the activities of organizations pertaining to the product system:

- workers/employees
- local communities
- consumers
- society
- other actors in the value chain

Moreover, the guidelines propose a list of potential social impacts to consider (named "impact subcategories"), which are derived from six broad impact categories: human rights, working conditions, health and safety, cultural heritage, governance, and socioeconomic contribution. (It shall be noted that there is no chain of causality or impact pathway between the subcategories and the categories of impact. The latter are simply categories with higher levels of abstraction than the former—they are thus well positioned for summarizing results.) These subcategories reflect key issues taken into account in leading CSR instruments and international conventions (in particular ISO 26000, GRI, and various United Nations Conventions). Impact subcategories can be classified according to the impact categories they belong to or to the stakeholders they are associated with. The latter is often preferred by SLCA practitioners, as presented in **Table 1**.

The indicators that are used to evaluate/measure each impact subcategory are not standardized. Each study will specify the indicators to be used, in line with the context of the study and data availability. The *Methodological sheets for impact subcategories* propose a series of generic indicators allowing to operationalize the concepts presented in the subcategories of impact.

Table 1 Stakeholder Categories and Impact Subcategories

Stakeholder category	*Impact subcategories*
Workers	Freedom of association and collective bargaining
	Child labor
	Fair salary
	Working hours
	Forced labor
	Equality/discrimination
	Health and safety
	Social benefits and social security
Local community	Access to material resources
	Access to immaterial resources
	Delocalization and migration
	Cultural heritage
	Safe and healthy living conditions
	Indigenous people's rights
	Community engagement
	Local employment
	Secure living
Society	Public commitment on sustainable development issues
	Contribution to economic development
	Prevention and mediation of armed conflict
	Technological development
	Corruption
Consumers	Health and safety
	Feedback mechanism
	Consumer privacy
	Transparency
	End-of-life responsibility
Other actors in the value chain	Healthy competition
	Respect for intellectual property rights
	Promoting corporate social responsibility
	Suppliers relations
	End-of-life
	Feedback mechanism

Adapted from WBCSD. 2013. Measuring socio-economic impact—a guide for business. World Business Council for Sustainable Development, p. 39 and UNEP-SETAC, 2009. In: Benoit, C., Mazjin, B. (Eds.), Guidelines for social life cycle assessment of products. UNEP, Paris. p.49.

It shall be noted that further research is needed to refine some impact subcategories. In particular, the list of indicators pertaining to the "Consumers" Stakeholder Category is recognized as being incomplete. There are also debates ongoing as to how to best capture positive impacts, given that current subcategories are chiefly oriented toward negative impacts. Numerous critics also note that impact subcategories are geared toward issues occurring in developing countries, thus rendering an inadequate framework for the analysis of product systems mostly located in industrialized countries.

Steps and Implementation

SLCA methodology comprises four main steps, which ought to be performed in an iterative manner: the goal and scope, data collection (also called life-cycle inventory analysis), impact evaluation, and interpretation.

Goal and Scope

The first step consists in clarifying the reasons behind the study as well as its methodological framework. Even though there is general guidance as to how to conduct an SLCA, many choices are left to the practitioner, in particular in terms of the scope of the product system, indicators, data collection, and evaluation methods. The methodological choices will be shaped by the objective of the study, as well as resources and data availability. The goal and scope is thus a key step, which includes—but is not limited to—establishing:

- The study's objective
- The subject of study (product and its functions)

- The functional unit and activity variable
- The scope of the study
- The boundaries of the product system considered
- The stakeholder categories included
- The impact subcategories included
- The data collection and evaluation methods

The functional unit quantifies the service offered by the studied product. It determines the subject of the study. It provides a point of reference to quantify the magnitude of the system associated with the product considered. By doing so, it allows the comparison of different products providing the same/similar services. However, it shall be noted that given the nature and scope of the data used in SLCA, it is not always possible to scale the data to the functional unit with great precision. This has prompted researchers to use what are called an "activity variable."

The activity variable is a variable representing a quantifiable activity that can be measured at each life-cycle step (or process). Hours of work are the most commonly used activity variable. The utility of an activity variable is that it can be scaled to the functional unit and provide an indication of the relative importance of different life-cycle steps.

Identifying the scope of the study and setting the boundaries of the product system are key steps in the Goal and Scope. At this step, the studied product system is modeled, and its boundaries are set and described. In SLCA, product system modeling also consists in identifying the specific companies or sectors involved in the life cycle of the product, and/or their proxies. These companies and sectors ought to be georeferenced, given the geographical specificity of the social issues considered in SLCA. Various sources of information may be called upon at this stage, including internal knowledge of the organization producing the product (e.g., bill of materials, purchasing lists), literature review, and economic input–output models.

The scope of the product system considered varies widely from one study to the next—some studies cover a handful of life-cycle steps with a lot of depth (given their limited scope, these studies could be considered as social assessments with a life-cycle perspective), some others are very extensive but rely on high-level models and generic data, while others are hybrid in nature, combining depth of analysis for a few life-cycle steps and more general analysis for a more extensive system.

Data Collection

Data collection, also called the "life-cycle inventory," consists in the collection and organization of data, in preparation for evaluation. As indicators to assess impact subcategories are not standardized at present, it is necessary to choose them at this stage. Data is typically collected through questionnaires, literature review, existing instruments (monitoring results or audits), and/or databases.

Data can be qualitative, quantitative, and can be manipulated to become semiquantitative, depending on the methodology chosen. Data can reflect different phenomena along the impact pathway (as presented in **Fig. 1**). It can reflect performance at the activity, effect, and further effect level. For example, for data on health and safety, one could collect data on the hours of H&S safety provided to workers at a facility (activity), on the annual rate of accidents in the facility (effect), or the life expectancy of workers at a given facility (further effect). However, data representing further effects is often more complicated to link to the production system, given the numerous exogenous variables which can shape the further effect in question.

Inventory data can be at different levels of resolution with regard to the product system considered. Some data is at the same level as the product system's unit processes/organizations, while some is at a higher aggregation level than the object of study. For example, sector and country data are often used as proxies of phenomenon happening at the company level. Studies opting to use data that corresponds to a different level than the object of study often express their results in terms of social risks, rather than performance.

Given the challenges associated with data accessibility, the vast majority of studies tend to combine data of different nature (qualitative, quantitative), located at different steps of the causal chain (from activity to further effects) and with varying levels of resolution.

Impact Evaluation

During the impact evaluation step, collected data is analyzed to assess potential social impacts. At this step, an implicit or explicit value judgment is made on the collected data. Following the evaluation, the data is weighted, and then aggregated for interpretation.

Type I SLCA assessment methods are often summed up as performance reference points (PRPs) scale analysis (Chhipi-Shrestha et al., 2014; Parent et al., 2010). PRPs are typically defined as "internationally set thresholds, or goals or objectives according to conventions and best practices" (UNEP-SETAC, 2009, p. 72), which allow to assess either a social performance or a risk of encountering a specific social performance.

As depicted in **Fig. 3**, six key evaluation models are used in SLCA. Leading approaches are briefly discussed later.

Assessments based on norms and best practice (No.1 in **fig. 3**) are most widely used. 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 (Quantis et al., 2012; Ciroth and Franze, 2011). In some studies, multiple connected issues can be addressed in one scale (Quantis et al., 2012), as presented in **Fig. 4**.

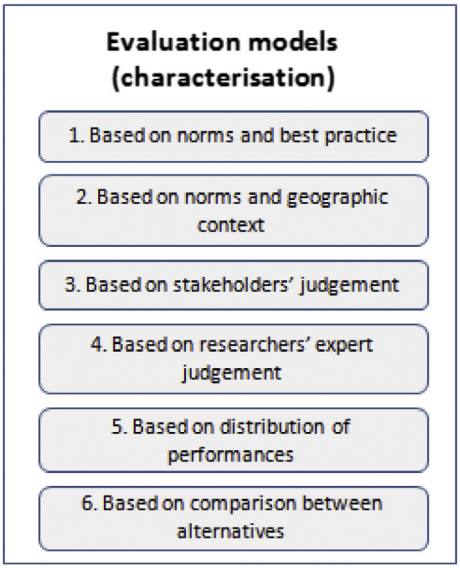

Fig. 3 Type I SLCA main evaluation models. From Russo Garrido et al. (2016).

REFERENCE SCALE Impact Subcategory: Working hours	
Scale level	Indicators
+2	Normal working week does not exceed legal limit or 48 hours for hourly workers. Overtime is recorded, voluntary, compensated at premium rate and does not exceed 12 hours.
+1	Normal working week does not exceed legal limit or 48 hours for hourly workers. Overtime is recorded, voluntary and compensated, but either not at premium rate or exceeds 12 hours.
0 (compliance)	Normal working week does not exceed legal limit or 48 hours for hourly workers. Overtime is recorded, voluntary and compensated, but not at premium rate and exceeds 12 hours.
-1	Normal working week exceeds legal limit or 48 hours for hourly workers in peak seasons only. Overtime is not recorded or compensated.
-2	Normal working week regularly exceeds legal limit or 48 hours for hourly workers. Overtime is not recorded or compensated.

Fig. 4 Reference scale for working hours. From Pre (2015), p. 35.

Other approaches propose not only to assess data on the basis of whether or not it meets norms and best practice standards but to also consider the social, economic, and political context of the companies investigated in the life cycle (No.2 in Fig. 3). This logic takes into account the fact that the social performance of organizations is affected by their operating environment. These approaches take into consideration the fact that certain geographical locations are challenging environments for attaining compliance (Sanchez Ramirez et al., 2014). Some also consider that the social issues have different outcomes, depending on the context (Dreyer et al., 2010).

Other approaches propose to assess corporate performance by relying on stakeholders' perceptions or experts' judgments on the compliance to societal expectations of the companies investigated (No.3 in Fig. 3). In this type of approach, the data collected is stakeholders' or experts' input. Here, the evaluation is performed upon collection, when stakeholders or experts are asked—on a multilevel scale—how they rate the social performance that may be associated to a corporate activity, based on their knowledge and experience.

Lastly, some evaluation approaches focus on assessing a company, a sector, or a country, based on how it performs on social issues in comparison with others. This is the approach often used by SLCA databases (see Section "**Databases for SLCA**"). 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. For example, in the Social Hotspots Database (SHDB), the distribution is divided in quartiles—and a level of risk is attributed according to the quartile where it falls (low, medium, high, or very high risk) (Benoit Norris et al., 2012).

Evaluation is always accompanied with an explicit or implicit weighting step in order to obtain final results. Through this step, the impact subcategories evaluation results are given a different relative weight in the final aggregated results. Some approaches to weighting are based on the principle that not all impact subcategories considered are of equal importance (e.g., forced labor can be considered as a more important issue than the promotion of CSR in the value chain). These approaches will thus assign greater weight to more important issues, which can be decided upon in a variety of processes. Other approaches will weigh according to the relative importance of life-cycle steps. Accordingly, steps (or unit processes) which are more significant—where more hours of work are invested, or where greater added value is generated—will be weighed accordingly, through the activity variable (as discussed in Section "**Goal and Scope**").

Databases for SLCA

Databases can be used in SLCA in order to support the product system modeling, data collection, evaluation, and weighting. Two databases have been developed specifically for the purposes of supporting SLCA practice: The Social Hotspots Database (SHDB), operated by the US-based not-for-profit organization New Earth, and the Product Social Impact Life-Cycle Assessment (PSILCA) database, operated by Germany-based database and software developer Greendelta. Their chief objective is to compile and analyze generic social data at country and sector levels, in order to attribute levels of social risk to different country-specific sectors involved in the product system. They both are based on life-cycle attribute assessment (LCAA), a methodology developed by Norris (2006).

Drawing on statistics and information issued by governments and international organizations (such as International Labor Organization, World Bank, CIA, World Health Organization, US Department of Labor), the databases centralize social data on specific countries and sectors. The social issues considered in the data mirror a portion of the Guidelines' impact subcategories, as well as key international frameworks relevant for CSR (Benoit Norris et al., 2012).

Both databases link the social data with global economic input/output (I/O) models (SHDB's I/O is derived from the Global Trade Analysis Project (GTAP) and PSILCA is linked with Eora), which reflect commercial exchange of goods between sectors and countries around the world. They map out how different economic sectors are linked to one another, based on economic input and output (e.g., how much economic activity in other sectors does 1 M $ of US dairy products generate). The I/O models are thus very useful in modeling potential product systems which lie behind products. However, the product systems derived from these models are generic and have low levels of granularity (the sector categories which the I/O models take into account can be very broad (e.g., "chemicals, rubbers, and plastics" or "fruits, nuts, and vegetables"), and the values and modeling comprise varying levels of uncertainty).

For every country-specific sector considered in a given product system, SHDB and PSILCA will evaluate social data according to levels of social risk. There are four to five possible risk levels in the databases, ranging from very low risk (SHDB has four risk levels: from low risk to very high risk and PSILCA has five levels: from very low risk to very high risk) to very high risk (New Earth, 2013). The points of reference for the assessment scales vary, but the overall majority are based on how a company, or a sector or a country is positioned with regard to worldwide performance. The databases will also link these results with the number of hours worked at each stage of the life cycle (this data being supplied through a combination of the I/O model and ILO statistics). Results are thus expressed as worker-hours at a specified level of risk for a given social issue, per dollar of process output. Through a conversion rule, these levels of social risks can also be converted to a single unit (medium-risk equivalent hours) (the conversion rules are such that hours worked at a low risk will be converted to proportionally fewer medium-risk equivalent hours than hours worked at a high risk) which allows overall aggregation of different levels of risk (Benoit Norris et al., 2012).

Below is an example of results from a fictive study carried out with the SHDB, for illustrative purposes. The results present the overall medium-risk equivalent hours per Impact Category and present which material/input (the material/input itself and its upstream chain) is responsible for the lion's share of hours at risk in those different categories (**Fig. 5**).

Results

The format of SLCA results is not standardized and varies from one study to another. However, there are some commonalities that emerge. Studies will typically

- Identify the steps along the life cycle where most important potential social impacts are likely to arise
- For these steps, identify the types of social issues that are likely to arise (identify the impact subcategories involved), and which stakeholders they are related to.

The results will typically be presented either in a textual form, summarizing the main findings, in Graedel diagrams, in Tables, or else in bar graphs, presenting results per life cycle step or per impact subcategory or category. The interpretation will focus on

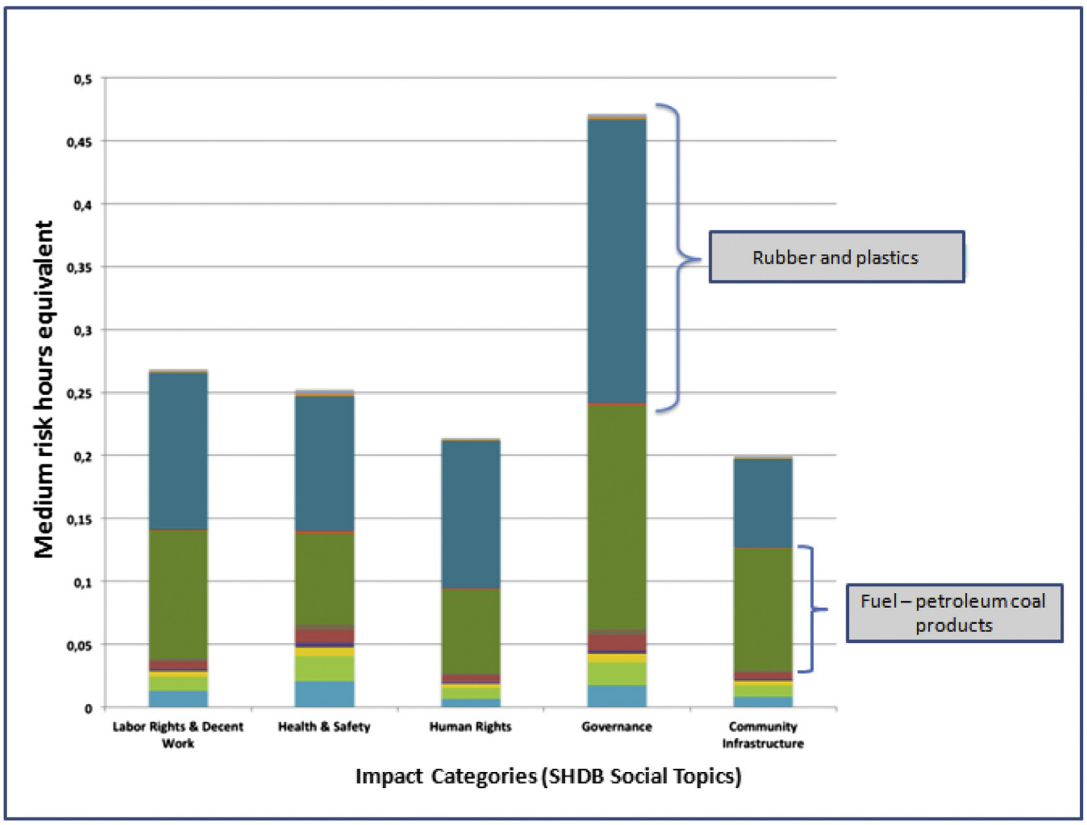

Fig. 5 Example of SHDB results for illustrative purposes: Key inputs (and their upstream system) which contribute to hours at risk in Impact Categories.

explaining these results, discuss root causes, and propose recommendations derived from this analysis, in line with the study's initial objective.

Below are some examples of figures which provide partial summaries of results in different studies—most of these figures would be presented alongside other ones (covering results for other life-cycle steps or stakeholders or category of impacts). The first one is from an SLCA on laptops in Belgium (Ciroth and Franze, 2011)—it provides results on the entire foreground product system, for issues pertaining to the Stakeholder Category "Local community". This type of figure provides insights on the potential social impacts (called 'effects' here) attributed to the different life cycle steps considered in the study. Here, all impact subcategories within a given life cycle step are aggregated into a single color-coded level (ranging from very negative effects to positive effects). The figure thus provides a quick summary of the varying levels of positive and negative potential social impacts within each life cycle step (**Fig. 6**).

The second example is from an SLCA on milk production in Canada (Quantis et al., 2012), where results are provided for one life-cycle step (milk production) and all stakeholder categories and impact subcategories within. This type of figure provides detailed insights for a single life cycle step and allows the reader to understand how the different social issues considered compare to one another within that life cycle step (**Fig. 7**).

The third example comes from (Benoit Norris et al., 2012) SLCA on strawberry yogurt. The figure is a plot of the prominent social issues present in particular countries and sectors involved in the supply chain of strawberry yogurt This type of Figure provides a quick read on what social issues are more at risk in the entire system. Here, all life cycle steps are aggregated – what is important here is not what life cycle step has obtained to the best/worst results, but rather what impact sub-category is more/less at risk (**Fig. 8**).

At present, there are no guidelines in SLCA as to how to present results. The leading factor deciding whether to present results in one way or another—e.g., with a focus on multiple life cycle steps, on a single life cycle step, on aggregated results per social impact subcategory, etc.—rests on the nature of the question in the goal and scope of the SLCA and on the practitioner's expert judgement.SLCAs have been used in the context of various sectors, to respond a range of questions as discussed in Section "**Uses of SLCA**." For illustrative purposes, we list a few sectors where published studies have been performed and describe the studies' focus and general purpose (**Table 2**).

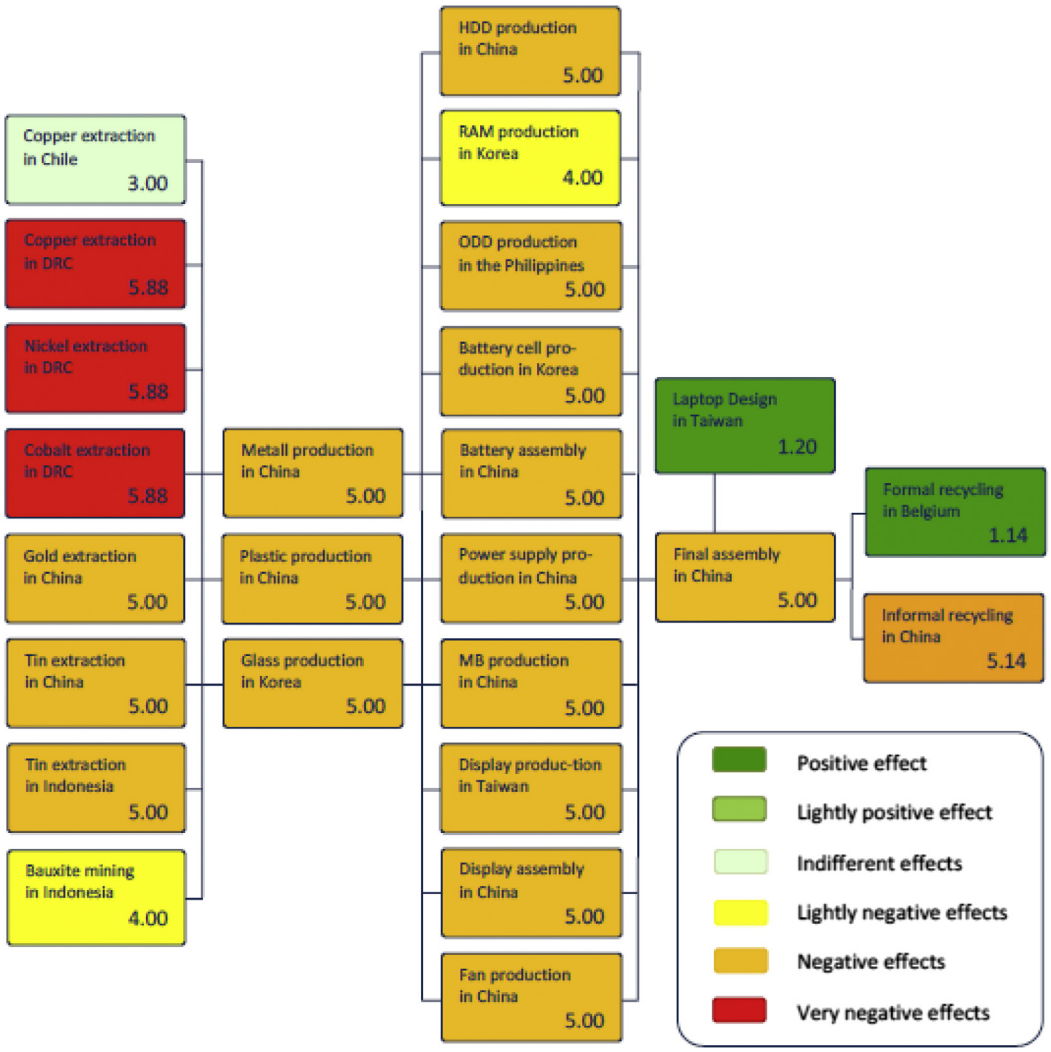

Fig. 6 Example of SLCA results from Ciroth and Franze (2011): Results in the product system for the "Local community" Stakeholder Category.

Looking Ahead

Increased pressure to include social aspects of sustainability, as well as life-cycle perspective, in every day decision-making is prompting private and public sector actors to explore new tools such as Social Life-Cycle Assessment (SLCA). While still in development, SLCA is being increasingly called upon to shed a new perspective of the potential social impacts emanating from product's supply chains and end of life. It distinguishes itself from other tools available through its holistic life-cycle perspective, its unique product focus, and the typologies of stakeholders and social impact subcategories it focuses on.

The field of SLCA has reached a basic level of maturity with regard to its operationalization. Yet, much research and experimentation is left to be done, namely to improve understanding of the impact pathways between activity and final impacts, to improve modeling tools and techniques to define product systems, to improve evaluation methods for potential social impacts, and to refine the way in which results are communicated and understood. However, recent publications led by private sector actors have underlined the need for SLCA to become more standardized, so as to ensure coherence over time.

In order to continue its development and increase its uptake, SLCA practitioners and researchers will thus have to negotiate the uncertain yet exciting terrain of contributing to the development and application of SLCA, of moving increasingly into the realm of impact measurement (rather than practices), while working toward greater convergence of methods.

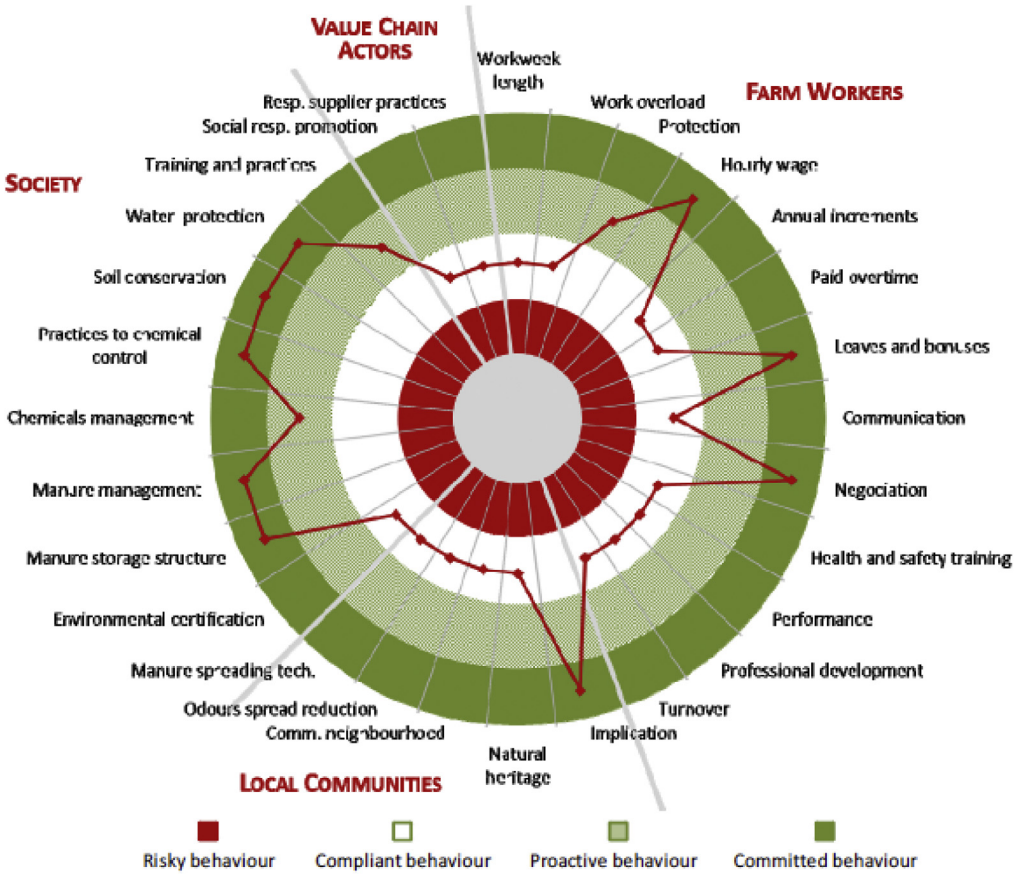

Fig. 7 Example of SLCA results from Quantis et al. (2012): Results for life-cycle step "milk production" and multiple Stakeholder Categories and Impact Subcategories.

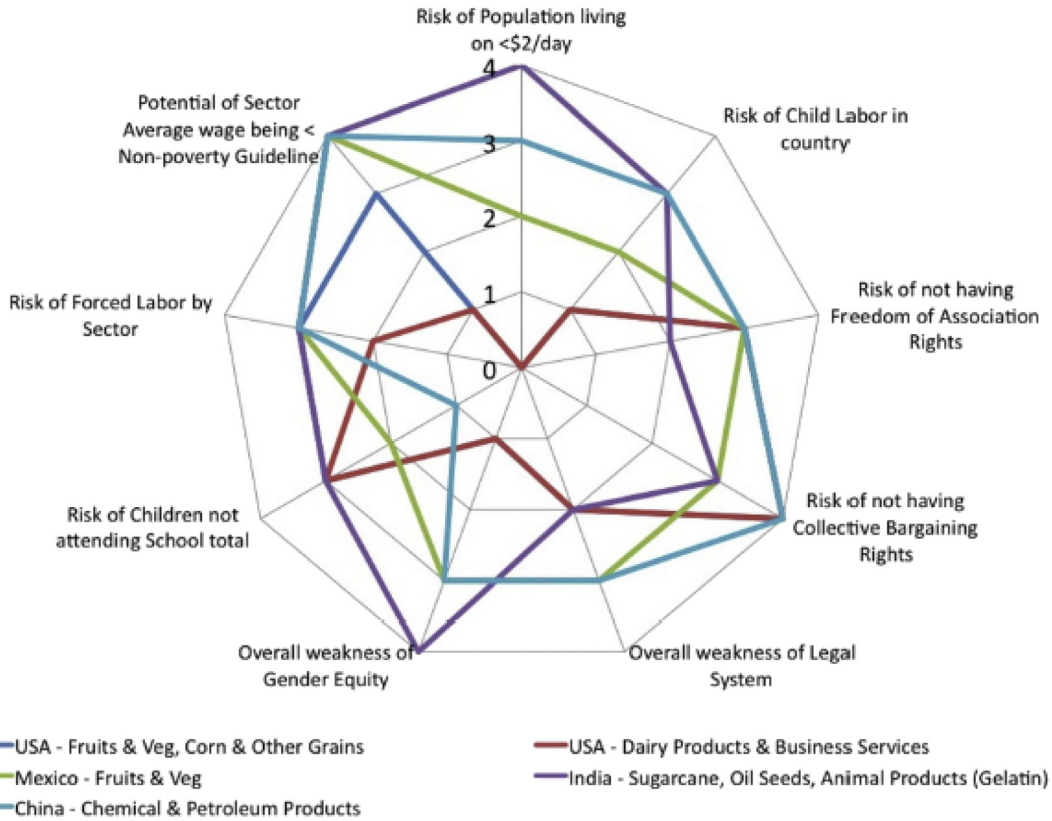

Fig. 8 Example of SLCA results from Benoît et al (2012): Results for prominent social issues in countries and sectors involved in the life cycle of strawberry yogurt.

Table 2 Selected examples of SLCA application

Broad sector	*Product(s) of focus*	*Example of study focus*	*General purpose(s)*
Information technology	Laptop computers	1. Identifying location and nature of hotspots in the product system (Ciroth and Franze, 2011; Ekener-Petersen and Finnveden, 2013)	To inform policy decision by Government of Belgium and to develop/refine SLCA methodology
		2. Comparing end-of-life scenarios for laptops (CIRAIG and AGÉCO, 2011)	To inform policy making on computers' end-of-life in Quebec, Canada
Food and agriculture	Milk	Identifying location and nature of hotspots in the product system and in-depth understanding of social performance in one life-cycle step (Quantis et al., 2012)	Understanding supply chain social risk External communication for sector positioning
	Beef	Identifying location and nature of hotspots in the product system	Understanding supply chain social risk External communication for sector positioning
	Wine	Identifying salient social issues specifically in two life-cycle steps (Beaulieu et al., 2014)	To support/orient supply chain management and monitoring
	Fertilizers	Comparing three types of fertilizers (Martínez-Blanco et al., 2014)	To develop/refine SLCA methodology
Consumer goods	PET bottles	Comparing the environmental and social impacts of four selected disposal alternatives of used PET bottles (Foolmaun and Ramjeeawon, 2013)	To inform policy decision by Government of Mauritius
Automotive	Tires	Comparing life extension options and in-depth understanding of social performance in one life-cycle step (Beaulieu et al., 2014)	To support/orient supply chain management and monitoring To inform long-term strategic decisions
	Automotive parts recycling	To compare social profile of different auto parts	To support external communications regarding social sustainability of a product
Energy	Energy supply alternatives	Comparing social dimensions of energy supply alternatives in steelmaking (Weldegiorgis and Franks, 2014)	To inform prospective policy
Processes	Recycling system	To compare social impacts of formalized recycling systems in low-income countries in comparison with informal systems (Aparcana and Salhofer, 2013)	To develop/refine SLCA methodology

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